UNIVERSITY OF EDUCATION, WINNEBA

THE USE OF SCIENCE PROCESS SKILLS TO FACILITATE STUDENT'S' LEARNING OF PHYSICS.

ABEL BATIIGEMME BALAGUMYETIME

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THE USE OF SCIENCE PROCESS SKILLS TO FACILITATE STUDENT'S' LEARNING OF PHYSICS. A STUDY AT BOLGATANGA SENIOR HIGH SCHOOL

ABEL BATIIGEMME BALAGUMYETIME

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2015

DECLARATION

CANDIDATE'S DECLARATION

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate‟s Name: ABEL BATIIGEMME BALAGUMYETIME

Signature: ....

Date: ....

SUPERVISORS' DECLARATION

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

Principal Supervisor‟s Name: PROF MAWUADEM KOKU AMEDEKER

Signature: ....

Date: ....

ABSTRACT

The main purpose of the study was to give suggestions to facilitate student‟s‟ learning of physics using science process skills at Bolgatanga Senior High School in the Upper East Region of Ghana. This was to be achieved through the use of group activity approach and the organisations of laboratory practical activities. The study was an Action Research that used fifty five second year students out of a population of 680 physics students in the school based on purposive sampling procedure. The sampled students were further divided into 11 groups with five members each through simple random sampling technique. A series of practical activities were conducted to find out the students‟ level of understanding of the science process skills before group activity approach and laboratory practical activities were used as an intervention. The results revealed that there was an improvement in the performance of the students as well as their content knowledge in physics as a result of the use of science process skills. It is therefore, appropriate that science teachers prepare their science instructions such that equal opportunities are given to all students under their care. As a result there is a need for teacher‟s educational institutions to reinforce science process skills in the science teaching and learning in their science lessons. Additionally, science process skills should be employed by all physics teachers in the instruction of physics concepts.

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DEDICATION

This work is dedicated to the whole Balagumyetime‟s family. My Guadians Chief Nyarkora Mantii and Mrs Juliana Crowe. My siblings Shilla and Phina Balagumyetime and to my lovely wife Mrs. Bernice Bonkenna Balagumyetime. And to my caring brother Mr. Valentine Garinbang and my uncle Mr. Isaac Yindan.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter comprises the background of the study which gives insights into the study, statement of the problem which brings into focus the problems which caused the researcher to undertake the study, the purpose of the research also involves the reasons for the study, objectives of the research also brings to mind what the researcher seek to achieve by the research, research questions, and significance of the study. The limitations and delimitations identified during the study are also presented. Finally, it presents the organization of the study.

1.1 Background of the Study

Science curriculum innovation and reforms were characterised by the attempts to incorporate more practical oriented and investigative activities into science classes (Clark, 2003). Hofstein and Naaman (2007) reviewed and reported several studies conducted in various countries about laboratory applications. In their evaluation, they stated that laboratory applications aimed to enhance students" science process and problem-solving skills and their interest in and attitudes toward scientific approaches in accordance with the objectives of basic science education.

From the learning point of view, process skills are important and necessary means by which the learner engages with the world and gains intellectual control of it through the formation of concepts and development of scientific thinking. The scientific method, scientific thinking and critical thinking have been terms used at various times to describe these science process skills.

Science leaning follows a process approach. In scientific investigations, some of the key science process skills that scientists do follow are: observation, analysis, and classification, and description, interpretation of data, hypothesis, prediction, planning, and experimentation, keeping of records, measurement, conclusion and communication.

Experience from the researcher‟s teaching showed that students put much enthusiasm in their studies whenever time for practical work is announced and when science process skills are used in tuition. Performing practical activities regularly and consequently, the use of science process skills in regular class tuition regularly, may serve as reinforcement for students to learn. Feedback from the regular use of science process skills in teaching may help teachers to estimate students understanding of the physics concepts.

Accepting that the main objective of efficient physics education is to improve student skills of critical thinking, scientific operation, and comprehension of scientific meaning and principles and also although a study presenting the use of science process skills to facilitate students learning of physics has not been encountered in the field of literature, it is thought that this present study would bring a new point of view for secondary school science education and the related studies.

1.2 The Statement of the Problem

The persistent low performance of Bolgatanga SHS students in physics both in the internal and external examinations which was evident from the poor drawing and observation skills of the students in the practical and theory examination informed the researcher‟s decision to undertake the research. The persistence of this problem implies that whatever local interventions the physics teachers applied have only had minimal effects. Due to the importance of science process skills in the generation of valid scientific knowledge, there was the need for this problem to be addressed during their practical and normal classroom activities in the schools to provide a basis for future attempts to find a lasting solution to this gap in the SHS student‟s science process skills.

1.3 Purpose of the Study

Developing good process skills in science has been the primary concern of physics teachers at all levels of the educational ladder. Therefore, the main purpose of the study was to facilitate the performance of SHS students in physics using activity group method of teaching and practical laboratory techniques. There has been a series of transformations in the educational system in Ghana. The reason for the transformations is to improve the performance of the students who pass through such schools to acquire skills such as observation and analysis through scientific investigations. It is only through the activity method of teaching that this expectation will be met.

1.4 Objectives of the Research

The objectives of the study were to:

1. Use a variety of teaching and learning materials in practical demonstration to develop scientific principles and facts behind a particular concept.

2. Use activity method to teach students science process skills such as observation, recording and manipulation.
3. Perform a variety of experiments using activity group approach which leads to discovery.

1.5 Research Questions

The research questions were;

1. What type of teaching and learning materials could be used in practical demonstration to develop scientific principles and facts behind particular concepts?
2. What activity methods in physics teaching can help Bolgatanga SHS Physics students to acquire scientific skills?
3. How will Bolgatanga SHS Physics students‟ performances improve if group activity approach is applied in teaching?

