UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF PRACTICAL ACTIVITIES ON LEARNING AND UNDERSTANDING OF SELECTED PHYSICS CONCEPTS.

(A CASE STUDY)

ISSAH SALIFU

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A DISSERTATION IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF EDUCATION IN SCIENCE EDUCATION.

DECEMBER, 2016

DECLARATION

Student's Declaration

I, ISSAH SALIFU, hereby declare that this dissertation with the exception of quotations and references contained in published work which have all to the best of my knowledge been identified and acknowledge is entirely my own original work and it has neither in whole nor in part been presented elsewhere for the award of another degree.

Signature:…………………….. Date:……………………….

Supervisor's Declaration

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

PROF. K.D. TAALE

Signature:…………………………….. Date:……………………………..

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DEDICATION

All thanks and glory be to the Almighty Allah for the favours he has bestowed on us all. I dedicate this work to my parents, Hajia Sahada Salifu and Issahaku Salifu, my wife, Ibrahim Awabu, my children: Issah Mohammed Mashud, Issah Mohammed Nasir, Issah Rahamatu and my late son Issah Mohammed Salim. I also dedicate this work to all my brothers, sisters and friends.

ABSTRACT

This study was designed to investigate the effects of laboratory practical activities on students' learning and understanding of selected Physics concepts at E.P College of Education, Bimbilla in the Northern Region of Ghana. The target population was all the physics students in four training colleges in the northern region of Ghana. However, the accessible population was 95 students in E.P.College of Education, Bimbilla. The study was a quasi-experimental design. It comprised one experimental group and one control group. The main unit of analysis was the 95 first year students who were purposively sampled from the science class. The two groups were exposed to the pretest. The experimental group was taught using the laboratory practical approach for four weeks while the control group was taught the same topics using the traditional method. Three instruments were used in the study. Namely: A pre-test Physics Assessment Test, Test of Physics students motivation questionnaire (TOPM) and a Post-test Physics Assessments test. The data collected was analysed using the statistical package for social sciences (SPSS) Version 21. Student's t-test was used to compare the mean of the experimental and control groups. The significance of the results was tested at $\alpha = .05$ confidence level. The results of the study revealed that laboratory Practical Approach resulted in higher students' learning of physics concepts. It also yielded good understanding of physics concepts leading to improved students' motivation to study physics at E.P. College of Education. The study concluded that, laboratory practical Instructional Approach in Physics is an effective teaching method which Physics teachers should use to enhance students' achievements in physics.

The study recommended that further studies be conducted into the use of laboratory practical activities in teaching physics in other colleges. Since this research was conducted in only E.P College of Education the findings may be limited in making generalizations.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter focuses on the following subheadings: Background to the study, statement of the problem, purpose of the study, objective of the study, research questions, the significance of the study, limitations and delimitations of the study and the organization of the study.

1.1 Background to the Study

Practical work is seen as an essential part of teaching and learning physics (Abrahams & Millar, 2008; Hodson, 2005; Jenkins, 1999; Solomon, 1999). Practical work has been confirmed by researchers, teachers as well as national curricula. Students seem to enjoy practical work and it is thus generally regarded as adding to the students' motivation to study physics (Abraham, 2011). In most countries practical work is either considered a central part of physics classes or its status is wished to be lifted to such a position (Hodson, 2005). Admittedly, educational researchers hold divergent views about the efficiency of practical work as a teaching and learning method. In England and North America, researchers of science education have been interested in the efficiency of practical work for decades. However, it cannot be lightly argued that practical work does not have its place in science teaching. Solomon (1999) talks about the importance of practical and theoretical learning supporting each other. She uses an example of a medical student who, when seeing his very first X-ray picture in a lecture, could not first make sense of either the picture or the lecturer's words but when comprehension came, both the picture and the theory made sense simultaneously. Her point to make is that "neither the one nor the other is the primary [representation], and that neither of them alone corresponds to the full internal image" (p.24). This can be easily applied to the meaning of practical work in science teaching: scientific phenomena are such that they can be fully understood by neither practice nor theory. The empirical and the theoretical are intertwined and cannot be separated.

Experiments have so central a role in physics education that hardly any textbook fails to mention that physics is an 'experimental science' and that in physics 'knowledge is based on experiments' (Jenkins, 1999). Of these statements there seems to be a general agreement among physicists doing their science, philosophers interpreting the physicists' activities, and finally, science educators trying to give a picture of physics to their students. However, as soon as the epistemological role of experiments needs to be made more definite, there is a broad spectrum of views ranging from experiments as a basis for simple inductions to views that experiments are used for refuting theories. Therefore, there is the need to pay more attention to the epistemology of experiments in physics education. Abrahams and Millar (2008) introduced an observation linked to the inefficiency of practical work in teaching theoretical knowledge: In their study, the teachers expected the students to learn the ideas through the work but yet did not plan or implement any sort of actual effort to bring this about. Similarly, Ntombela (1999) states that amongst teachers and teacher-students, "there is a strong belief that by following steps given in the worksheets pupils can 'discover' the theory for themselves" (p.37). Clearly the teaching strategy behind these findings must be inductive or discovery learning.

Hodson (1990) argues that teachers' views on discovery learning are distorted by some faulty assumptions about the importance and potential of observations. For instance, that explanations of these [gained] trends and generalizations, in the form of principles, laws and theories, can be extracted from these data. In both these cases, the problem has to do with discovery learning and inductive teaching strategies. He goes on to argue that discovery methods are "psychologically unsound and pedagogically unworkable" as it is very unlikely that students will without the needed theoretical framework make the correct deductions from the data. Such a situation usually has two possible outcomes: either the students make the wrong observations and draw inaccurate conclusions or the teacher issues clear recipe-like instructions which ends up in the students doing instead of thinking.

The verificatory role of experiments is the preferred physicists' stance, expressed by Feynman, Leighton, and Sands (1963) mentioning: 'The test of all knowledge is experiment; experiment is the sole judge of scientific truth' (p.102). Physicists often mention experiments in the role of 'supporting' theory (Weinberg, 1993; Einstein, 1970), but the idea that experiments are for refuting theories by falsification (Popper, 2002) is, however, denied (Weinberg, 1993; Einstein, 1970). The 'textbooks' science', on the other hand, follows the scheme of verificatory justification, and it displays physics as a logical chain of steady progress, experiments verifying the predictions based on theory (Kuhn, 1996). Contrary to this conception, inductivist views about the role of experiments are common in the 19^{th}-Century physics literature (Duhem, 1914; Robin, 1904). However, towards the end of the 19^{th} Century, there was a shift to hypothetical-deductive views of science, and questions related to the logic of discovery were set aside in favour of the logic of justifying theoretical knowledge (Suppe, 1977; Giere, 1988).

There has been an upsurge of studies concerning science teacher education in Ghana and beyond. These sequences of studies focus on content knowledge and the pedagogy of trainee teachers in the Universities and the Colleges of Education in Ghana. The need for research in this area is a result of the strong relationship between the teachers' content knowledge and the pedagogy that is employed in the teaching process. Admittedly, teachers' knowledge affect the teaching and learning process whiles the learners' knowledge is influenced by teacher experiences that reflect on such experiences (Caldderhead, 1996; Clark & Peterson, 1986). In the light of this it is essential to investigate the impact of practical activities on the learning and understanding of selected concepts in physics in E.P College of Education, Bimbilla.

The teacher education sector has received tremendous support from Governmental and nongovernmental organizations. One of these is the Japanese International Cooperation Agency (JICA). This organization has established science resource centers in three colleges of education in Ghana. These are Akrokeri College of Education, Akrokeri, Akropng College of Education, Akropong and Bagabaga College of Education, Tamale. These resource centers are charged with the mandate of developing teaching and learning materials for the colleges of education mainly to facilitate the teaching and learning of science.

1.2 Statement of the Problem

Research has proven that there is a very strong relationship between practical lessons and the understanding of concepts in physics. Jenkins (1999) argues vehemently that in physics knowledge is based on experiment. There seems to be a general agreement to this statement particularly among physics doing their science, philosophers interpreting the work of the physicist` activities and finally science educators trying to give a picture of physics to their students. At the E.P College of Education, teacher trainee students do not take keen interest in physics lessons; they often complain that physics is a difficult subject. Some of these science students who completed senior high school sometimes admit performing few practical lessons in the secondary schools. Therefore, it is thought prudent to investigate the impact of the use of laboratory practical activities in fostering understanding of physics concepts. This notwithstanding, the number of periods allocated in the Institution's time table is limited for laboratory practicals. It is therefore of immense importance to investigate into the effects of practical activities on learning and understanding of selected concepts in physics in the College.

1.3 Purpose of the study

The purpose of the study was to investigate the effects of laboratory practical activities on learning and understanding of selected physics concepts at the E.P College of Education, Bimbilla. This study also investigated the affective domain of laboratory practical activities on learning and understanding of physics concepts. These affective domains include motivation of students towards the study of physics.

1.4 Objectives of the Study.

The following objectives guided the study:

1. To determine if there is a significant difference in learning of physics concepts between students who are taught using laboratory practicals and those taught using conventional method at E.P College of Education.
2. To determine if there is a significant difference in understanding of physics concepts between students who are taught using laboratory practicals and those taught using conventional method at E.P College of Education.
3. To determine if there is a significant difference in motivation of physics students between students who are taught using laboratory practicals and those taught using conventional method at E.P College of Education.

1.5 Research Questions

The following research questions were formulated to guide the study.

1) Will there be any significant difference in the post-test achievement score on learning between students expose to laboratory practical activities and those expose to the conventional method.
2) Will there be any significant difference in the post-test achievement score on understanding between students expose to laboratory practical activities and those expose to the conventional method.

3) Will there be any significant difference in the post-test treatment score on motivation between students expose to laboratory practical activities and those expose to the conventional method

1.5 Hypotheses

This study was guided by the following null hypotheses:

Ho1: There is no significant difference in student learning of Physics for first year students taught Physics through practical work and those not taught through practical work.

Ho2: There is no significant difference in student understanding of Physics for first year students taught Physics through practical work and those not taught through practical work

Ho3: There is no significant difference in motivation towards physics for first year students taught Physics through practical work and those not taught through practical work.

1.6 Significance of the Study

The importance of practical activities in physics lessons cannot be overemphasized. As physics underpinned all engineering and technology related programs, there is the need to develop a teaching strategy that can enhance understanding of scientific concepts

The main aim of teaching Science in the Ghanaian school curriculum is for every Ghanaian citizen to acquire a general scientific literacy to function in a technological advancing world. There is no doubt that Physics underpinned all technology and engineering related disciplines in Science.

In this study, there is a strong focus to discover the impact of laboratory practical activities on trainee students at E.P College of Education. This focus relates to students' learning and understanding of some selected Physics concepts and the motivation that is derive in the physics laboratory.

Findings from this study would inform tertiary institutions that run teacher education programs to modify the teaching strategy and the curricular to suits students learning style.

A research of this nature involves the use of materials and equipments in the laboratory. Therefore implementing this research would improve the resources available for Science teaching and learning at the Colleges of Education.

Teacher empowerment allows teachers to implement instructional programs that best meet the need of their students (Johnson, 2005; Mertler, 2006). This can only be realize when teachers design research study and collect data and ultimately become decision makers in the curriculum development process.

1.7 Delimitations of the Study

The study was conducted at the E. P College of Education, Bimbilla in Northern Region. Marilyn (2011) outlined the meaning of delimitation as saying that delimitations are those factors that limit the scope and defined the boundaries of the study. Delimiting factors are in the control of the researcher. These include the choice of research questions, objectives, theoretical frame work and the population of the study. The study focused on the effects of practical activities on learning and understanding of selected concepts in physics. The sample population of the study included first year students of E.P College of Education.

1.8 Limitation of the study

The focus of the study was limited to only E.P College of Education, Bimbilla. Also the instrument used in soliciting respondents view on the issue under study has its own limitations. The close ended questionnaire might not have given the respondents the freedom to express their views as much as they could. The findings therefore was limited to only E.P College of Education and therefore cannot be used as a generalization of all Colleges in the country.

1.9 Organization of the Work

The study is presented in five chapters. Chapter One, the introduction of the study, covers the background to the study, statement of the problem, objectives of the study, significance of the study, limitation and delimitation, and organization of the work.

Chapter Two covers the review of literature relating to the study, Chapter Three focuses on the research methodology encompassing the research environment, population, sample and sampling techniques, research design and instruments. Chapter Four discusses the analysis of data while the final chapter, Chapter Five presents the summary of the findings of the study, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter deals with the literature that is related to the subject under study. The chapter underscores the need for practical activities as a form of activity based teaching and learning as this method facilitates understanding of physics concepts.

2.1 Theoretical framework of the study.

The theoretical base of this research is encapsulated in the constructivist theory of learning. Constructivism is one of the theories of teaching and learning which is based on the idea that learning is the result of mental construction. Constructivism believes that students learn by fitting new information together with their prior knowledge and experience. Constructivist asserts that learning is affected by the manner in which an idea is presented as well as by the student's personal beliefs and previous experiences.

Constructivist's theory deals with learning that "is a process of constructing meaning, it is how people make sense of their experience" (Merriam, Caffarella, & Baumgartner, 2007, p.291). Notable developers of constructivist theory were John Dewey, Lev Vygotsky and Jean piajet (Davis & Sumara 2002; Henson, 2003; Merriam, et al, 2007; Proulx, 2006; Wilson & Lowry, 2000). Admittedly, constructivism place emphasis on learning in line with teaching. The emphasis is therefore laid on the learning environment and is learner centered rather than teacher centered (Proulx, 2006). The teacher's role is to ask "what should be taught "and "how can this be learned". Some of the benefits of learner-centered education as espoused by john Dewey include; student's increased intellectual curiosity, drive, creativity and leadership skills (Henson, 2003). Educators who practiced learner-centered approach do challenge students to unearth their hidden potentials and at the same time provide reinforcement and appropriate rewards for student's success.