1.6 Significance of the Study

It is hoped that the findings of the study may serve as a resource for teachers and schools who seek to improve the performance of their students in physics. The findings of the study may also bring to the notice of curriculum planners and implementers the need to involve process skills when designing the syllabuses for all levels of education. More importantly, the findings of the study may also serve as reference for future researchers who seek to study about the use of science process skill and related topics.

1.7 Limitations of the Study

According to Marilyn and Jim (2013), limitations were described as matters and occurrences which arise in a study which are out of the researcher‟s control. They limit the extensity to which a study can go, and sometimes affect the results and conclusions that can be drawn.

Thus, in this study, the limitations were that; the period of the study was short. The study was to cover all the Physics students in Bolgatanga Senior High School but due to time and financial constraints, the research was limited to only form 2A class of 55. Due to the confinement of the research in Bolgatanga Senior High School, it may not be proper to generalize the results.

1.8 Delimitation

According to Marilyn and Jim (2013), delimitations of a study are those characteristics that arise from limitations in the scope of the study which define the boundaries and by the conscious exclusionary and inclusionary decisions made during the development of the study plan. Leedy and Ormrod (2005) also stated in her study that delimitations are what the researcher is not going to do.

Thus in this study, the delimitations were that; because of time constraints and work load involved, collection of information and data analysis will be restricted to only form 1A class of the first year group of students.

1.9 Organization of the study

This write-up is divided into five chapters; the first chapter provides an introduction to the study. It also includes background of the study, statement of the problem, the purpose of the research, objectives of the research, research questions, and significance of the study, limitation and delimitations. The second chapter consists of a review of related literature. The third chapter outlined the methods and systematic measures that the researcher employed to get the needed data for the research work. The forth chapter presents the data collected, their analysis and discussions of the results. The fifth chapter presents the reflections, recommendation and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter comprises the science process skills, which gives a brief description of the various skills employed by scientist in their scientific investigations. It also involves the science teaching strategies which bring to mind the various teaching strategies, the concept of practical activity technique of teaching science, merits of practical activity technique of teaching science, demerits of practical activity technique of teaching. This chapter also comprise the role of teaching and learning materials in teaching science (physics), the role of science process skills in learning science and the empirical evidence for the study. Finally, the conceptual framework of the study is described.

2.1 Science Process Skills

Science and teaching students about science means more than scientific knowledge. There are three dimensions of science that are all important. The first of these is the content of science, the basic concepts, and our scientific knowledge. This is the dimension of science that most people first think about, and it is certainly very important. The other two important dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. Since science is about asking questions and finding answers to questions, these are actually the same skills that we all use in our daily lives as we try to figure out everyday questions. When we teach students to use these skills in science, we are also teaching them skills that they will use in the future in every area of their lives.

Science Process Skills is the logical operations of thinking in investigations. They are either basic or integrated. Basic Process Skills include; observing, comparing, classifying, quantifying, inferring, predicting, communicating and manipulative skills. Integrated Process Skills which are embodied in experimenting includes hypothesising, controlling variables and classifying data (Stein, McNair, & Butcher, 2001).

The Basic Process Skills are explained below:

Observing is the most basic and fundamental of the process skills. One cannot compare, classify or perform the other process skills without being a good observer. We observe objects or events through our five senses: sight, smell, touch, taste and hearing. Example: Describing a pencil as yellow. The Process of observing can be: Qualitative – this is identifying and naming the properties of an object such as its shape, colour, size, texture, smell, and sound. Quantitative – This kind of observation involves measurement and Change – this could be as a result of crushing, pounding, burning, decaying, cutting etc (Stein, McNair, & Butcher, 2001).

Comparing usually involves the use of observable properties in discovering similarities of and differences between objects and phenomena. Through comparison, we are able to identify relationships among objects and phenomena observed.

Classifying takes into consideration the fact that there is an overwhelming number of things around us – nonliving and living things. Order can be attained by observing similarities, differences and interrelationships and by grouping them accordingly to suit some purpose. Example: Placing all rocks having certain grain size or hardness into one group (Stein, McNair, & Butcher, 2001).

Also while observing is getting information by using one or more senses, inferring is explaining or interpreting an observation. Example: Saying that the person who used a pencil made a lot of mistakes because the eraser was well worn.

Predicting is the process of using past observations or data along with other kinds of scientific knowledge to forecast event or relationships. A statement not based on observation is not a prediction. It is simply a guess. Interpolation – is predicting new data based on and within a trend/ pattern of previously observed data. Extrapolation - is predicting new data outside or beyond the range of previously observed data (Stein, McNair, & Butcher, 2001).

Quantifying is making and manipulating quantitative observations. This involves: 1. using numbers 2. measuring 3. using time and space. Example: Using a meter stick to measure the length of a table in centimetres.

Communicating involves expressing ideas in many forms, such as orally, in writing or with graphs, diagrams, tables of data or photographs. Example: Describing the change in height of a plant over time in writing or through a graph.

Manipulative skills involve using equipment and materials properly and accurately, preparing setups for investigation, and handling specimen carefully (Stein, McNair, & Butcher, 2001).

2.2 Science Teaching Strategies

There are numerous teaching strategies that the science teacher can use in teaching the subject. Modern science teaching strategies involve the deliberate planning and organisation of teaching learning experiences and situations in the light of psychological and pedagogical principles with the view of achieving specific goals. When the deficiency needs are met, students are likely to function at the higher levels (that is growth needs level). This means that when the deficiency needs are met, self directed learning or desire to know and understand would be engaged in more easily. The implication of this is that teachers can encourage students to meet their growth needs by enhancing the attractiveness of the learning situation. In the light of these, when the environment where the students are learning (in this study, class and laboratory) is made attractive, effective learning is likely to take place.

Gagne"s theoretical formulations are attempts to identify aspects of learning and to match these with the intellectual demands of the individual. While development is subordinated to learning, Gagne"s paradigm insists on identifying valid ordered sequences of instruction (pre-requisites) that can facilitate the learning of intellectual skills. Gagne"s theory offers an opportunity for the physics teacher to diagnose students" limitations and strengths more effectively, thus permitting more adequate individualisation and personalisation of science (physics) instruction. Gagne"s learning hierarchy also offers physics teachers the opportunities of developing and conceptualizing agreed-upon science goals and objectives in reality –oriented and learner-centred way.

It is on this premise that Gagne anchors his beliefs that students learn an ordered additive capability. That is, the simpler and more specific capability is learned before the more complex and general capability. Gagne therefore considered previous experience to have a major role in determining an individual‟s learning ability (Gagné & Deci, 2005). Ideal classroom environment is therefore a condition for the students to actively carry out such activities and construct new information into the already existing mental framework for meaningful learning to occur (Huith, 2003).

To begin with, theoretical approach as a teaching strategy is a process of delivering verbally a body of knowledge according to a pre-planned scheme (De Corte, 2000). This method is also known as the lecture method. Thus the emphasis is on writing notes on discoveries made by scientist. By this method, the teacher prepares and gives out information verbally to students without student‟s participation in the lesson. The students therefore listen, take down notes and memorize facts and concepts. This approach to science teaching makes students get bored during science lessons. The lecture method reduces teacher-student‟s interaction. However, this method of teaching is economical because no laboratory and expensive apparatus are required. It also encourages efficiency in time management since a single teacher can teach any number of students at a time (De Corte, 2000).

According to De Corte (2000), people follow the theoretical approach due to limited knowledge of science that the students possessed. In modern times science is seen more to be practically oriented or activity based (De Corte, 2000). Students enjoy science lessons when they are involved in activities concerning the topic. There is therefore the need to adopt the activity-based and inquiry methods in teaching of science especially at the basic and secondary levels.

Secondly, discussion as a teaching strategy is one of the best ways of helping students to understand and learn ideas (Tschannen-Moran & McMaster, 2009). According to Tschannen-Moran, & McMaster (2009), when students are given the chance to talk about things, it becomes easier to find out their knowledge in that topic, in order that learners see clearly how an idea applies to everyday life, they must be given the opportunity to use the discussion approach and that the teacher only acts as a catalyst during the interaction among the students (Douglas, Burton & Reese-Durham, 2008). According to Limón, (2001), in situations where class discussions are frequent each student develops self-confidence since he realizes that he is contributing something. This method provides an excellent opportunity for students to practice their oral communication skills. It also encourages critical and evaluative thinking.

Another teaching strategy is an activity-based method. It is the process of assisting students to discover their own knowledge through an activity (Akerson, Abd-El-Khalick, & Lederman, 2000). According to Akerson et al (2000), in addition to acquisition of knowledge, the approach also leads to acquisition of process skills such as measuring, recording, analyzing and interpretation of data. Activity-based method is more of a child-centred approach, as such; students may learn better and faster when they are taught through activities. When a student performs an activity as an individual, the learner easily understands and never forgets (Hedegaard, 2005).

According to Hedegaard (2005), the activity method is used to teach science in which the students are at the centre of the learning process and made to interact with materials and experience things for him or herself. In this method, the student discovers concepts and facts either unaided or with minimum teacher interference. The teacher is less active, a facilitator, co-learner and a guide. The activity method takes full advantage of the learner"s natural tendency to explore the familiar environment.

The advantages of this method include students learning to use their hands and minds. Students learn to organize, observe and become more curious to manipulate and carefully handle equipment during activity-based lessons. Again, activity–based methods of learning science results in performing experiments or practical exercises with scientific apparatus (Hamilton-Ekeke, 2007). This method takes full advantage of the student"s individual differences and abilities (Hamilton-Ekeke, 2007). However, the method is time consuming. It is also very expensive, since it involves the use of more materials (Hamilton-Ekeke, 2007).

Another strategy which is rarely used in science education is the field trip or excursion (Hamilton-Ekeke, 2007). It involves organizing a group of students to visit companies or industries where things taught in theory can be seen practically. Field trip or excursion can be likened to a visit to another laboratory away from the school"s premises, which is equipped with instruments and materials that the school"s laboratory does not and cannot contain (Hamilton-Ekeke, 2007). Those places they visit can serve as a resource centre to allow the students to acquaint themselves with principles and phenomena which had been hitherto abstract to them. Field trip enables learners to see those things they have theoretically and makes learning real (Hamilton-Ekeke, 2007). It becomes very difficult for learners to forget what has been learnt and seen in field trip (Hamilton-Ekeke, 2007). This method is therefore recommended for students at the secondary school level since they easily remember things they have been taught and seen (Hamilton-Ekeke, 2007).

Another important strategy of science teaching is the demonstration approach. The goal of this strategy is to help students acquire skills. The demonstration must be done in the full view of the class. In some cases, the teacher does it first and later asks students to perform while he goes round to watch, guide and give comments as the students work. Even though this approach involves mainly teacher‟s activity, it still involves experimentation which some science educationists agree to as being an essential aspect of science teaching (David, 2007). According to Meece, Anderman, & Anderman, (2006), once the concepts are firmly established, the other higher-order varieties of learning like problem solving can also take place.

One of the unique features of effective science teaching and learning is laboratory work which involves students in observation, experimentation through measuring and manipulation of equipment (Hofstein & Lunetta, 2004). Therefore, laboratory work is seen as an integral part of learning science.