Teachers address the needs and expectations of individual learners when developing learning experiences that is aimed at giving maximum benefits to students. In preparing for lesson delivery, viewing the lesson from the learners perspective and from its relevance to the learner promotes learning experiences that will have maximum impact on students (Garmston, 1996; Henson, 2003; Spigner-Little & Anderson, 1999). To ensure maximum conditions for construction of meaning, educators need to create a safe learning environment where individuals are free from fear and open to constructive learning. In addition learners must feel welcome, comfortable, and respected (Henson, 2003; Spigner-Little & Anderson, 1999). performing practical activities in the laboratory does not only provides the environment it also provides a stimulating scientific arena where students have the opportunity to observe natural objects in the form of scientific equipment's, learn scientific measurement and observation. For instance the use of rectangular glass block to demonstrate refraction of light allows students to conceptualize the passage of light from air to glass, it ensures practical work enable learners to acquire skills and promotes acquisition of first hand information.

2.2 Educational Views on learning

Educational research is replete with a lot of principles of how learning takes place within an individual student. The three prominent views of learning are: Behavioural, Social Cognitive and Cognitive views of learning (Eggen & Kauchak, 2004; Ormrod, 2003; Woolfolk, 2005). According to Skinner (1995), behaviourists emphasize that learning takes place if there is a relatively permanent change in the learner's behaviour as a result of stimuli from environmental events. The social cognitive view considers learning process when learners observe other people and interact with them (Bandura, 1986). These two views of learning are silent about the mental processes that occurred in the mind of the learner as they make sense of their experiences.

Cognitive theory asserts that the change in learners behaviour could be explained by the change in mental associations arising from experiences. A cognitive view on learning is considered as the most popular view on Scientific psychology in the 1970s (Robins, Gosling, & Craik, 1999). Cognitive theory of learning seems to suggest an additional twist to the two theories of learning by the recognition of the changes in mental processes that are responsible for the change in behavior. Cognitive views of learning is based on the suggestions that learning involves a modification of mental structure or schemes where understanding or comprehension takes place. The modification is influence by learners who actively pay attention to the information they respond to. The focus is shifted to knowledge construction rather than learners passively influence by the teacher, giving the information in a lecture.

It is however very crucial to deal with the fundamental principles of learning in order to understand learners performance and behaviour and to improve instruction. Teachers and instructors often overlook the basic principles and theories of learning and rely only on their past experience to diagnose learning problems. When instructors consider learning principles they will get to know for instance why teaching by telling is ineffective at most times, why motivation results in better achievement and why real life elements in instruction promote achievement.

2.3 Piaget's theory on learning

Jean Piaget is one of the most influential development psychology researchers in recent history. Piaget had an initial career in science and later became interested in developmental psychology. He also studied epistemology (the study of how knowledge is acquired) and regarded the child's incorrect responses to be as important as the correct ones (Ashlock, Johnson, Wilson & Jones 1979).

One of the most notable theory of Piaget is that children pass throgh distinct stages of mental and emotional development. These stages are; Sensory-motor, pre-operational, concrete operational and formal operational. These stages represent distinctive stages in the qualitative thinking abilities (Ashlock et al., 1979).

Piaget's theory viewed the teacher as a facilitator and a guide and not a director who provides support for students to explore their world and discover knowledge (Santrock, 2005). In his view, Piaget opposed teaching methods that treat children as passive receptacles (Bergma, 2008). This view is one of the underpinning principles of the use of laboratory practical work in this research study, where the teacher becomes a facilitator rather than being the sole repository of knowledge. The learners are given the opportunity to interact with the real world around them and make significant contribution to the acquisition of their own knowledge. Piaget also explained the concept of reflective abstraction as the construction of Logico-Scientific and Mathematical structure by an individual during the course of cognitive development (Tall, 1991). Reflective abstraction according to Piaget has no absolute beginning but is present at the earliest stage in the coordination of sensory-motor structure.

When laboratory practical work is organized as lesson instruction, students are free to interact with concrete learning materials to foster understanding of scientific concepts and a minimum element of abstract thinking through reflection.

Piaget's theory of learning has far-reaching implication in educational practices. In one of these implications has a bearing on the use of laboratory practical work in that it allows students to learn best by interacting with concrete materials and also reflect on their experiences in order to construct meaning of concepts.

The use of concrete objects gives a complete paradigm shift from the teacher as the sole repository of knowledge to a facilitator of knowledge acquisition and the learner from a receiver of information to a learner who can construct his own knowledge. The teacher there after becomes less of an expositor and more of a facilitator that promotes and guides learning rather than teach everything directly (Santrock, 2005). This is the hallmark of this research work.

The educational implication of Piaget view in the use of laboratory practical work in teaching physics concepts is that students learn by making their own discoveries, reflecting on ideas and discussing the ideas rather than imitating Physics teachers or doing things by rote learning which blocks meaningful learning.

2.4 Vygotsky's theory of learning.

Vygotsky's theory also focuses more on cognitive process that occur in the mind of the individual learner. Like Piaget, Vygotsky emphasized the active construction of knowledge and understanding by the learner. In Piaget's theory, the learner develops ways of thinking and understanding by interacting with the physical world. In Vygotsky's theory, learners are more often described as social beings by their interactions with one another. Cognitive development is achieved through social interactions. The cognitive development of the learner depends largely on the tools provided by society and their minds are shaped by the cultural context in which they live (Santrock, 2005). In the laboratory students are allowed to work in groups in which they interact with one another and also learn from one another. Learning becomes more meaningful when learners are given minimum level of support and guidance. Vygotsky also proposed the Zone of Proximal Development (ZPD) for a learner to learn concepts that are difficult but can be learned with guidance and support from adults or more skilled persons.

In ZPD also include a place where new external ideas are accessible to the learner with those ideas already developed. The lower limit of ZPD is the level of skills reached by the child where he/she can learn independently, this is also known as spontaneous concepts, that is ideas are develop within. The upper level is the level of assistance of an able instructor that is called Scientific Concept, an idea external to the learner. Aside the ZPD, Vygotsky also explained the concept of scaffolding. Scaffolding means changing the level of support (Van de Walle, 2007).

In using laboratory practical in learning Physics concepts scaffolding is a major element/component to facilitate learning in which the teacher gauges the level of support being offered to the learner. The level of support given depends largely on the level of the difficulty of the problem if the problem is so simple Scaffolding may be unnecessary when very little assistance is needed. On the other hand, if the problem is cognitively challenging, the zone may be too big for the learner to bridge even with the help of peers and teacher scaffolding may intervene. The theory postulated by Piaget and Vygotsky are the theories that form the bedrock of theory of constructivism.

2.5 Pedagogy of Teaching Science.

Many research references have been made to the teachers' knowledge on the subjects and the methodology that is employed in the teaching known as Pedagogical content knowledge (PCK). Educational researchers view the teaching as a complex and dynamic process.

Expertise in teaching is dependent on flexible access to highly organized systems of knowledge (Putnam & Borko, 2006). The effectiveness of a teacher revolves around the knowledge he/she possessed. The importance of PCK in teacher education cannot be over-emphasized.

Pedagogical content knowledge was first proposed by Shulman (1986) and developed with colleagues in the knowledge growth in teaching project as a broader viewpoint model for understanding teaching and learning (Shulman & Grossman, 1988)

The project centred mostly on knowledge acquired by newly trained teachers on their respective subject content areas and the impact of this knowledge in the delivery of their core duties relative to teaching and learning. This knowledge included, content knowledge, pedagogical knowledge, knowledge of curriculum, knowledge of learners, and knowledge of assessment. Pedagogical content knowledge was unique to teachers and separated a science teacher from a scientist. Although the idea of pedagogical content knowledge started in 1986, the whole concept was introduced as an essential element for teaching in 1987. To give further clarity on the uniqueness of PCK, Cochran, King and DeRuiter (1991) added the following views: Teachers differ from biologist, historians, writers, or educational researchers not necessarily in the quality or quantity of their subject matter knowledge, but in how that knowledge is organized and used. In another study conducted to find out the best way of transfer of knowledge, Geddis (1993) concluded that pedagogical content knowledge has been viewed as a set of special attributes that helps a teacher to transfer knowledge of content to others. Pedagogical content knowledge deals with the "most useful forms of representation of ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations– in a word the ways of representing and formulating the subject that make it comprehensible to others"(Shulman, 1987, p.9). When teachers adopt the activity-base method in teaching such as that of the laboratory practical activities they are able to use concrete objects to make representational ideas, analogies, illustrations and demonstrations that make the concept understandable to the learners.

According to Shulman (1987) pedagogical content knowledge are a set of special attributes that a teacher uses to help him or her guide a student to understand content in a manner that was personally meaningful. He further added that "this special attributes included an understanding of how particular topics, problems or issues are organized, presented, and adapted to the diverse interest and abilities of learners for instruction"(p. 8).

Shulman (1987) also suggested that pedagogical content knowledge was the best knowledge base for teaching. The most characteristic of this knowledge base lies at the intersection of content and pedagogy, the capacity of a teacher to transform the content knowledge into forms that are pedagogically powerful and yet adaptive to the variation, in abilities and background of students.

Although, many educational researchers see teaching as both an arts and a science, Sarason (1999) looks at teaching as an art of creativity and discusses the art of teaching and the role played by a teacher in organizing productive learning experiences. He posits that post World-War II education has increasingly focused on subject matter to the detriment of pedagogy – "The obligation of the teacher to know who the learner is and make the subject matter interesting, motivating, and compelling for their students" (p. 97).

Sarason (1999) identifies three overarching characteristics of productive learning. The first is recognizing and respecting the individuality of the learner. The second is for the teacher to know the subject matter sufficiently to be able to determine when the learner may have difficulty and be able to intercede to prevent the difficulty from happening. The third tenet is that the teacher is constantly looking for ways to engage and stimulate the leaner to learn. The flavour in this findings is about the teacher and how the adopt teaching strategies with the student in focus to foster meaningful learning. By organizing practical activities for students in a laboratory, students get the opportunity to interact with concrete materials and also see how natural phenomena are related. This will result in cognitive engagement and stimulate the interest of the learner. Students learn more effectively by performing concrete activities, by comparing experimental data to a model. The recent development in cognitive Science (Klein, 2006; Praint & Tytler, 2007) now attributes conceptual knowledge of learners with more sensitive, perceptual and concrete experience.

2.6 Challenges in Teaching and Learning Physics.

In most empirical instances the challenges faced by Physics include teachers` training and conceptualization of the subject and students understanding of the subject. Students come to class with their view about Physics and about the world. These are the misconceptions students bring to class. Traditional lecture instructions do not consider the view of students. This technique is limited in helping a learner to develop Scientific concepts (Tarekegn, 2009).The practical approach arouses the interest of students and leads to relational understanding.

Chiu (2000) observed that students taking Physics at all levels find it difficult to internalized Physics concepts which do not agree with what they had already internalize.

In furtherance to his statement Chiu (2000) stated that to capture and sustain the interest of students in the subject is one of the many difficulties faced by teachers. This is an indication of the fact that adopting teaching strategies that ignite the interest of students is one of the antidotes to challenges in teaching Physics.

Other research studies also indicate that teaching of Physics is bedeviled with the same challenges in almost the whole parts of the world. This is also evident in the work of MacDermott (1998) who explained that students from different cultural and social background have different understanding of Physics concepts. However, many young people have similar understanding of Physics concepts.

A research study conducted by Juan and Ruiz (2009) on didactic teaching-learning process in Physics concluded that the challenges faced in Physics teaching is due in part to the teaching of Physics in the classroom. He also found out that such teaching appealed more to the cognitive domain and little to the effective- emotional domain.

From this research finding, there is therefore the need for a paradigm shift in the teaching strategies from traditional lecture method to activity-based or inquiry based teaching so as to ensure effective learning and meaningful conceptual understanding. Also there is the need for Physics teachers to see practical and theory as teaching activities that cannot be separated from each other. Practical work should be integral part of teaching and theory should be derived from practical work (Juan & Ruiz, 2009). This is the basis of this current study.

Maria, Medina and Alfredo (2012) considered a problem within the teaching of Physics and has therefore proposed new approach to teaching of Physics in two aspects; the first which is the didactic part borders on the competences of the teacher since Physics courses generally, are imparted without given the student an active role and with knowledge and concepts unlinked to his/her environment. This approach makes teaching and learning of Physics lose its essence and significance. The second aspect of finding has to do with the student, which is the discipline aspect. In this aspect it is observed recurrently that even with the education, the student does not apply the concepts in a precise manner when explaining or arguing a Physics problem or situation.

This research work also takes into consideration the essence of evaluation in teaching and learning process. The traditional method of evaluation usually require students to regurgitate and recite facts of knowledge and solve exercises or problems which is the same set of information presented in lectures, in laboratory, or the textbooks. This is an indication of the fact that evaluation is wanting particularly in Physics teaching.

2.7 Methods of Teaching Physics.

There are several ways of teaching Science in general and also Physics in particular. These methods have continuously evolved with time due to new research in education. Recent studies in the field of cognitive Science especially the works of Piaget, Bruner, Gagne` and Bloom laid much emphasis on teaching methods that allow active participation of the learner in the acquisition of knowledge. This calls for process–based Science learning (Bybee, Burton, & Harrison 1981). The main aim of Physics education is to produce students with requisite knowledge of natural phenomena occurring within the immediate environment with much implication in areas such as the effects of Renewable and Non renewable energy in the environment. Zdeneck and Hana (2008) stressed the need for strong relationship between curriculum changes and the interest of students in solving issues which are within their environment.

Physics education research shows that alternative approaches results in wider range of students making much greater changes in their understanding of the phenomena than the conventional method (Dykstra, 2012). Practical approach in teaching Physics is a learner–centred approach which enable the learner to acquire Physics concepts through a process rather than memorization. This method enables students to construct their own understanding of the subject. The two overarching elements that allow for quality of the construction of meaning are; the availability of the conceptual tools and the facilitation provided by the teacher. Technical knowledge about teaching and learning is as essential as subject content knowledge (Fadaei, 2012).

When Physics contents are presented following an active Physics learning methodology (investigative Science learning) in which students observe, explain and test their explanatory models through predictions and posterior observation positive results are obtained (Mendez & Slisko, 2013).

A recent study was conducted by Garuma and Tesfaye (2012) to investigate and contrast the effectiveness of guided-discovery, demonstration, and traditional lecture methods of teaching on students achievement in rotational motion among Grade II students from three selected school in Aba Bora Zone in South Western Ethiopia. The study found that guided-discovery is more effective in improving students achievement followed by demonstration method and the least method was the traditional lecture method. The research recommended the use of guided-discovery method in teaching with sufficient guidance by the teacher to help students create, integrate and generalized knowledge through constructivism problem solving by providing them with materials available in Physics lab or locally prepared teaching materials.

Tesfaye (2012) carried out an experimental study in Nigeria to investigate the effects of instructional interventions on students learning gains. The study investigated the effect of question – answer approach on gain in students understanding of the basic concepts in mechanics. The results of the research indicated that students exposed to question-answer approach with group discussion as a teaching intervention performed better than students taught by teacher lecture method on mechanics based line text (MBT).

Laboratory practical activities use by the teacher in teaching foster the understanding of concepts. A study conducted by Refik and Bahattin (2008) concluded that when laboratory practical work is use in teaching and learning of Physics meaningful understanding of Physics concepts is achieved, concretised and students interest are aroused. Practical work helps the teacher and learner to bring the real world into the laboratory and help the learner compare the two and thus have better understanding of the principles (Chiu & Lin, 2002). Many research studies that are conducted to find the impact of practical activities on students` achievement has confirm that Science process skills help the student to understand concepts and other global issues (Juan, & Ruiz, 2009)

2.8 Activity based learning.

The term activity-based is usually used interchangeably and synonymously with hands-on or learning-by-doing in the literature (Prawat, 2000; Woolnough, 1991). In this research the same ideology about activity-based learning is adopted. John Dewey is seen by many educational philosophers as the pioneer and advocate of activity-learning (Prawat, 2000) in the early part of 20th century. Dewey explained this approach in learning relative to children.

The prominent feature of activity-based approach, according to Dewey is learner's engagement in situations that appeal to their curiosity and interest. The relevance of activity-based learning in science education will continue to flourish as most science educators believed that the knowledge is constructed not imparted. By the afflux of time, the focus of activity-based learning on children has shifted to adults as more educators employ hands-on experience as an approach to teaching and learning.

Activity-based or hands-on learning is defined in a variety of ways with only subtle differences between their meanings. Lumpe and Oliver (1991) defined activity-based science as any science laboratory activity that allows the pupils to handle, manipulate and observe specific process. Activity-based learning is different from lectures and demonstrations. In activity based learning the central criterion is that students interact with materials to make observations, but the approach involve more than mere activity. Science educators believe that with direct interactions with natural phenomena thought and curiosity are evoked. Therefore a recent twist has been added, and the topic is called hand-on /minds-on science.

Lumpe and Oliver (19991) explained that hands-on learning can be thought of as comprising three different dimensions; the inquiry dimension, the structure dimension and the experimental dimension. They stated that in inquiry learning the students uses activities to make "discoveries". The structure dimension refers to the amount of guidance given to students. The third dimension is the experimental dimension that involves the aspect of proving a discovery, usually through the use of a controlled experiment.

Geller and Dios (1998) view activity-based / hands-on learning as any activity with an inclination towards instructional techniques/ methods that enhance learning and comprehension, with an emphasis on learning by doing.

From the literature above on activity-based learning it is obvious that learners participate actively in the knowledge gaining process. In activity-based learning, the role of students shifts from passive listeners and note takers to that of students who take direction and initiation in the learning process. It gives them the opportunity to engage in in-depth manipulation and investigation of objects, materials, phenomena and ideas and allows them to draw insight and understanding from those experiences. Activity-based learning has the potential of enabling students to become critical thinkers to apply the process of learning to various life situations. In this research activity-based learning is given special recognition as student-centered, experimental oriented education that facilitates science inquiry in a cooperative problem solving learning environment.

2.8.1 Characteristics of Activity-Based Learning.

Steinberg and Sabella (1997) and Hakes (1998) have maintained that if students are actively engaged in learning, their performance is significantly better than students who are taught in the traditional way. This aspect is meant to explore some of the characteristics of such activity and to the extent to which such inquiry learning can enhance students` understanding of concepts.

Science instruction for young and adult students is known to be more effective when concrete experiences establishes the basis for the construction of scientific concepts especially when they encounter a new topic or a different treatment of a familiar topic (McDermott, Shaffer & Constantinou, 2000). Laws (1997) espoused a learning system culled from cognitive psychology and educational research, where students predicted the outcomes of the activity before observation. Students also explained the reasons for their predictions.

Students were allowed to reflect on the outcomes of the observations and were also encouraged to apply the learned ideas to new contexts. This process allowed the students to verify and examine the effectiveness of the transfer of the learning experience to new problems and new settings. Tinker (1992) stressed that students work collaboratively in these activities as they solve problem. The more hands-on experiences and mentally engaging tasks presented to students, the better they grasp the material (Tilya, 2003). The findings of these researchers revealed that, the inherent qualities of well-designed hand-on activities motivate the students to interact and experience the phenomena directly and to learn in a way with the effects of self-chosen variations in procedure. The approach can also help to discover what fails as well as what succeeds and can also be a significant contribution on which formal science learning is build.

The researchers also believe strongly that hands-on learning encompasses social and enjoyment dimensions. The students habit of both giving and taking suggestions and of collaboratively combining efforts is an essential aspect of much real science, both academic and industrial (Tilya, 2003). Enjoyment comes about as a result of the delights of discovering with satisfaction and gaining significant knowledge and experience. Activity based learning is use to evaluate students understanding of scientific concepts by discovering misconceptions among students and to determine the effectiveness of the instruction. Activity-based learning is also aim at developing critical thinking skills that are necessary to increase scientific literacy and also to encourage students to learn more. This can be achieved through mastery of concepts and investigative skills. The form of activity based learning used in this study is experiment.

2.8.2 Benefits of Activity-Based Learning.

Many researchers and educators attributed a lot of benefits to activity-based learning in science education. Stohr-Hunt (1996) enumerated a lot of benefits. These include communication skills, independent thinking and decision-making based on direct evidence and experience; perception of creativity, better science process skills, logic development, increased learning and achievement in science content. Sokoloff and Thornton (1990) claimed that activity-based learning can result in a better understanding of science. McGervey (1995) believes that hand-on activities are means to fostering students participation in physics class and can be used to illustrate basic concepts that are often overlooked. Carlton (2000) argued that hands-on activities could be used to overcome misconceptions. Tinker (1992) asserts that activity-based learning supports deep, interdisciplinary, collaborative study, it puts students in charge of their own learning, and makes learning relevant and interesting. Also Bruder (1993) noted that it is capable of motivating students to continue with informal science education as part of their life-long learning process. Triadafillidis (1996) noted that educational experiences can be used as a way of enhancing motivation and provoking thought among students. In summary, activity-based learning will play a very significant role in this research. Activity-based learning when properly apply has the inherent propensity to promote inquiry skills which underpinned learning science. The approach can also foster student's constructive learning, conceptual understanding and understanding of the nature of science. These are the benefits that are envision to be incorporated to the teaching of science in the colleges of education particularly E.P College of Education, Bimbilla.

2.8.3 Science Laboratory Experiment and Activity-Based Learning.

Woolnough (1991) asserts that the terms practical work, laboratory work experiments or hands-on activities are all synonyms referring to the performance of experiments or practical exercises with science apparatus in a laboratory setting. He added that, practical work includes any activity that involves the basic ingredients of science and would be useful for all students. According to Arce and Betancourt (1997), there are many arguments to support the use of practical work in science. Student's understanding of physics concepts are enhance through the use of experiments as it allows students to change abstract to concrete, fostering internalization. Students are motivated to deepen their understanding by applying the concepts in new situations.

Hodson (1996) contend that, the additional benefit of laboratory work is the acquisition of skills, which can be classify as content-free or craft. Hodson (1996) elaborate content-free skills as generalized and transferable skills which are of value to all students. These skills encompass decision making and problem solving abilities, skills that can be utilized in any aspect of society. Hodson (1996) maintained that craft skills are science specific skills that are deemed essential for future scientist and technicians. These skills can be attributed to inquiry skills such as hypothesizing, forecasting, visualizing, identifying and manipulating the relationship between variables, processing and analyzing data; and technological problem-solving skills such as developing a plan, testing a design and evaluation.

Hodson (1990) again believes that the development of scientific attitudes is directly linked to experimentation and in this regard He pointed students understanding of the approaches and attitude towards information, ideas and procedures essential to the science practice. Arce and Betancourt (1997) opined that practical work is widely noted to generate motivation, curiosity, enthusiasm and confidence in learning science especially when students design their own experiments, as they find the work challenging and rewarding.

Laboratory practical activities has obvious benefits and merits and these are accepted by science educators in many industrialized countries. However, there are a number of researchers who have questioned the efficacy of laboratory practical activities as they claim there are no clear evidence supporting the supposed benefits. In his attempt to espoused the relationship between laboratory practical work and learning, white (1996, p. 768) concluded, "there is insufficient evidence that laboratory promote better understanding of methods of science and abstraction processes, make information memorable, reveal links between topics, and motivation". Wastson, Goldsworthy and Wood-Ribunson (1998) came to the conclusion that students were often unaware of the educational aims of investigational lessons and that there was a mismatch between teachers aims for an investigation and things students considered they learn during the investigation. Many researchers are of the view that the fundamental concern of many students while in laboratory is completion of task and that this concern can over whelm any serious learning possibilities (Berry, Mulhall, Loughran, & Gunstone, 1999) .

The argument put forward by these critics are that laboratory work does not provoke cognitive thought and provide a context that precludes reflective thought. Despite the much critism labeled against practical work, many researchers are still discussing proposals to improve laboratory activities and to create innovation in laboratory practical activities. The new trend is to try to make laboratory work an active learning environment where collaboration and discussion are pivotal and students are offered opportunities to better direct their enquiry (Dvir & Chem, 1998). This new trend can help students to understand how scientific facts are established.

Many studies have suggested a number of ways that are in line with the new trend. Gil-Perez and Carrascosa-Alis (1994) proposed a problem-solving approach in science teaching including laboratory work.

2.9 Forms of Laboratory Learning.

This aspect attempts to explain the impact of learning environment relative to laboratory settings and what learners experience. The expository laboratory which involves verificatory approach mandates learners to follow a definite set of procedure and the teacher expects certain outcome for assessment. However, this approach is criticized by (Domin, 1999) who proposes the guided approach as the best option for laboratory learning. The approach allows more learners control of the learning activities which in turn promote deep learning. From the work of Christina, Bergendah, Berg and Lundberg (2005) a casual comparison of single experiment presented in expository and inquiry formats, suggest that inquiry version led to a more positive outcome both in terms of learning and learners perception of the exercise. In order to enhance positive learning environment laboratory activities must be design in a way that does not put excessive demand on assessment, therefore allowing students to focus on the implication of what they are doing (Viana, Sleet, & Johnstone, 1999). In any learning activity cognitive engagement in the activities is critical if meaningful learning is to occur and that physical activity alone is not a sufficient condition for learning to take place.

It is crucial to relate cognitive activities to educational goals to promote positive learning environment. Viana, Sleet and Johnstone (1999) have also opined that learning environment that are leaner-centered, peer interactive and teacher-facilitated help engineering students to develop more fruitful conceptions of the learning environment than others.

2.9.1 Learner Outcome in the physics laboratory.

There is a strong relationship between learner's outcome and the status of their physics laboratory. Example is Wahyudi (2004). Other researchers findings centered on the relationship between performing practicals in the laboratory and learners motivation, attitude and cognition (Paris, 2001; Wigfield & Eccles, 2000). This research indicates that learner's perceptions of their abilities to succeed on academic task and intrinsic interest in a task are positively associated with their academic performance, learning environment either in the classroom or the laboratory, choice and persistence. Fosnot (2005) explained expectancy for success (self-efficacy) which he attributed in most cases to the influence of the laboratory and beliefs about how one can perform an academic activity. He continued by saying that the self-efficacious learner tends to put more efforts to succeed on a task whether the task is content based or involves practical investigations and challenges during unknown experiences. The studies also revealed self-efficacy beliefs affect learners academic goals orientations, attribution and future career choice. Umbach and Wawrzynski (2005) concluded that the educational environment created by teachers' behaviour, beliefs and attitudes has a dramatic effect on learners learning, attitude, motivation and cognition. Also Meyer and Turner (2002) observed that if a teacher is perceived by learners to be more approachable, well prepared, willing to help and sensitive to their needs, learners tend to get more committed, hard working and opened to express their opinions. Learners feel part of their classroom activities and they get more, if they are supported by teachers who establish inviting learning environment such as the laboratory (Purkey & Novak, 1996). From the above literature, it is reasonable to argue that the laboratory should encourage and promote learners` autonomy and control since learners will be willing to put in more efforts which will ultimately lead to development of mastery goals orientation. In line with this, many researchers have shown that the laboratory has great influence on the learners motivation in terms of self-efficacy, intrinsic values and benefits and goals orientation (Green, Miller, Crowson, Duke, & Akey, 2004).

Practical work helps learners to understand physics. Getting learners involved in authentic experiment of inquiry-base learning such as problem solving and investigations can help them develop scientific knowledge, creativity and habits of minds that enable them to question and learn about the real world phenomena around them (Haigh, 2007). Piaget (1971) argues that learners thinking are increasingly sophisticated and are a powerful representation of the world around. Students learn by acting on their current understanding, modifying this understanding in the light of the data generated (Colen, 2013). Through action, we generate sensory data which can either be assimilated or change in to existing schemas to accommodate the new data and re-establish equilibrium between the internal and external realities. This indicates that, learners construct a deep understanding of objects and the behaviour of those objects. If the assumptions of Piaget (1971) are right, then practical activities will provide the direct interactions of observation and more importantly for understanding of physics.

2.9.2 Teacher's interactions in the laboratory

Constructivist theory of learning views the laboratory as a mini-society, a community of learners engaged in activity, discourse, interpretation, justification, and reflection (Fosnot, 2005). It is widely accepted by constructivist theory of education that knowledge is constructed individually by the students, the main process of learning occurs in a place where there are positive interactions between the learner and the instructor/teacher with organization of experiences by the teacher. Fosnot (2005) noted that the constructivist teacher encourages a consideration of others points of views and a mutual respect allowing the development of independent and creative thinking. The constructivist believes that the teacher facilities the learning by considering relationships. Recent theories and researchers beliefs have shifted from isolated student mastery of concept to ideas that real learning is about interaction, growth and development (Fosnot, 2005).