Pre-university schools which were just being established as educational institutions soon began to create science laboratories as well. The aims of these laboratories were to provide scientific literacy and also to prepare students for further study, work and citizenship. Early times laboratory manual‟s consisted mainly of description of experiments which included menstruation, heat, hydrostatics, the pendulum, determination of latent, demonstrating reactions and other such simple experiments (Kirschner, Sweller & Clark, 2006). Thus, most laboratory work involves teacher demonstrating classical scientific experiments and students repeating experiments whose outcomes are already known.

2.3 The Concept of Practical Activity Technique of Teaching Science

It is often argued that practical work is central to teaching and learning in science and that good quality practical work helps develop students‟ understanding of scientific processes and concepts. The SHS teaching syllabus for elective physics, advices that teaching of physics should be student –centred and activity oriented. The teacher acts as a facilitator. Practical activities are learning experiences in which students interact with materials or with secondary sources of data to observe and understand the natural world (Abell and Lederman, 2007). In a report written for the US National Academy of Sciences, Robin Millar pointed out that when using the term "practical work" it referred to "any teaching and learning activity which at some point involves the students in observing or manipulation the objects and materials they are studying" (Lynch, 2010, p. 2).

We use practical work in science classes when students are likely to have observed the phenomenon we are interested in, or to have observed it in sufficient detail in their everyday lives. The researcher sees activity based instruction as the form of learning were the learner is actively engaged in a task. The focus is on making the abstract concrete and focuses on learning by doing. It can be teacher-driven with directions from an instructor or learner-driven with the learner having freedom to explore.

2.4 Merits of Practical Activity Technique of Teaching Science

Lynch (2010) provides an explanation as to why the notion of "pupil as scientist" is attractive to science educators. Encouraging students to pursue their own enquiries, laps into their natural curiosity needs. Finding things out for you, through your own efforts, seem natural and developmental, rather than coercive, and may also help you to remember them better. It seems to offer a way of holding up evidence rather than authority, as the grounds for accepting knowledge. It is enabling, rather than dismissive, of the individual"s ability, and right, to pursue knowledge and understanding for him/her. Indeed one of the great cultural claims of science is its potential as a liberating force which the individual can and may enhance his/her own interaction with the natural world, challenge established traditional or prejudice by confronting it with evidence, an enquiry-based approach may also encourage students to be more independent and self-reliant. In this way it supports general educational goals such as the development of the individuals" capacity for purposeful, autonomous action in the world. He also identifies the value of practical activities in school sciences.

More specifically practical work is essential; it enables learners to manipulate tools and equipment effectively. It is also an important tool for teaching about experimental design. Indeed research suggests that students design better investigations when they actually carry out rather than when only asked to write a plan.

Some researchers have reported that practical work can increase students; sense of ownership of their learning and can increase their motivation (Brady, 2001). The researcher therefore concludes that practical activities help to: encourage accurate observation and description, make phenomena more real, arouse and maintain interest and promote a logical and reasoning method of thought. Activity based learning does give the child scope for independent leaning and exploring things on their own, without direction from a teacher.

2.5 Demerits of Practical Activity Technique of Teaching

Firstly, it is clear that doing science and understanding science theories are different (Tsay and Brady, 2010). Secondly, there is evidence that many students particularly girls, are not very positive about doing experiments (Wanbugu, Johnson and Francis, 2013). As Bennett and Kennedy (2001) pointed out in their study, the plurality of espoused aims for practical work in science make the task of assessment difficult.

Despite curriculum reform aimed at improving the quality of practical work, students spent too much time and consequently, practicing lower level skills. As a result, "students fail to perceive the conceptual and procedural understandings, which were the teacher"s intended goals for the laboratory activities" (Lunnetta, 2007, p.403). Activity is just part of learning. Without reflecting on activity; thinking about it in certain ways to make a theory; testing that theory again etc; the active learning will have very little lasting value. There will be activity but nothing particular gained from it. Active learning should be balanced with other less concrete experiences. Active learning can become very trivial for advanced learners. When a concept is understood and the learner is ready to move on, it would be very tedious and time consuming to carry out another practical activity based around the concept. Comprehension of the concept can be tested in more efficient ways and the learner spared the hassle associated with lengthy practical exercises.

Focusing on activity to make learning fun can actually hamper those students who wouldn‟t make good progress without it. Those more able learners could also come to believe that all learning should be fun and this may hamper their enthusiasm for tackling more difficult and advanced topics that does not so easily render itself being made into an "activity". Much advanced work in science is abstract and does not lend itself to activity. The learners may be limited in their learning because of being directed towards more practical elements of knowledge.

2.6 The Role of Teaching and Learning Materials in Teaching Science (Physics)

Teaching and learning materials reduce verbalization and make learning more interesting, diversified, and effective (Murphy, 2013). They provide opportunity of adaptation of the teaching to learner‟s ability level.

Progression in learning is usually from the concrete to the abstract (El Euch, 2007). People learn to do well mainly what they practice doing. Therefore, teachers should be consistent with the scientific technology and concentrate on the collection and use of materials. Effective science teaching depends on the availability and organisation of materials, equipment, media and technology. Therefore, science program must extend beyond the walls of the school to the resources of the community.

2.7 The Role of Science Process Skills in Learning Science (Physics)

The educational system must act to sustain effective teaching and learning by helping students to utilize the science process skills. All teachers of science have implicit and explicit beliefs about science learning and teaching. Huppert, Lomask, & Lazarowitz, (2002) said that students need ample opportunities to practice the science processes within a variety of investigations. The students will be able to apply the science process outside the classroom if teachers make connection between the domains in a specific context and extend to the general one.