When a teacher interacts with students, he/she understands how a particular student acquires knowledge. Vygotsky (1978) opined that higher mental functioning are socially formed and culturally transmitted. Cognitive development is mediated through language dialogues between one who knows (teacher) and one who is learning (student). Vygotsky theorized that the instructional message gradually moves from teacher-student dialogue to inner speech where it organizes the students thought and becomes an internal mental function. Combs (1982) has stated that many researchers have produced results giving strong indication of the relationship between student's perception and teacher's classroom interaction.

Sarason (1999) view teaching as an art and discusses the art of teaching and its relationship to teacher interaction in a productive learning environment. In a study of interactions in the laboratory, Jackson (1968) stated that there is a social intimacy in the laboratory that is unmatched elsewhere in our society. From the study of Jackson, the teacher is in charge with managing the flow of the classroom dialogue.

Dorwney (2008) carried out a study with the rationale to examine teaching practices that made a difference for all students particularly, students at risk of academic failure. The study indicated that teachers' personal interaction with his/her students made a significant impact. The recommendation from Downey (2008) were that "students need teachers to build strong interpersonal relationships with them, focusing on strengths of students while maintaining high and realistic expectation for success''(p.17). Studies from

Marzano (2003) also indicated that the impact of decisions made by an individual teacher is far greater than the impact of decision made by the school.

Again Sarason (1999) contend that there are three overarching features for productive learning. The first is to recognized and respect the individual learner. The second is for the teacher to know the subject matter sufficiently to be able to determine when the learners have difficulty and to intercede. The third tenet is that the teacher is constantly looking for ways to engage and stimulate the learner so he/she wants to learn.

This means that a strong interpersonal relationship between teachers and students through the organization of practical activities can help stimulate and excite students to learn. Therefore using practical activities can maximize the interaction between teacher and student as teachers offer instructions to students and give them guidelines. The above write up underscores the significance of teacher-student relationship in promoting learning of science in our schools. In the physics laboratory there is an increase interaction between teacher-students and also between student-student. By these relationship a science teacher can achieve what Sarason (1999) mean by overarching feature of education which he describe as a tenet of looking for ways to engage and stimulate the learner to learn more.

2.10 Effectiveness of Physics Practical Activities.

There have been a lot of research findings into the effectiveness of laboratory practical activities in enhancing the understanding of concepts in Physics.

The research results of many Science educators in developed countries across the world underscore the important role of practical activities in teaching and learning Science. In recent years, laboratory practical activities has gain central role in Science education and Science educators have suggested that there are rich benefits in learning that is build up using laboratory practical activities (Hofstein & Lunetta, 2003). Many introductory Physics courses in developed countries used laboratory practical activities as an integral part of instructional process: Student -centered teaching style which is inquiry based teaching has re-emerged as a modern teaching style in Science. In this regard laboratory practical activity is especially important. Meaningful learning is possible in the laboratory only if the students are given opportunities to manipulate real equipment and materials in an environment suitable for them to construct their own knowledge of the phenomena and related Scientific concepts (Tobin, 1990). This view goes to support the current generation of cognitive Science that associates conceptual knowledge of the learners with more sensitive and concrete experience.

Hofstein and Lunetta (2003) also opined that the laboratory practical activities provides avenue for students to design and conduct an investigation in order to solve a Scientific problem

As stated by Hodson (1991), the dominance of head over hand leads to an increased in intellectual understanding of Physics and the way in which kinesthetic activities provoke learning in the laboratory is of much interest and obvious.

The relationship between doing and learning in Science cannot be underestimated, especially between practical actions and reflection on Scientific theories behind them.

Bell, (2005) surmised that laboratory practical work holds significant promise for being able to support conceptual and epistemological learning when facilitating conditions are put in place for students. Laboratory practical experiences have been purported to promote science educational goals including the enhancement of students' understanding of concepts in science and its application, scientific practical skills and problem solving abilities; scientific habits of mind: understanding of how science and scientist work, interest and motivation (Hofstein & Lunnetta, 2003).

Hence practical activities occupy a central position in Science education and Science educators have suggested enormous benefits in learning especially using laboratory practical activities.

2.10.1 Motivation in physics Practical Activities

Motivation is considered as an important element in efficient learning of concepts. Motivation is as complex as learning which is mostly concerned with the drive, incentive or energy to do an activity. Pintrich and Schunk, (2002) defined motivation as "the process whereby goal-directed activity is instigated and sustained" (p.5). Psychologist see motives as the needs, wants, interests and desires that propel people in certain directions. A number of theoretical approaches have been proposed by psychologist on motivation.

Incentives theories of motivation posited that an action will be performed when people realized the performance will yield a desire outcome or is important to them (Rotter, Phares, & Chance, 1972). Pintrich and Schrauben (1992) conducted an extensive review of literature on motivation and come out with a conclusion that the value of an outcome to the student affects that student's motivation.

Motivation always yield positive result in cognitive engagement which are manifested in the use or application of various learning strategies. Intrinsic motivation in students lead learners to choose a learning task, develop various learning strategies of how to accomplished the task and pursue the task vigorously and successfully achieved results Pintrich (1988). Pintrich (1988) proposed expectancy-value model on motivation. In this model, the efforts a student will direct towards a task is a function of how well they feel they will do on the test, the efforts it will take to complete the task and how well the task will appeal to the affective reactions regarding the task. The affective domain is therefore the aspect that can motivate students to learn.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter focuses on the research methodology that was employed in the study. It covers the research environment in section 3.1. The chapter also gives a vivid description of the research design in section 3.2, research population in section 3.3, sample and sampling techniques in section 3.4, research instrument and research procedure in section 3.5, the method of data analysis and the intervention procedure in section 3.6.

3.1. Research Environment

The study was conducted in one of the Colleges of Education in Ghana specifically, E.P. College of Education, Bimbilla. E.P College Of Education is located on a land area of about two kilometers square. It is sited in a town called Bimbilla in the Northern Region of Ghana. The inhabitants of Bimbilla speak Dagbani as their native language and belong to the Mole Dagomba group in the Northern Region. This part of the region where the college is situated is in the Nanumba North District that has a landscape of the savanna agricultural zone. Until recently, the people in this community engaged mostly in farming owing to the fertile nature of the land. Many people in this area are also engaged in trading. E.P College of Education was established by the Evangelical Presbyterian Church as a mission school but now under the control of the Government of Ghana. The school is endowed with modern facilities and infrastructure. These include spacious classrooms and a science laboratory well furnished with modern equipment to promote teaching and learning.

3.2 Research Design.

A research work in any area serves to gain scientific knowledge in an effort to extend the frontiers of knowledge relating to a particular subject or topic. Research design can therefore be explained as all the stages and processes involved in reaching the respondents. These stages and processes could include the nature of the hypothesis statement, research questions, parameters and variables used and even the selection and modification of the topic before the research is published (Fink, 2001). Yin 2003, in his statements to explain the meaning of research design adds further that "colloquially a research design is an action plan for getting from *here* to *there*, where '*here'* may be defined as the initial set of questions to be answered and '*there'* is some set of (conclusions) answers" (p. 19). In this plan, the kind of data needed, the method used for the data collection, the procedures for obtaining data, and data analysis procedures are clearly outlined. For every research two clear distinctions can be made with regard to the purpose of the research. There is research that is geared towards describing and there is the kind of research is mainly aimed at explaining or understanding a certain phenomenon more (Boeije, 2010). The study adopted a quasi-experimental pre-test-post-test design. It involved first year Diploma in Basic Education (DBE) science students who are offering physics as an elective subject. The class was divided into two groups thus one experimental and one control group. The two groups were subject to the pre-test achievements test at the start of the study to measure the level of performance of both groups. The experimental group was then taught using the practical approach while the control group was taught using the conventional approach or teacher-centred approach. This was done for one month according to the duration of the topic as stipulated in the curriculum course outline. A the post-test achievement tests was administered at the end of the teaching period and the results analysed. There are many advantages for the use of questions. One advantage is that it measures most of the cognitive domain of learning. Some of these domains are understanding, comprehension, application and analysis. Questionnaire was also administered to both the experimental and the control groups to solicit their response. The advantage of the questionnaire also lies in the fact that questionnaires can be administered by the researcher himself or by any number of people and also the results of the questionnaires can usually be quickly and easily quantified by either a researcher or through the use of a software statistical package (Akbayrak, 2000). The rubrics for the design are presented in table1.

Table 1: Design of the study.

Experimental group	R	T_1	Y	T_3
Control group	R	T_2	Yo	T_4

Where
Y = Treatment

Yo = No treatment

T_1 = pre-test result for the experimental group

T_2 = pre-test result for the control group

T_3 = post-test result for the experimental group. T_4 post-test result for the control group

Figure 1 also represent a summary of the entire research design and process.

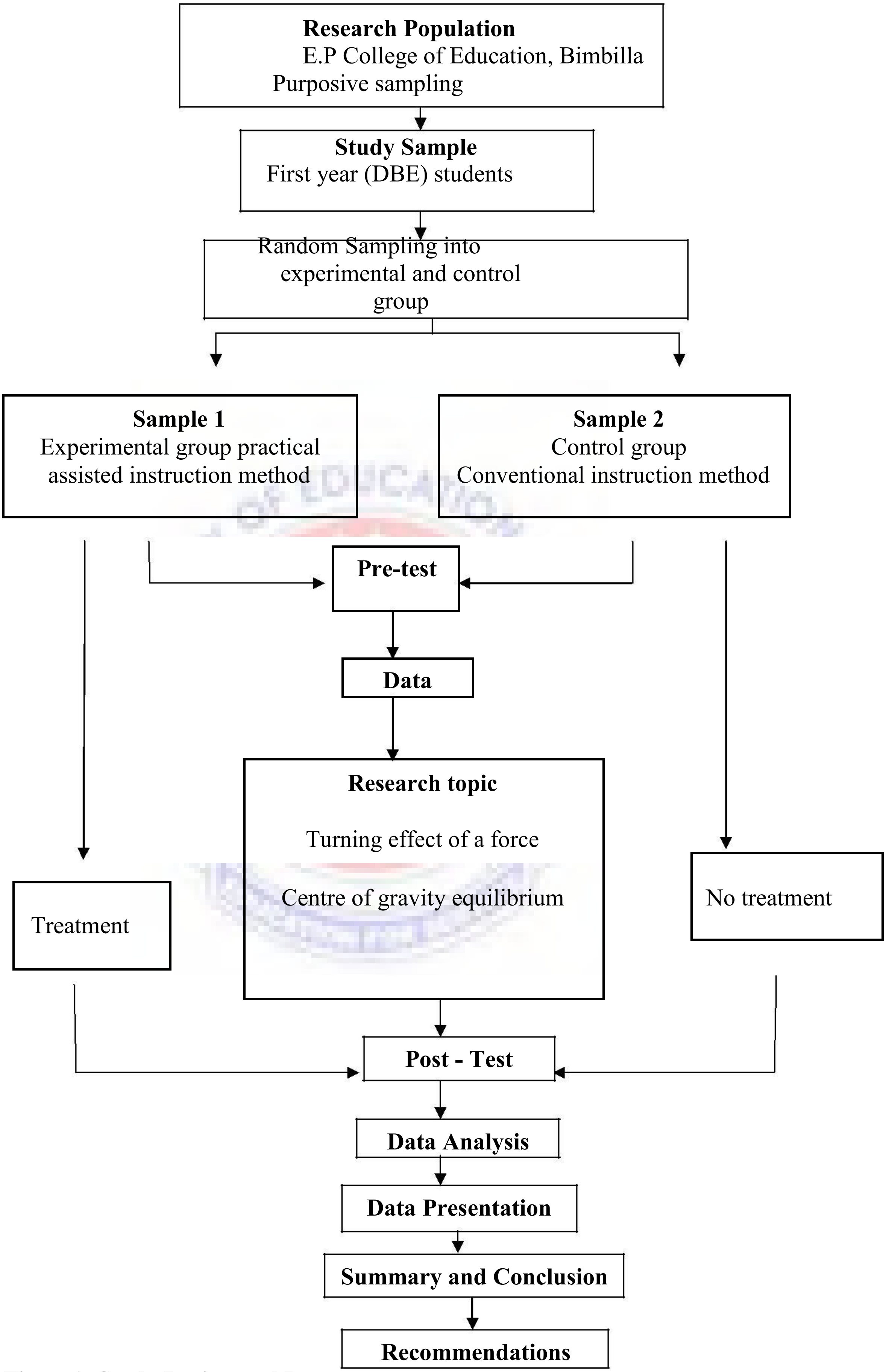

Figure1: Study Design and Process

Figure1 above shows how the study was conducted. The first year DBE students who are offering physics as an elective was first sampled into experimental and control groups. The two groups were first made to take pre-test achievement test in order to make sure they were both at the same level of achievement before the start. The experimental group was given a treatment whiles the control group was not. The two groups were exposed to the post-test achievement test and the mean for each group was computed and the difference analyzed using t-test.

3.3 Research Population

The research work targeted all first and second year students in E.P College of Education in Bimbilla. However, due to constraints regarding time and other resources the actual population used was the first year science students from E.P College of Education, Bimbilla. Considering the purpose of this research, the effects of practical activities on learning and understanding of physics concepts, it is absolutely imperative to choose a College where laboratory equipment are available and where the researcher can have direct interaction with the students. Mokhado (2002) pointed out that it is necessary to select information rich cases because it helps to address the purpose of the research. McMillan and Schumacha (2001) underscored the need for purposeful sampling because the samples that are chosen are likely to be knowledgeable and informative about the phenomenon under investigation

3.4 Sample and Sampling Techniques.

A population can be defined as a group of individuals or people with common characteristics and in whom the researcher is interested or a group of individuals or people that the researcher generalizes his or her findings to (Polit & Hugler, 1995). The research is aimed at finding out the effects of laboratory practical work on students learning and understanding at E. P. College of Education, Bimbilla. The target population was all the first and second year science students of E.P College of Education, Bimbilla. Sampling is most essential in research process as this allows the researcher to pick respondents and units or elements that will be examine closely in research work. The sample is the representative proportion or a subset of the population. Sampling is effective and saves time that is used to conduct the study (Boeije, 2010). Probability sampling methods such as simple random sampling technique and purposive sampling technique were used to select respondents for the study. However, purposive sampling was used to select the respondents for the study since the number of students was very small. According to Cohen, Mannion, and Morrison, (2003) purposive sampling entails one that deliberately selects cases on the basis of the specific qualities they illustrate. Cohen, et al. (2003) proposed that a right sample size is one that fulfils the requirements of the study.