Bilgin (2006) in his book "the effects of hands-on activities incorporating a cooperative learning approach on eight grade students" science process skills and attitudes toward science" contended that lack of science process skills in students, causes low performance in their final examinations. He added that to find a lasting solution to this problem requires a careful and a systematic analysis of curriculum content and making time to conduct enough appropriate practical lessons before introducing the theoretical law.

According to Abd-El-Khalick, et al, (2004), a science study reveals scientific concept and principles and provides opportunities for students to inquire into scientific knowledge. It stimulates students to experience solving scientific problems by applying the scientific method. Hence, science cannot be learnt merely by reading science books, but emphasis should be placed on carrying out activities, observing, analysing and drawing conclusions. And this will enable the student to be aware of the application of science in everyday life.

DebBurman, (2002) emphasised that; the primary purpose of instruction is not to cause students to memorize the fact but to participate actively in the process that lead to creation of new knowledge.

It is activity oriented and therefore its learning cannot be successful without the hands-on practical work, it is apparent from the above that science process skills are inevitable in science teaching and learning.

2.8 Empirical Evidence

The abysmal performance of science students in physics theory and practical examinations is becoming alarming and needs to be given a second look. Empirical evidence abound, tracing the cause of such unfortunate situation to the doorsteps of teachers" non-performance.

Studies have shown that the candidates more often than not are not familiar with the laboratory techniques and process skills needed to tackle the questions. It is the fervent hope of the researcher that this work would go a long way to expose the inadequacies of the teaching methods as far as Physics theory and practical work is concerned. It is therefore recommended that students should be given more exercises if possible on daily basis to expose them to the rudiments of practical and process skills. It is also advised that most ill-equipped laboratories in our schools be revamped. Critical areas of practical works that the students were found wanting were the six process skills; observation, classification, communication, measurement, keeping of records and drawing of appropriate conclusions. With the World becoming more scientific and technological, the necessary measures must be put in the earliest possible time so as not to put Ghana at a disadvantage in scientific and technological advancement.

2.9 Conceptual framework of the study

The conceptual framework of a study refers to the system of concepts, assumptions, expectations, beliefs, and theories that supports and informs a research. It is a key part of the research design (Robson, 2011). Also according to Ravitch & Riggan (2011) conceptual framework refer to the actual ideas and beliefs that researchers hold about the phenomena studied, whether they are written down or not.

In this study the conceptual framework of the study is premised on science process skills, students, teachers, practical activities, and classroom environment. Therefore, theories that has to do with the characteristics of these entities as they affect learning would be applicable. Since the learning of any subject matter depends on the way it is presented to the learner by the teacher the way the learner interacts with the learning experiences, and the environment within which the learning takes place are very essential. It is therefore expected that these entities will be affected by class size, teaching learning material adequacy, instructional methods employed by teachers, and supervisory role during practical lessons.

Maslow‟s motivational theory expresses that there are two groups of needs. These are deficiency need and growth need which make science teaching more comprehensible, reduce forgetfulness, lead to transfer of knowledge and therefore help students to acquire favourable attitude towards science (Gagné & Deci, 2005). Their study would therefore provide theoretical basis for the study. Also the learner‟s understanding of any topic being taught is strongly influenced by the relationship that exists between the teacher, teaching strategies employed by the teacher and the students (Mbajiorgu & Ali, 2003).

The diagram on the next page shows the conceptual framework of the study.