The total sample chosen to conduct the study comprised fourty eight (48) students for the experimental group and fourty seven students for the control group, making a total of ninety five students (95) students.

3.5 The research instruments.

This research made use of the type of instruments that can capture and investigate the relevance of laboratory practical activities relative to aiding and fostering better understanding of physics concepts. There were three instruments employed in this research. Their development and roles are explained in the following sections.

3.5.1 Pre-Test Achievements Test

Pre-test was used to measure the performance of the learners in Physics of both the experimental and the control group before the treatment was administered (Appendix B). The test items in the pre-test achievement test were structured to measure the learning and understanding of physics concepts. This was to ensure that both the control group and the experimental group were at the same ability in terms of learning and understanding of Physics. The achievements test was composed of 15 structured questions which took one hour.

3.5.2 Post-test

The post-test was also named Students Achievements Test (SAT). The students achievement test was administered to both experimental and control groups in a staggered manner throughout the term (Appendix B). Specific tests which measured the work done in each topic for both the control and the experimental group were administered at the end of the topic. These was recorded and eventually complied for analysis

3.5.3 Test of physics students' Motivation (TOSM) Questionnaire

This questionnaire was termed Test of physics students' Motivation (TOSM)-questionnaire. This questionnaire is a simplified form of the questionnaire that was used in a study by Fraser (1978) in introductory physics students' attitude and motivation. The study was carried out by Fraser to test students' attitude towards science in the early 1970s. He used a forty-eight item (48) questionnaire from four subscales namely: attitude scale, a confidence scale, science motivation scale teacher perception scale.

The instrument used in this research (TOSM) however consisted of thirty (30) items. These items were designed in line with students' motivation that arises from their participation in physics laboratory practical activities. All these dimensions consist of both positive and negative items.

Each of the items in the questionnaire was scored on a five-point likert scale. An item is scored

(1) For "strongly disagree"
(2) For "disagree"
(3) For "not certain"
(4) For "agree"
(5) For "strongly agree"

A respondent can chose any of these possible outcomes depending upon the degree of agreement or disagreement with a particular question or statement (see Appendix (C) the structure of the research questionnaire.).

3.6 Validity of the instrument

Joppe (2000) explained that validity is used to ascertain whether a research truly measure that which it is intended to measure or how truthful the research results are. In effect, the research instrument must be able to identify and measure effectively the problem at hand. Content and construct validity of the research tools were initiated at the design stage. Some of the items used in the achievements tests were adapted from University of Cape Coast Diploma in Basic Education (DBE) 2012, 2014 ans 2015 end of Semester examination for Colleges of Education. The test items were constructed using the first year DBE syllabus. (See appendix J)

This process ensures both content and constructs validity. The test was also subjected to pilot study to ascertain the appropriateness of the language and to conceptualize them for predictability and reliability. The questionnaire on physics students' motivation in physics laboratory practical work named (TOSM) was given to my supervisor for his review and comments. My colleague researchers with considerable knowledge in the field were also given the chance to look at the questionnaire and also made corrections and comments. The comments were used to refine the questionnaire before they were administered. The test items in both the pre-test and post-test achievement test were also given to senior lecturers at the University of Education, Winneba for their review and comments. These comments were used to refined the question items.

3.7 Reliability of the instruments

Joppe (2000) again stated that the reliability of an instrument is the measure of the extent to which results are consistent over a period of time and become an accurate representation of the total population under study. He further stated that if the results of the study can be reproduced under similar conditions, then the research instrument can be considered as being reliable.

In order to determine the quality and the efficiency of the questonnaire (TOSM) for the research study, the alpha coefficient were determine for the research questionnaire. Reliability analysis was conducted using Cronbach's alpha coefficient.

The Cronbach alpha (α) values for the students' questionnaires were found to be 0.5. 0.5-0.7 are considered reliable (Kline, 2005). (see Appendix C). The split-half method was also used to determine the reliability of the assessment test. In the split-half method the total number of test items were divided into halves by assigning the odd numbered items to one half and even numbered items to the other half. Correlation between the two halves was determined. Spearman-Brown

Prophecy formula was used to estimate the reliability of the whole test. Reliability coefficient of 0.81 and 0.82 were obtained for the Pre-test and posttest tests respectively. According to Elzinga, Salzer, Willoughby and Gibbs (2001) if the split half correlation was 0.7 and above then the test was considered reliable.

3.8 Data collection method and procedure

A letter of introduction outlining the purpose of the research was obtained from the head of science department (Appendix A). The letter was presented to the vice principal seeking permission to carry out the research. The Vice Principal gave the permission for the research to be carry out.

Data collection was done by administering pre-test and post-test and by questionnaire. At the beginning of the research the two groups were given the standard achievement test which was the pre-test. The pre-test question items were based on the topics covered previously. The results from this test was first analyzed using percentages for each correct and incorrect response and then follow by the SPSS to determine the achievement levels in terms of learning and understanding of physics concepts of both the experimental and the control groups. A colleague teacher who also teaches physics and has agreed to teach the control group was made to undergo a short exercise to get familiarization with the topics. The experimental group was taught using the practical approach whiles the control group was taught using the conventional method (teacher- centered) method.

The topics include: moment and force, equilibrium and centre of gravity. These topics were selected based on the syllabus for Colleges of Education by University of Cape Coast, (UCC). The respondents were taught using the conventional approach whiles the experimental group were taught using the practical approach. The instructional technique in the experimental group emphasized practical work during the teaching process. The experimental group was engaged in setting the equipments and apparatus and with manipulation of the equipments. The experimental group was also taught the procedure, data collection, manipulation and analysis procedure before they were require to write the experimental report. The student achievement test (SAT) was administered to both the control and the experimental groups. The question items were base on the topics covered for both the experimental and the control groups. This was used as the post- test scores.

Also, the two groups were given the questionnaire termed Test of Science Attitude and Motivation (TOSAM) to respond to. The questionnaire was based on a five point likert type attitude and motivation towards physics.

3.9 Methods of Data analysis:

Data analysis is the process of converting raw data collected into usable information (Statistics Canada, 1998). The data collected was analysis using the statistical package for social science (SPSS) version 21, computer software. This data underwent various stages of preparation. In the first place, the data was edited and coded.

A code sheet was prepared using the code book. The code sheet was later used to synthesize the data. After the data entry, the data was clean to remove any error committed during data entry.

The data used in this study were both quantitative and qualitative. The quantitative data were analyzed using statistical package for social science (SPSS) version 21. Quantitative analysis involved the presentation of data in the form of frequency tables which can be explained using descriptive or inferential statistics.

The significant difference of the results between the experimental and the control groups was determined at $\alpha = 0.05$ confidence level. The independent t-test was use to analyses the quantitative data.

Students' responses to the question items in both the pre-test and post test were analysed based on whether they reflect learning and understanding of concepts. In this regard, answers with correct explanation including examples that indicate application of principles learnt were classified as understanding of concepts and termed as Correct Answer. Responses that were related to questions but with incorrect explanations and also wrong answer were classified as no understanding and termed as Incorrect Answer. Answers that included explanations were use to determine the level of learning. In this regard responses that included explanation were classified as "with explanation (WE) and those without explanation were classified as "no explanation" (NE). The results from these analyses were expressed as percentages and tabulated. Student's response that reflected understanding (Correct Answer), no understanding (Incorrect Answer) were used to analyze research questions one and two. Student t- test was also use to compare if there was significant difference in the means between the control and the experimental groups in the pre-test and post- test. In respect to research question three and four which borders on students motivation and attitude towards physics the student t-test was also used to establish the significant difference in the mean in the attitude and motivation scale between pre-test and post-tests for both the control and the experimental groups.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.0 Overview

In this chapter the data garnered from the study have been presented. This chapter takes into consideration the effect of laboratory practical activities in physics on students learning and understanding of selected physics concepts, the attitude change in students towards physics upon exposure to laboratory practical activities, and the motivation derived in engaging in laboratory practical activities in E.P College of Eduration, Bimbilla.

4.1 Effects of laboratory practical activities in physics on learning and understanding of physics concepts.

In order to ascertain the effects of laboratory practical activities on students learning and understanding of physics concepts, the control group and the experimental group where both subjected to a Pre-test to determine their level of ability in terms of learning and understanding of physics concepts. A physics assessment pre-test was used (see Appendix B)

4.1.1 Students learning and understanding of physics assessment pre-test

The experimental group and the control group were both subjected to the students' assessment pre-test. This consisted of fifteen question items which was used to measured learning and understanding prior to the start of the laboratory practical activities. The result of the students' assessment pre-test is presented in Table1.

Table2: Student response to physics Assessment Pre-test (PAT)

Question item	Control group(47)		Experimental group(48)	
	Correct Answer	Incorrect Answer	Correct Answer	Incorrect Answer
1	20(42.5%)	27(57.5%)	21(43.8%)	27(56.2%)
2	19(40.4)	28(59.6)	19(39.6)	29(59.6)
3	22(47%)	25(53%)	23(48%)	25(52%)
4	24(51%)	23(49%)	25(52%)	23(48%)
5	17(36%)	30(64%)	17(35.5%)	31(64.5%)
6	24(51%)	23(49%)	25(52%)	23(48%)
7	20(42.5%)	27(57.5%)	21(43.8%)	27(56.2%)
8	27(57.4%)	20(42.6%)	28(57.3%)	20(42.6%)
9	18(38.3%)	29(62.7%)	18(38.2%)	30(62.8%)
10	20(42.5%)	27(57.5%)	21(43.8%)	27(56.2%)
11	17(36%)	30(64%)	17(35.5%)	31(64.5%)
12	24(51%)	23(49%)	25(52%)	23(48%)
13	16(34%)	31(66%)	15(31%)	33(69%)
14	24(51%)	23(49%)	25(52%)	23(48%)
15	17(36%)	30(64%)	17(35.5%)	31(64.5%)

The results of students' assessment on the pre-test are presented in the table 1 above. The number of students in each of control and experimental group who had correct or incorrect answer to each question item is presented in Whole number and in percentages for vivid descriptions. For question items 1, 2, 3 the number and percentage of student from the control group who had correct answers are 20(42.5%,) 19(40.4%), and 22(47%) respectively and for the same questions items 1, 2, 3 the number and percentage of student from the experimental group who had correct answer are 21(43.8%), 19(39.6%) and 23(48%) respectively. The percentage is the same in terms of incorrect answer in both the control and the experimental groups. This trend is also the same for all the other question items in the pre-test. Conclusively the percentage of students in both the control and the experimental group who had correct or incorrect answers are almost the same in the pre-test. This is an indication of the fact that both the experimental and the control group have the same ability in achievement in the pre-test i.e before the start of the practical activities.

Again the total marks of each student from both the control and the experimental groups were also computed and mean calculated to find out the significant difference between the two groups in the pre-test. The results of the mean for each group and the t-test are tabulated in table 2 and table 3 respectively

Table3: Mean scores of the Pre-test for each group

Group	N	Mean	Std Deviation
Experimental	48	23.73	7.87
Control	47	23.17	5.82
Total	95	23.45	6.84

The table above is the mean score of both the control and the experimental group in the Pre-test assessment test. The mean of the experimental group (M= 23.73 S.D =7.87) and that of the control group (M= 23.17 S.D=5.82) this means that the two groups had almost the same mean score in the pre-test. The difference in the mean was not also significant.

Table 4: Comparison of mean scores between Experimental and control group.

Group	N	Mean	T	df	Sig(2-tailed)
Experimental	**48**	**23.73**	**0.04**	**93**	**0.67**
Control	**47**	**23.17**			

$\alpha = 0.05$

Table 4 above is an independent t-test conducted absolute t(93)= 0.04 at $\alpha = 0.05$ confidence level. This reveals that there was no statistically significant difference in the performance in Pre-test for both the control and the experimental group. This underscore the fact that both the experimental and control groups were starting on a faily even background in terms of learning and understand of physics

1) **Research question one: Will there be any significant difference in the post-test achievement score on learning between students expose to laboratory practical activities and those expose to the conventional method.**

In order to answer research question one the experimental group was taught for four weeks using laboratory practical approach as an intervention, while the control group were taught with the conventional approach/ teacher centered approach which is characterized by the absence of practical activities. At the end of the four weeks a post-test was administered to both the control and the experimental groups (see

Appendix D). The post test question items consisted of 20 items in which items one (1) to item ten (10) were used to evaluate students learning of physics concepts. Whiles the other items eleven (11) to twenty (20) were used to evaluate students understanding of concepts learnt in both the control and the experimental group. The question items were constructed base on different cognitive demands. An increasing cognitive demands leads to critical thinking and enhances internalization of concepts.

Table 5: Post-test Achievement test on learning

Group	N	Mean	S.D
Experimental	48	30.51	9.52
Control	47	23.41	8.45
Total	95	26.95	7.51

Table 5 above indicates that the experimental group performed higher in terms of learning than the control group. From the table the experimental group had a mean (M=30.51 S.D=9.52) while the control group had a mean of (M=23.41 S.D=8.45). Based on the comparison of the means between the two groups it can be argue conveniently that the use of laboratory Practical activities as an intervention was effective in enhancing learning in the experimental group.

Table 6: Independent t-test for post-test on learning

t-test for equality of mean					
Group	**N**	**Mean**	**T**	**df**	**Sig(2-tailed)**
Experimental	48	30.50	4.2	93	0.002
Control	47	23.40			

Significant at $\alpha = 0.05$ confidence level

From table 6 above it can be inferred that there was a significant mean difference between the experimental group and the control group. It was significant for experimental group (M = 30.50) and control group (M = 23.4) at t(93)= 4.2, ρ >.0001, α = 0.05. The significant mean difference t(93) = 4.2 between the experimental group and the control group can be attributed to the implementation of laboratory practical activities which entrances learning of concepts in the experimental group far more than the control group.

Taking into consideration the first null hypothesis on learning Ho1, which states that there is no significant difference is students` learning in physics between those taught in a practical activities and those not taught using practical activities. The null hypothesis one on learning was rejected. The alternative hypothesis, H1 is then accepted that there is a significant difference in student learning in physics concepts for year one students taught physics through practical approach. The study therefore concluded that students who are exposed to laboratory practical activities achieve higher learning of physics concepts than those taught through the conventional method/teacher-centered method. This conclusion is supported by many similar research findings (Wasanga, 2009; Hofstein et al. 2003; Mendez & Slisko, 2013). Wasanga (2009) found a similar correlation between practical work and learning of science subjects which leads to improved achievement in a physics achievement test. Fadaei (2012) indicated the essence of laboratory practical activities as fostering effective learning and understanding of physics concepts. The stimulation provided in the laboratory and challenges to unravel the mystery surrounding the behaviour of natural phenomena leads to increased curiosity of learner to develop an insight into the understanding of concepts

Hofstein et al, (2003) indicated that engaging in scientific practical activities provide stimulating experiences which situate students learning in states of inquiry that require heightened mental and physical engagement.

1) **Research Question two: Will there be any significant difference in the post-test achievement score on understanding between students expose to laboratory practical activities and those expose to the conventional method.**

In order to answer research question two on understanding of physics concepts, the same laboratory practical activities were used to teach the experimental group whiles the conventional method were used for the control group as in research question one on learning. However, in the post-test achievement test administered to the two groups question items one to ten were used evaluate students' learning whiles question items eleven to sixteen were used to evaluate students' understanding of concepts base on high cognitive demand in the question items. (See Appendix D).

Post-test Achievement test on understanding of physics concepts

The experimental group was taught for four weeks using laboratory practical activities while the control group went on with the conventional approach which does not use many practical sessions. At the end, a post test was administered (see Appendix D). Question items eleven to twenty in the post-test achievement test were used to evaluate students understanding of physics concepts. This question items including sub-questions measured increasing cognitive demand.

Table 7: Post-test Achievement test on understanding

Group	N	Mean	S.D
Experimental	48	29.51	7.25
Control	47	22.45	5.52
Total	93	25.98	6.39

The above table on understanding of physics concepts shows that the experimental group exceeded the control group in terms of achievement in understanding of physics concepts. The experimental group had a mean of 29.51 whiles the control group had a mean of 22.45. Again, this clearly indicates that the use of laboratory practical activities as an intervention is more effective in fostering understanding of physics concepts.

Table 8: Independent t-test for post-test on understanding.

		t-test for equality of mean			
Group	**N**	**Mean**	**T**	**Df**	**Sig(2tailed)**
Experimental	48	29.51	3.5	93	0.002
Control	47	22.45			

Table 8 shows that there was a significant mean difference between the experimental group and the control group. The significant difference for experimental group (M =29.51) and control group (M = 22.45) at t(93) =3.5, ρ=.002 and α = 0.05 confidence level. The significant mean difference at t(93)=3.5 between the experimental group and the control group can be attributed to the implementation of the practical activity in the experimental group which makes understanding of physics concepts exceed that of the control group. Considering the second null hypothesis Ho_2, that there is no significant difference in students understanding of physics concepts between those taught in practical activities and those not exposed to physics practical activities, the null hypothesis $H0_2$ was rejected. The study then accepted the alternative hypothesis; H_2 that there is a significant difference in students' understanding of physics concepts for first year students taught physic through practical work and those not taught through practical activities. From this analysis it can be concluded that students expose to laboratory practical activities in physics performed better in terms of understanding of physics concepts than those taught through conventional method. Millar (2004) also found a similar correlation between laboratory practical activities and understanding of physics concepts. According to Millar (2004) laboratory practical activities engages the learner in observing and manipulating real or virtual objects and materials. When laboratory practical activities are properly organized, it enhances learners experience and understanding of physics concepts.

According to Millican, Richard and Mann (2005) physics is an experimental subject and therefore depends on observation. General principles and concepts are more easily understood if they are demonstrated in the laboratory. Ideas and theories are more fully appreciated and internalized if students investigate and verify them at the laboratory bench. This study can argue plausibly that laboratory practical activities in physics as an instructional strategy significantly enhance understanding of physics concepts.

Research Question three: What are the effects of practical activities on motivation of students towards learning and understanding of Physics concepts at E.P College of Education?

The study also sought to investigate the effects of practical activities on motivation of students towards the study of physics. In this regard, this research question was formulated. The fifteen (15) items on the students' questionnaire (TOSM) was used to determine the level of motivation in physics. In order to explore the level of motivation in students the study presented the results of students pre-test motivation towards physics between the experimental and the control groups and then followed by the post-test motivation towards physics.

The research study also aimed to establish the effects of laboratory practical activities in Physics in motivating students towards learning and understanding of Physics concepts. The questionnaire named Test of Physics Students' Motivation (TOPM) was used for this purpose.

Pre-Test Students' Motivation towards Physics

From the Test of physics students motivation (TOPM) questionnaire, items one (1) to fifteen (15) were used to investigate whether laboratory practical activities can motivate students for effective learning and understanding of physics. Each statement in the scale was rated on a scale of 1 to 5 that is strongly disagree, disagree, neutral, agreed and strongly agreed respectively. The questionnaire comprised fifteen (15) items which were used to evaluate students' motivation (Appendix C). This implied that a student could get a maximum score of 75 (15 x 5 points) or minimum score of 15 points (15 x 1). The total scores for each respondent were recorded. The mean score per student was then computed. Finally, the average score for each group was determined. Student's t-test was then performed to determine whether there is significant difference in the mean scores on students' motivation towards Physics between the experimental and control groups. The results are presented in Table.

Table 9: Pre-Test Students' motivation towards Physics

				t- test		
Group	**n**	**Mean**	**S.D**	**t**	**df**	**Sig. (2tailed)**
Experimental	48	3.10	9.880	1.86	93	.853
Control	47	2.91	9.988			.142

*Significant at α = .05

Table 9 shows that the experimental group (M = 3.10, SD = 9.880) had a higher mean motivation towards Physics than control (M = 2.91, SD = 9.988). However, these results show that there was no statistically significant mean difference between the two groups. These results show that there was no statistically significant mean difference between the experimental and control groups. This is important as it shows that the experimental and control group started off at the same level in terms of motivation towards Physics.

Post-Test Students' motivation towards Physics

Table 10 below shows the results of the post-test students' motivation towards Physics. The students' motivation scale which comprises fifteen items from the

TOPM questionnaire that was used during the pre-test was administered at the end of the laboratory practical activities which serves as an intervention so as to establish if the students' are motivated to study physics by virtue of participating in practical activities.

Table 10: Post-Test Students' motivation towards Physics

				t- test		
Group	**n**	**Mean**	**S.D**	**t**	**df**	**Sig. (2-tailed)**
Experimental	48	3.53	8.710			
				3.16	93	.002
Control	47	2.92	8.159			

* Significant at .05 confidence level

Table 10 shows that experimental group had a higher mean in motivation towards Physics (M = 3.53, SD = 8.710) than control group (M = 2.92, SD = 10.291). The statistical difference between the two groups, t (93) = 3.16, ρ =.002, α =.05, implies that the experimental group taught Physics through practical work is much more motivated towards the subject than those taught through the conventional method. This also confirms that practical work approach improves motivation towards physics than those taught through the conventional method

Comparison between the Pre-Test and Post-Test Students' motivation towards Physics

The results of the comparison between the pre-test and post-test students' motivation

towards Physics scale are presented in Table 11.

Table 11: Comparison between the Pre-Test and Post-Test Students' motivation towards Physics

Group	n	Mean pre-test	Mean post-test	Differenc E	S.D	t	df	Sig. (2-tailed)
Experimental	48	3.10	3.53	+ 0.43	6.583	-4.28	47	.000*
Control	47	2.91	2.92	0.01	4.783	-2.44	46	.240*

*significant at 0.05

Table 11 shows that there was a mean gain of + 0.43 in the motivation for experimental group, which was significant (t (47) = 4.28,ρ =.001, α =.05). However there was no significant mean gain in students' motivation towards Physics for the control group. For control group the mean gain was +0.01 which was not significant (t (46) = 2.44, ρ = 0.240, α = 0.05).

The research study, therefore, rejects the third null hypothesis H_{O3} that there is no significant mean difference in motivation towards Physics for students' taught Physics through laboratory practical activities and those taught through conventional method. The study therefore accepted the alternative hypothesis; H_3, that there is a significant mean difference in motivation towards Physics for students taught Physics through practical work and those taught through the conventional method.

The implications of these findings' are that the experimental group taught Physics through laboratory practical activities had enhance motivation towards physics than those taught through the conventional method. The findings of this study concerning respondent motivation are also corroborated by the observation of Pintrich (1988). Pintrich (1988) found out that learners are intrinsically motivated to achieve higher successes in science as a result of exposure to practical courses. Academic failurs and low student performance is often blamed on low motivation and therefore attempts are often made in giving rewards to increase that vital component of motivation. When rewards are given, they often have the opposite effect of what was intended. Rewards as reinforcement in skinners operant conditioning often fails to motivate students to learn.

Deci (1972) found that when a person receives a reward for an action, the person puts forth more effort in the activity purposely for the reward and not the action. The type and amount of a reward have a detrimental effect on motivation and performance.

High student achievement comes from students who are motivated from inside. Therefore, in lieu of rewards, teachers need to organise learning experiences that enable students to become intrinsically motivated. For instant, intrinsically motivated students become deeply involved in the task at hand and experience a feeling of enjoyment (Amabile & Gitomer, 1984), and seek out challenges with the intention of conquering them (Adelman and Taylor, 1990). According to DeCharms (1972), an intrinsically motivated person feels that he can try to produce a change in the environment, and feels confident that the change will occur. Students seen demonstrating these characteristics in the classroom would be characterized as motivated, good students. Amabile et al, (1984) have reported that laboratory practical activity was an instructional practice that could be used to instigate intrinsic motivation in students which is needed in developing students' scientific knowledge and habits of mind. Toplis and Allen (2012) suggest that practical work has been used as an integral effort of ensuring that learners develop an in-depth understanding of content during the formative years of introductory college physics. This understanding also leads to developing disposition in intrinsic motivation.

This research also confirms that students taught using practical approach had a better motivation towards the subject than those taught through the conventional method. According to Adelman & Taylor (1990), intrinsic motivation is acquired through participating in an activity that appeal most to the conscience and can be sustained by providing a variety of techniques. in order to sustain long-term academic growth, instructional approaches need to be tied to a broader teaching strategy or model that ultimately focuses on the internalization and the development of an intrinsic orientation toward learning.

The study established a significant difference in motivation towards Physics for students taught Physics through practical and those taught through conventional methods. Nouli et al. (2003) added that mastering skills by students makes study more enjoyable and effective which in turn strengthen the students' interest so that he/she spends more time studying. Research has made us know that the attitude towards science change with exposure to science, but the direction of change may be related to the quality of that exposure, the learning environment and teaching method (Craker, 2006).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

The study investigated the effects of laboratory practical activities on learning and understanding of selected physics concepts at E.P College of Education, Bimbilla. The study also sought to investigate the impact of physics laboratory practical work on motivation and attitude that is derive from an exposure to physics practical activities. The overview in this final chapter is presented under: summary of findings, conclusions, recommendations, limitations to the study and suggestion for further research.

5.1 Summary of the Findings

The study was carried out at E.P College of Education, Bimbilla, in the Northern Region of Ghana. The study was a quasi-experimental research which employed the use of experimental and control group. The purpose of the study was to investigate the effects of laboratory practical activities on learning and understanding of selected physics concepts at E.P College of Education. Students seem to enjoy practical work and it is thus generally regarded as fostering conceptual understanding, adding to the students' motivation and improved attitude towards physics (Abraham, 2011). The study therefore sought to find out the effects of laboratory practical activities on learning and understanding of selected physics concepts. It also sought to find whether there is an effect of laboratory practical activities on motivation of students towards the study of physics. The study revealed that there was no significant difference in the mean scores for first year science students on learning and understanding in the pre-test between the experimental group(M= 23.73 S.D = 7.87) and the control group (M=23.17 S.D=5.82), (independent t-test t(93) = 0.04, α = 0.05) (see table 2). This indicated that both groups were at the same level in terms of learning and understanding of physics before the introduction of laboratory practical activities as an intervention.

Analyses of data collected from the post-test revealed that there was a significant difference in the mean scores on learning between the experimental group (M=30.51 S.D=9.52) and the control group (M=23.41 S.D=8.45), (independent t-test t(93) = 4.2, α = 0.05) (see table 5).This indicated that practical activities which was used as an intervention was effective in enhancing learning in the experimental group compare to the control group. Again the post-test revealed that there was a significant difference in the mean scores on understanding between the experimental group (M=29.51 S.D=7.25) and the control group (M=22.42 S.D= 5.52), (independent t-test t(93) = 3.5, α = 0.05) (see table 7). Again, this clearly indicates that the use of laboratory practical activities is more effective in fostering understanding of physics concepts.

On the motivation of students towards physics, the post-test analysis revealed that there was a significant difference in the mean scores on motivation between the experimental group (M= 3.53 S.D = 8.710) and the control group (M=2.92 S.D= 10.291), (independent t-test t(93) = 3.16, α = 0.05) (see table 11). Again, this also indicates that the use of laboratory practical activities motivate students in the experimental group to learn physics concepts more than the traditional teacher-centered method in the control group.

5.2 Conclusions

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

Laboratory Practical work has been confirmed by researchers as a teaching strategy for fostering effective learning and understanding of physics concepts (Hodson, 2005; Jenkins, 1999; Solomon, 1999). The exposure of the experimental group to the laboratory practical activities as an intervention strategy lead to improved learning and understanding of the selected concepts in the experimental group than the control group. Most of the students in the experimental group provided correct answers to questions that were low in cognitive demand as well as high cognitive questions. Students in the control group could not provide answers to higher cognitive questions. Students learning and understanding in the experimental group was enormous and exceeded the control group. The mean score of the experimental group in both learning and understanding exceeded that of the control group and there was a significant difference in the mean between both groups. The study therefore concluded that laboratory practical activity is more effective in promoting learning and understanding of physics. Also the mean score of the experimental group in motivation exceeded that of the control group and there was a significant difference in the mean between the experimental and the control group. The study therefore concluded again that laboratory practical activity is more effective in exciting the motivation of students and creating positive attitudes towards the study of physics.