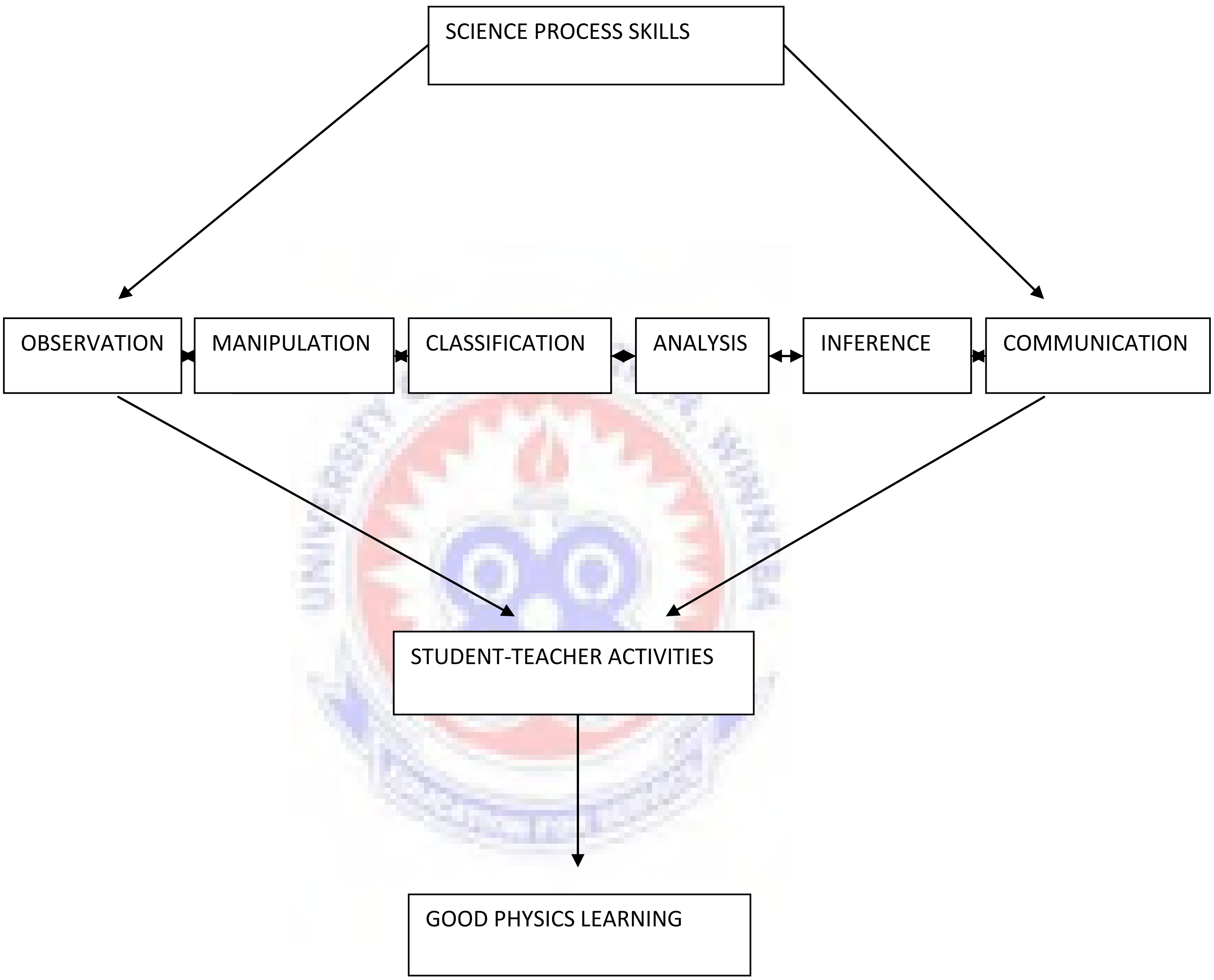

Figure : A diagram of the conceptual framework of the study

The figure above represents the data collection procedure of the study and begins with science process skills which can be described as the logical operations of thinking in investigations (Hamilton-Ekeke, 2007). The figure also shows that science learning follows a process approach. Thus, in scientific investigations, the key science process skills that a scientist follows are; observation, analysis, classification, description, interpretation of data, hypothesis, prediction, planning, experimentation, keeping of records, measurement, conclusion and communication (Hamilton-Ekeke, 2007).

Observation involves noting the attributes of objects and situations through the attributes of the senses. Analysis is a means of trying to think of the possible causes of the event happening. Classification goes one step further by grouping together objects or situations based on shared attributes. Describing what is happening and explaining or interpreting it leads to guessing (hypothesis) what you think is the possible cause of what is happening. Predicting involves forecasting or saying in advance what would happen before the event or what is happening comes to an end. Then there is the planning to perform actual experiments during which records and measurements are taken as the experiment proceeds. It expresses physical characteristics in quantitative ways. Based on the records and measurements taken, conclusions could be drawn from the outcomes of the experiment. The conclusion formed could then be communicated or made known to the people.

Also, Figure 1 shows student-teacher activities which involve the deliberate planning and organisation of teaching learning experiences and situations in the light of psychological and pedagogical principles by the teacher with the view of causing students to use the science process skills to facilitate physics learning. This goal could easily be achieved by the use of activity-based teaching approaches which is the process of assisting students to discover their own knowledge through an activity (Akerson, Abd-El-Khalick, & Lederman, 2000). This method is more of a child-centred approach, as such; students may learn better and faster when they are taught through activities (Hamilton-Ekeke, 2007). When a student performs an activity as an individual, the learner easily understands and never forgets (Hedegaard, 2005).

The activities could include teachers allowing students to interact with materials and experience things for themselves which could cause them to discovers concepts and facts either unaided or with minimum teacher interference, hence taking advantage of the learner"s natural tendency to explore the familiar environment.

This will help students learn to use their hands and minds to organise, observe and become more curious to manipulate and carefully handle equipment during physics practical lessons.

Finally, the figure expresses good physics learning which could result from the use of the science process skill with appropriate student-teacher activities. Learners using instructional materials are expected to acquire science process skills in addition to mastering the content of the subject matter. To know to what extend learners have acquired the science process skills then effective assessment of learner"s competence in practical activities is required. An effective assessment of the physics content knowledge of learners could also give an idea about extend to which learning of physics has taken place.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter discusses the methodology employed for the study and comprises of the design of the study which gives insight to the design type of the study and the rationale for the choice of the design. It has the sample population as well as sampling procedure used for the study, which gives an idea of the methods of sampling techniques employed in the study. The chapter also includes the research instruments that were used in collecting data. It continues with how the data were analysed.

3.1 Research Design

This comprises the steps used to collect data for the study. According to Johnson and Christensen (2008) research design is the plan or strategy the researcher used to investigate the research question (s). The design of a study gives a picture of events and assists in explaining people‟s opinion and behaviour on the basis of data gathered at a point in time (Polit & Hungler, 2003). This is an Action Research in which the researcher explored a single entity or phenomenon bound by time and collected detailed information by using a variety of data collection procedures during a sustained period of time (Creswell, 2005). Almost every phenomenon can be examined by means of the case study method. Action Research was chosen because it would improve teacher‟s classroom practices; enhance students‟ learning also promotes personal professional growth of the teacher (Johnson, 2005).

This research was based on a case study of Form Two physics students of Bolgatanga SHS. The case study has been chosen because it ensures detailed study of the subject matter under investigation. Science process skills were employed in every aspect of their practical and regular class lessons.

This study is an Action Research designed to use science process skills to facilitate the learning of physics. The research design made use of activity group instructional approaches as an intervention as well as observation.

The study was carried out in three phases. The first phase consisted of pre-intervention activity which included review of basic laboratory skills learnt in the previous term (s). The second phase was the implementation of intervention strategy. Under this, the Researcher developed lesson plans and used them to teach physics laboratory practical lessons and normal class lessons for a period of four weeks.

The last phase involved the implementation of post-intervention activities which enabled the Researcher to assess the effect of the intervention strategy on facilitating the performance of students‟ in physics. Below is a diagrammatic representation of the research design.

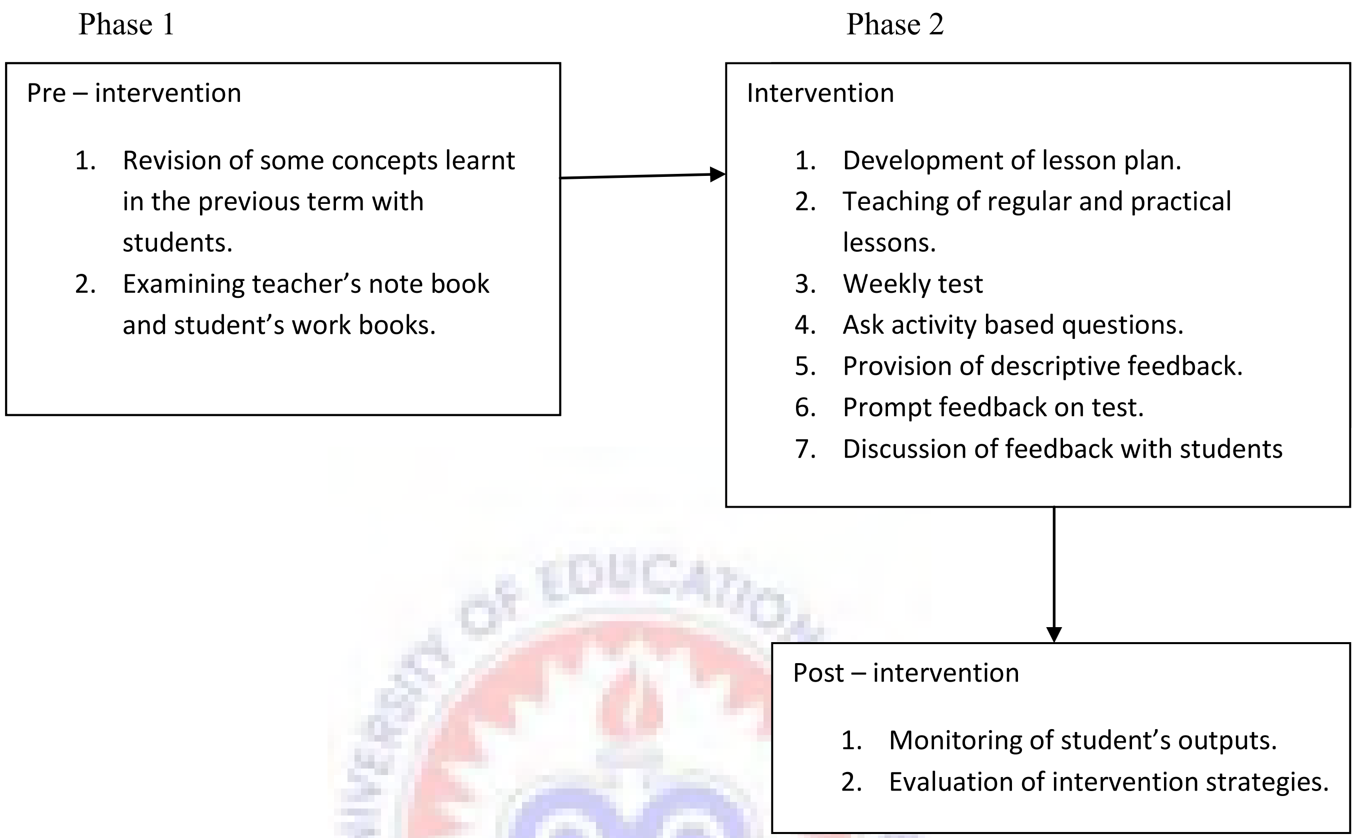

Figure : The design of the study

Fig.2. shows the systematic approach which the study used. The study began with a week‟s revision of some concepts learnt in the previous term. This was followed by analysis of student‟s workbooks in the classroom. Lesson plans were then developed and used in teaching students some physics concepts and practical activities. At the end of each week students were made to take a test. Students‟ outputs in class and practical lessons were monitored.

3.2 Pre-intervention Stage

This phase consisted of an activity which was done to ascertain the level of student"s" usage of science process skills in physics classes and practical lessons. This activity was the revision of some of the topics and concepts learnt in the previous term. The concepts included dimensional analysis, motion and forces. It also included the revision of some of the basic skills learnt in the previous terms under practical. These included manipulation and setting up of practical apparatus/equipment, measurement of physical quantities, presentation of results in tabular forms and graph works. The teaching-learning strategy adopted was mostly activity group discussion and demonstration after which students were allowed to demonstrate the skills developed through performance of hands-on practical activities. Pre-test exercises for both normal lessons and practical work were administered to students. Students" responses to the pre-test exercises were marked and analysed.

3.3 Intervention Stage

Intervention is a set of strategies planned and implemented to solve a specific problem or improve an educational practice located in an immediate situation (Cohen, Manion & Morrison, 2000). It involves a step-by-step procedure which is constantly monitored over varying periods of time and by a variety of mechanisms. It is a series of concrete measures, put in place to solve a specific problem (Muijs, 2004).

In this study, weekly lesson plans were developed focusing on the laboratory practical skills to be developed by the students. Lesson plans for classroom content knowledge teaching on Simple Harmonic Motion and light energy. Teaching strategies adopted included class demonstrations and activity group discussions. Students were given instructions to perform laboratory practical experiments on their own. The lesson plans incorporated the laboratory practical exercises to be performed for the weeks. Students" responses to these exercises were marked and scripts distributed to students before the next week"s lesson. Descriptive feedback was provided on each wrong response provided by students. This was done to enable students" identify specific strengths and areas needing improvement.