5.2 Recommendations

Following the above conclusion, the study made a number of recommendations to various stakeholders. They are divided into two sections; (1) recommendation for action and (2) recommendation for further study.

5.2.1 Recommendations for Action

1. The research study has proven that laboratory practical activities improves learning and understanding of physic and excite motivation in students to learn for understanding. It is therefore recommended that teachers should use the practical approach in the teaching of the subject because it enhances students' understanding and eventually better students' performance in the subject. In furtherance to this, practical approach to the teaching of the subject leads to motivating students towards the study of physics.
2. The study also recommends that authorities in the Colleges of Education should construct and equip Physics laboratories since the practical approach to teaching the subject demands such facilities.
3. The University of Cape Coast, UCC, must design the curriculum of the colleges of Education in Ghana to allow more time for practical activities.

5.2.2 Recommendations for Further Study

The study finally recommends areas for further research.

1. A well equipped laboratory is needed for effective practical activities. It is therefore recommended that a study be conducted to find out the nature and status of the laboratories in Colleges of Education in Ghana.
2. The research was conducted in E.P College of Education, Bimbilla in the Northern Region of Ghana and therefore limited in generalizing conclusion to all Colleges in the Country. It is therefore recommended that for a more complete study on the effectiveness of the impact of laboratory practical

activities other research be conducted in other Colleges in the Region as well as the other Regions in the Country.

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APPENDIX B

Physics Assessment pre-test

Answer all the questions in this paper. Time 1 ½ hours

To be administered to both control and experimental groups before practical activity.

1. Classify the following physical quantities as either basic quantities or device quantities stating their SI units and symbols, mass, length, velocity, acceleration, momentum, impulse, time.
2. What is the difference between basic quality and derived quantity? Give one example of each
3. What is the difference between mass and weight?
4. Name the instrument you will use for the following measurement
   i. Diameter of a piece of wire
   ii. Internal and external diameter of a tube
5. Write down the venire reading in the diagram below
6. Write down the micrometer reading shown below.
7. Convert the following
   a. $0.54m^2$ to cm^2
   b. $0.078mm^2$ to cm^2
   c. $210km^2$ to m^2
8. Convert the following
   a. 85km/h to m/s
   b. The density of $250kg/m^3$ to g/cm^3
   c. The density of $10g/cm^3$ to kg/m^3
   d. $0.003m^3$ to cm^3

   2[illegible]√***h*** [illegible] is dimensionally correct, where T is the period, h is the length, Pth density and g the acceleration due to gravity.

   2[illegible] is dimensionally correct

11. The velocity V of a transfuse wave in a string depends on the tension F in the solving, the length L of the string and the mass, m of the string. Use dimensional analysis to find the relation between the V, F, L and M
12. Detine relative density. A piece of iron has a mass of 200g and a dimensions of 5.0cm x 3cm and 7cm. calculate the density of the iron in (i) g/cm^3 (ii) kg/m^3
13. The mass of an empty bottle of is 22g. its mass when fill with water is 44g and 55.5g when tilled with liquid x. calculate the density of liquid x (density of water $1000kg/m^3$).
14. A car accelerates uniform by from a velocity of $20m^{5-1}$ to a velocity of $70m^{5-1}$ if the acceleration is $13m^{5-2}$ calculate the distance travelled.
15. A particles starts from test and accelerate to a velocity 5m/s in 205. It maintains this velocity for 10s and then decelerates to rest in a further 10s
    i. Draw a velocity-time graph for the motion
    ii. Calculate the initial acceleration of the particle

iii. Calculate the total distance covered.

APPENDIX.C

Solution to physics pre-test

Fundamental quality	Derived Quantity	SI unit	Symbol
Mass		Kilogram meter	Kg
Length		meter	M
	Velocity	meter per second	M^{5-1}
	Acceleration	meter perselond^2	M^{5-2}
	Momentum	kilogram meter per	Kgm^{5-1}
	impulse	Newton second	Ns
Time		Second	S

Q2. Basic Quantity is the quantity from which all other quantities are form e.g, mass, length, time, Derived quantity if form from the combination of two or more basic of quantities e.g velocity, acceleration momentum

Q3.

Mass	Weight
1. The quantity of matter contain in a body	The gravitational pull actiny on an object
2.SI unit is the kilogram	SI units is newton
3. Basic quantity	Derived quantity
4. scalar quantity	Vector Quantity

Q4. i. Micrometer screw gauge

ii.Verinier Calipers

Q7. 1m= 100cm $\quad 1^2m^2 = 100^2\ cm^3 = 1m^2 = 10000cm^2$ if $1m^2 = 10{,}000cm^2$

Then $0.54m^2 = x$ cm

$1m^2\, x = 5400m^2\, cm^2$

$\frac{1m^2\, x}{1m^2} = \frac{5400m^2\, cm^2}{1m^2}$

(ii) 1cm= 10mm

$1cm^2 = 100mm^2$

If $100mm^2 = 1cm^2$ then $0.078mm^2\, mm^3$

$\frac{100mm^2\, x}{100mm^2} = \frac{0.078cm^2\, mm^2}{100mm^2}$

$X = 0.00078cm^2$

$0.078mm^2 = 0.0078cm^2$

(ii) $210km^2$ to m^2 iii. Log/cm^3 to kg/m^3

1km = 1000m log/cm^3 = log = 10kg =

0.01kg

$1km^2 = 1000000m^2$ $1cm^3$ 100

$1cm^3$

If 1 $km^2 = 1000000m^2$

Then $210km^2$ =x 0.01kg =

$10.000kg/cm^3$

$0.000001cm^3$ = 10,

$000kg/cm^3$

$\frac{1km\ x}{1km^2} = \frac{210,000,000\ km^2m^2}{1km^2}$

$X=210,000,000m^2$

8. 85km/h to m^{5-1}

$85km/h = \frac{85km}{1h} = \frac{85000m}{1h} = \frac{85000m}{3600s}$

$= 23.611m^{5-1}$

ii. $2500kg/m^3$ to g/cm^3

$= 2500kg/m^3 = \frac{2500kg}{1m^3} = \frac{2500000g}{1m^3}$

$\frac{2500,000g}{1000,000cm^3} = 2.5g/cm^3$

$\sqrt{hp/g}$ where h= length p= density g= acceleration due to gravity

Using the dimension T= [T] [L] p = $[ML^{-3}]$ g= $[LT^{-2}]$

$\sqrt{\frac{LML^{-3}}{MT^{-2}}}$ taking the square on both sides

$^2\ \frac{LML^{-3}}{LT^{-2}}$

$^2\ LML^{-3}$

$^2\ LML^{-3}$ since the right hand side of the equation is not equal to the dirension at left hand side is the equations is invalid (wrong).

$\sqrt{1/g}$ T= (T) I= (L) g= (LT^{-2})

$\sqrt{L/LT^{-2}}$ taking squar of both side

$^2L/LT^2$

Since the dirension on the righ hand side is equal to the dimension on the left hand side the equation is valid.
10 V & FLM V= velocity F=tension L= length

12. Relative Density is detire as the densing of a substance copare to the density of water

$$R.D = \frac{\text{Density of a substance}}{\text{Density of water}}$$

iii. Mass of iron = 200g volume of iron= 5.0cm x 3.0cm x 2cm
Volume= 30cm^2

$$\text{Density} = \frac{\text{mass}}{\text{Volume}} = 200g/\ 30cm^3 = 6.67g/cm^3$$

iii. Density in kgm^3 = 6.67 kg/m^3 6.67 x 10^{-3} kgm^{-3}

13. Mass of empty bottle Mo= 22g
Mass of bottle + water M1 = 44g
Mass of bottle + liquid x M2 = 55.5g
Mass of water = 44g – 22g = 22g
Mass of liquid = 55.5g – 22g = 33.5g

$$R.D\ (\text{liquid x}) = \frac{33.5g}{22g} = 1.52$$

$$RD\ (\text{liquid x}) = \frac{\text{Density of liquid x}}{\text{Density of water}} = \text{density of liquid x} = \text{RD x Density of water}$$

Density of liquid x = 1.5 x 1000kg/m^3 = 1500kg/m^3

14. u= 20m$^{5-1}$ V= 70m$^{5-1}$ a= 13m$^{5-2}$

$$V^2 = u^2 + 2as$$

$$2as = V^{2-}u^2$$

$$S = \frac{V^{2-}u^2}{2a} = \frac{70^2 - 20^2}{2x\ 13} = \frac{4900- 400}{26}$$

$$S = \frac{4500}{20} = 173.\ 1m$$

ii. initial acceleration a= V- u = 5- 0 = 0.25m$^{5-2}$

iii. Total distance covered = area under velocity time graph

= ½ h (ab +cd)
= ½ 5m$^{5-1}$ (10+ 40)
= ½ x 5m5-1 (50)s
= ½ x 250 = 125m

APPENDIX D

Physics Assessment Post Test

Answer all questions in this paper ***Time: one hour***

To be administered to both control and experimental Groups at the end of the topic

1. Define the term moments of a force and state its SI units.

2. Explain why the handle of a door is usually placed as far as possible from the hinges.

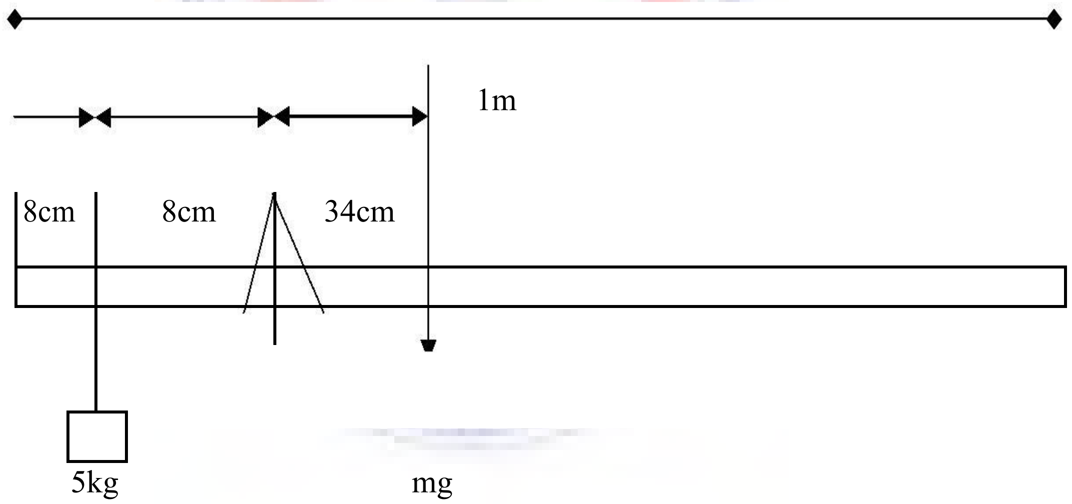
3. A uniform 50cm meter rule is balanced at its centre point. An object weighing 15N is placed 10cm from the ruler's midpoint on the right. Calculate the weight that can balance the metre ruler as from the other end

4.Two masses weight 20N and 50N are suspended at the end of a rod 5m long rod.

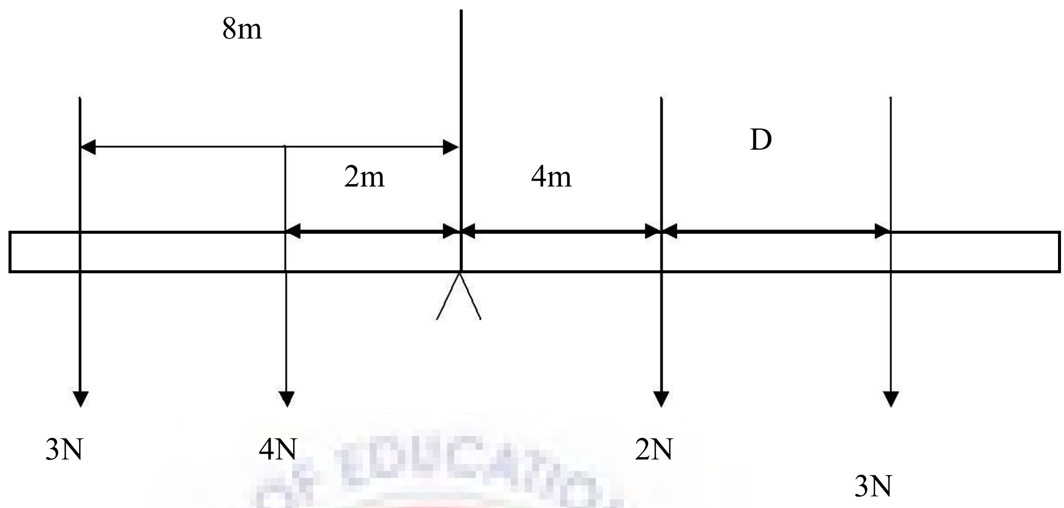
Determine the position of the pivot from the 20N mass

5. State the principle of moments

6.Calculate the weight mg of the uniform beam when the beam is in equilibrium and the weight acts through the center.



7. Define the term antiparallel forces
   1. State four application of antiparallel forces
9. Calculate the unknown distance in the diagram which is in Equilibrium.



10(a) Define centre of gravity(b)Equilibrium

15. Define the following terms i centre of gravity ii Equilibrium

iii State two conditions for a system to be at equilibrium.
16. Explain why laboratory stands are made with a wide heavy base

(c) Bus body builders have luggage compartments below seats rather than on roof racks

17. Name the three states of equilibrium

ii.Using diagrams, distinguish between the states named above.

Explain the significance of the centre of gravity.

18. i State Newton's first law of motion. ii what is inertia
19. i State Newton's second law of motion. ii. Using Newtons second law proof that F = ma, Where, F = forcw, m= mass, a = acceleration.

20 a 20kg body as rest on a rougth horizontal surface is pulled with a horizontal force of 100N. if the coefficient of friction is 0.3, what is the frictional force on the body and the resulting acceleration on the body.

21. a force of 50N acts on a body for 3s. calculate the linear impulse on the body.
22. a linear impulse of 50N is exerted on a 2kg body moving at 40ms- to slow it down. Calculate the final velocity of the body.

APPENDIX E

STUDENT'S QUESTIONNAIRE

TEST OF PHYSICS students' MOTIVATION (TOPM) QUESTIONNAIRE

The purpose of this questionnaire is to find out the impact of physics laboratory practical activities on learning and understanding of physics concepts in E.P College of Education, Bimbilla. You are requested to kindly complete this questionnaire as truthfully as possible. You are assured that your responses will be treated confidentially.

SECTION A: Demographics

Please give the appropriate response for the items in this section. Please tick where appropriate and write where you are supposed to write.

1. Gender: Male [ ]   Female [ ]
2. Age: 10 -16yrs [ ] 17-21 [ ] 22-24 [ ], others (specify)……….
3. Name of college ………………………….
4. Level of student………………………………

SECTION B

Directions:

For each item, please circle a number from the scale 1-5 in the right side of the item to indicate the degree of agreement or disagreement with the question item.

NB: Strongly disagree= 1, Disagree = 2, Not certain = 3, Agree = 4, Strongly Agree=5.

item	Question	SD	D	N	A	SA
1	Physics Practical work is interesting					
2	I will like to do more practical work					
3	I dislike doing practical investigations					
4	Practical work is boring					
5	I enjoy practical lessons					
6	Practical work is a waste of time					

7	Physics is not important compare to other subjects					
8	My physics teacher is my role model					
9	Physics practicals gives me hectic time					
10	I fear the physics practical					
11	My physics teacher makes practical fun					
12	Knowledge of the practical is vital					
13	Physics practical equipment are out of date					
14	Physic practical equipments scars me especially wires					
15	I have difficulty in understanding physics practical					

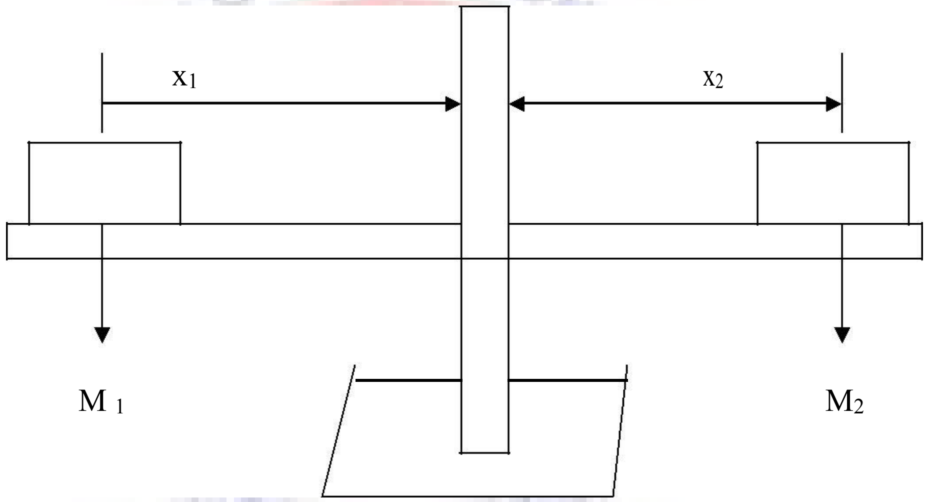
APPENDIX F

Experiment: **To verify the principle of moments**

Apparatus:- metre rule, known masses, string, retort stand

Procedure

1. Balance the meter rule at its center using the string at its ends
2. Place a known mass M_1, on one end of the metre rule and balance the metre rul by placing another known mass M_2 on the other side of the metre rule as shown in the diagram below



3. Record the distance x_1 and x_2
4. Repeat the experiment using different known masses for M_1 and M_2
5. Complete the table below

M_1	M_2	x_1	x_2	M_1 X x_1	M_2 X x_2
10	100				
20	80				
40	50				

6. Compare the value of M_1Xx_1 and M_2Xx_2
7. Conclusion

A Marking Scheme for practical on moments

2. 2 marks for balancing the metre at its centre (manipulative skills)
3. 4 marks placing the masses as instructed (manipulative skill, observation, interpretative skills)
4. 4 marks for being able to make correct reading (observation reading)
5. 4 marks for being able to (manipulate the masses, recording, reporting)
6. Table 6 marks (½ x 12) = 6 work for each reading and ½ work for working out the product. (observation skills, recording, manipulation, reporting, reporting, measurement, accuracy)
7. 2 marks for correct answer and correct comment (reporting)
8. 2 marks for correct conclusion (interpretation inferring)

APPENDIX G

Experiment on Newton's first law of motion

Inference and hypothesis: Many years ago, Sir Isaac Newton came up with some most excellent descriptions about motion. His First Law of Motion is as follows: "An object at rest stays at rest and an object in motion stays in motion unless acted upon by an outside force." Quite a mouthful. What that means is that something that is sitting there will continue to sit there unless moved. And something moving will keep moving unless something stops it**.**

Penny on a Card Experiment.

Materials for the Penny on the Card Experiment: small plastic cup, playing card and a coin.

Procedure:

- Put a playing card on top of the plastic cup
- Put a coin on top of the card
- With a sharp flick, hit the card out from under the coin! Or pull it really quickly toward you.
- The coin will drop into the cup.

Explanation:

The coin has inertia, meaning it really wants to stay in one place. If you move the card slowly, it isn't fast enough to overcome that force. If you flick it quickly, the coin stays in one place and then drops into the cup. An object at rest will remain at rest. If you are brave, put the card on your finger and the coin on top… try to flick the card out until the coin stays on your finger. It can be done!

APPENDIX H
EXPERIMENT ON SIMPLE PENDULUM

1. **Inference**: When the length of a simple pendulum increases, the period of oscillation also increases. The period of pendulum is affected by the length of the thread.

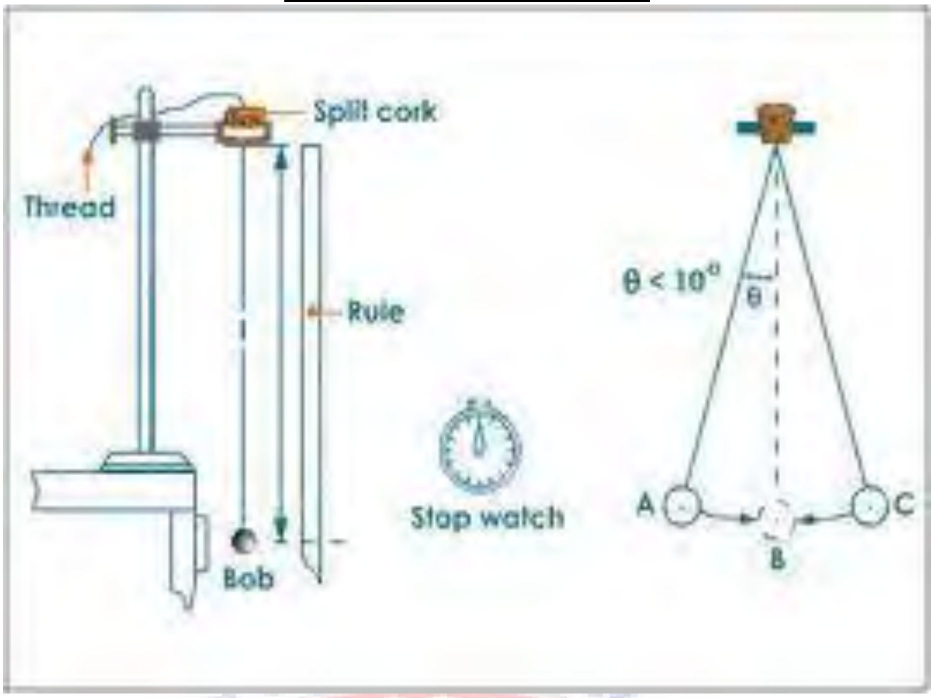
2. **Hypothesis**: The longer the length of a simple pendulum, the longer will be the period of oscillation

3. **Aim**: To find the relationship between the length of a simple pendulum and the period of oscillation.

4. **Variable**: a) Manipulated variable : Length, b Responding variable : Period, T.
   c) Fixed variable : Mass of pendulum bob.

5. **Materials**/ **Apparatus** : Retort stand, pendulum bob, thread, metre rule, stop watch.

FUNCTIONAL DIAGRAM



7. Procedure.

a) Set up the apparatus as shown in Figure above. A small brass or bob was attached to the thread. The thread was held by a clamp of a the retort stand.

b) The length of the thread , l was measured by a metre rule, starting with 90.0 cm. The bob of the pendulum was displaced and released.

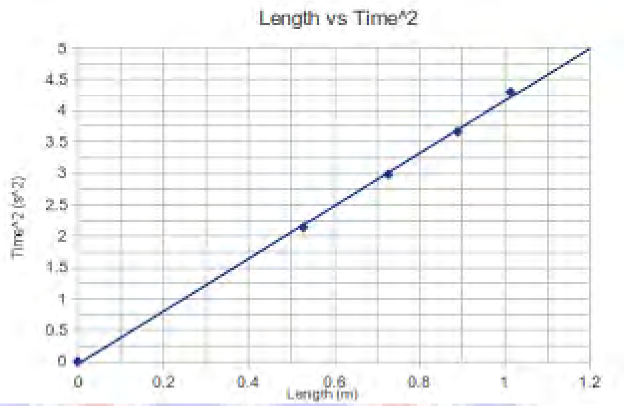
c) The time for 20 complete oscillations, t was taken using the stop watch. Calculate the period of oscillation by using, T = t / 20

d) The experiment was repeated using different lengths such as 80.0cm. 70.0cm, 60.0cm, 50.0cm and 40.0cm.

Expected values of the experiment.

Length of string, l / cm	Time taken for 10 oscillation, t (s)			Period of oscillation T	T^2 (s^2)
	t_1	t_2	Average, t		
40.0	25.2	25.1	25.2	1.26	1.59
50.0	28.1	28.2	28.2	1.41	1.99
60.0	31.0	31.0	31.0	1.55	2.40
70.0	33.5	33.6	33.6	1.68	2.82
80.0	35.7	35.9	35.8	1.79	3.20
90.0	38.2	37.9	38.1	1.91	3.65

8. Plotting the graph



Notes :

a) Plotting the graph

- The graph should be labeled by a heading
- All axes should be labeled with quantities and their respective units.
- The manipulated variable (l) should be plotted on the x-axis while the responding variable (T^2) should be plotted on the y-axis
- **Odd scales** such as 1:3, 1:7 , 1:9 0r 1 :11 should be **avoided** in plotting graph.
- Make sure that the transference of data from the table to the graph is accurate.
- Draw the **best straight line**.
  - the line that passes through most of the points plotted such that is balanced by the number of points above and below the straight line.

- make sure that the **size of the graph is large enough**, which is, not less than half the size of the graph paper or.

10. **Discussion / Precaution** of the experiment / to improve the accuracy

a) The bob of the pendulum was displaced with a small angle
b) The amplitude of the oscillation of a simple pendulum is small.
c) The simple pendulum oscillate in a vertical plane only.
d) Switch off the fan to reduce the air resistance

11. **Conclusion**

The length of simple pendulum is directly proportional to the square of the period of oscillation. //

T^2 is directly proportional to l (the straight line graph passing through the origin)

APPENDIX I.

Experiment on Newton's second law of motion

Demonstration.

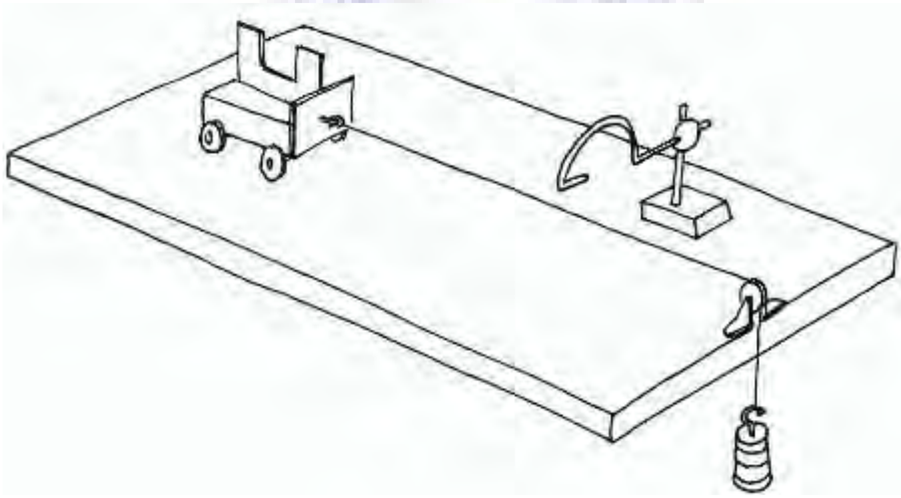
A trolley experiences acceleration when an external force is applied to it. The aim of this experiment is to explore the relationship between the magnitudes of the external force and the resulting acceleration.

Apparatus and materials: Dynamics trolley**,** Pulley and string**,** Slotted masses, 400g, Mass1g.

Clamp, Ruler, Double segment black card (see diagram)

Health & Safety and Technical notes

Take care when masses fall to the floor. Use a box or tray lined with bubble wrap (or similar) under heavy objects being lifted. This will prevent toes or fingers from being in the danger zone.



Pass a piece of string with a mass hanging on one end over a pulley. Attach the other end to the trolley so that, when the mass is released, it causes the trolley to accelerate. Choose a length of string such that the mass does not touch the ground until the trolley nearly reaches the pulley. Fix a 1 kg mass on the trolley with Blu-tack to make the total mass (trolley plus mass) of about 2 kg. This produces an acceleration which is not too aggressive when the maximum force (4 N) is applied.

The force is conveniently increased in 1 newton steps when slotted masses of 100 g are added. Place the unused slotted masses on the trolley. Transfer them to the slotted mass holder each time the accelerating force is increased. This ensures that the total mass experiencing acceleration remains constant throughout the experiment.

Fit a double segment black card on to the trolley. Clamp the light gate at a height which allows both segments of the card to interrupt the light beam when the trolley passes through the gate. Measure the width of each segment with a ruler, and enter the values into the software.

Connect the light gate via an interface to a computer running data-logging software. The program should be configured to obtain measurements of acceleration derived from the double interruptions of the light beam by the card.

The internal calculation within the program involves using the interruption times for the two segments to obtain two velocities. The difference between these, divided by the time between them, yields the acceleration.