General discussions on the feedback on the practical activities were done after the lesson. Student"s weaknesses and misrepresentation of scientific process skills showing less knowledge were addressed.

3.4 Post-Intervention Stage

This phase of the study involved monitoring the effects of the intervention approaches on the students" learning and evaluation of the intervention approaches. This was done by monitoring students work output at the end of each week. Student"s outputs were monitored by the Researcher based on their responses to questions during the class and practical activities. Their responses were judged on whether they were related to the questions asked. The findings from these series of observations were used to modify the intervention approaches to achieve the desired learning outcomes. Responses from these activities were to serve as bases for evaluating the performance of student"s process skills and the intervention approaches implemented.

3.5 Research Population

According to Best and Kahn (2006) the term population refers to a group of individuals that have one or more characteristics in common and of an interest to the researcher. The population of interest is typically a certain characteristic or set of characteristics (Frankel & Wallen, 2006).

In this study the Researcher was interested in using laboratory and group activity teaching and learning techniques to enhance the acquisition of science process skills to facilitate the performance of physics students in Bolagatanga Senior High School. The target population was only physics students of Bolgatanga SHS in the Upper East Region of Ghana. Target population is a list of items or objects which is ideally under consideration. Among this target population, the Researcher was however interested in only Second Year A-Class physics students of the school, hence this constituted the accessible population for the study. Accessible population is a part of the target population which is accessible. The selected school is chosen because of its proximity to the Researcher who was teaching in that school. The population of physics students in the school is 680 and this constitutes the population for this study.

3.6 Sample

A sample is any group on which information is obtained for the study (Fraenkel and Wallen, 2006). According to Muijs (2004) a sample is a smaller group that researchers study. The purpose of sampling is to obtain a group of subjects that will provide specific information needed (Cohen, Manion& Morrison, 2007).

In this study, out of 268 Form Two physics students, only 55 students of Form two A-Class of Bolgatanga Senior High School was chosen to serve as the sample.

3.7 Sampling Procedure

Sampling is the process of selecting units (e.g., people or organisations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen (Trochim, 2006). According to Tuckman (2000) sampling is the act, process or technique of selecting population for the purpose of determining parameters or characteristics of the whole population. Also, according to Cohen et al (2000) there are two types of sampling procedures, probability and non probability sampling. Probability sampling procedures include simple random sampling, systematic sampling, stratified sampling and cluster sampling. Non probability sampling procedures include convenience sampling, purposive sampling and quota sampling.

In this study all the fifty five Second Year A-Class physics students was used as an intact group based on purposive sampling. According to Cohen, Manion and Morison (2007) purposive sampling is the selection of sample on the basis of the judgement of their typicality or possession of the particular characteristics being sought. Patton (2002) also added that purposive sampling is the type in which the Researcher handpicks the people to be included in the sample on the basis of the judgement of their typicality. The Form 2 Science A-Class was chosen based on the fact that they were not new in the school and also not under any pressure to write any external examination. Also they had been introduced to some basic scientific inquiry skills in year one and at least had some basic principles in physics. The sampled students were further divided into small groups. A simple random sampling technique was used to divide the students into groups; numbers were written on pieces of papers and placed in a box. The numbers were picked from the box one after the other by students. Students who picked the same numbers constituted a group. There were eleven groups with five members each. The sampled class is made of fifty males and five females of an average age of 18 years.

3.8 Instruments

Research Instruments are measurement tools (for example, questionnaires or scales) designed to obtain data on a topic of interest from research subjects. Also, a research instrument is a survey, questionnaire, test, scale, rating, or tool designed to measure the variable(s), characteristic(s), or information of interest, often a behavioural or psychological characteristic (Pierce, 2009, p. 159). There are two main data gathering techniques, these include; quantitative and qualitative data gathering techniques. Quantitative data gathering method is one which codes data to numerical values so a lot of data can be gathered efficiently. On the other hand, qualitative research takes longer to conduct, because the data the researchers gather is more open-ended, and may not relate directly to a numerical value.

This study used both qualitative and quantitative data gathering instruments in order to gather more information from the research subjects. These include; students" learning evaluation form, teaching and learning document record form and observation schedule. The students" learning evaluation form is a document designed by the researcher to collect information on the students" continuous assessment during the research period. Also, teaching and learning document record form is a document designed to take data on students" performance during the previous term while observation schedule involves noting or monitoring a lesson or group of research subjects or event in other to record a significant event.

3.9 Students' Learning Evaluation Form

This a document designed by the researcher to collect information on the students" continuous assessment during the research period. The purpose of this form was to collect information on students" output in the pre-test, the weekly intervention practical exercises and post-test. The data collected were used to ascertain the performance of students from the beginning of the study till the end of the post intervention exercise. This form consisted of the criteria on which students" responses to the given tasks in the pre-test; weekly practical exercises and post-test were to be examined. Students" responses were examined to find out whether they satisfy the requirement of the test items. Detail of this form is shown in Table 1 below:

Table : Students' Learning Evaluation Form

Process Skills	n	Correct	Incorrect

Note: Figures in brackets are percentages

From Table 1, any respondent who presented a blank sheet, repeated the same question on the sheet or gave unclear response were classified under „incorrect‟ which implies the required skills have not been understood by the respondent, whilst respondents whose responses contained all of the process skills required were classified under „correct‟ which means the required skills have been fully understood by the respondent.

3.10 Observation schedule

This is a primary technique of collecting data on non-verbal behaviour of participants and involves getting to the field to collect data based on their behaviour. In this study, participants observation which involves the researcher taking on an insider role in the group being studied and does not declare that he is a researcher (Le Compet & Preissle, 2003) cited in Cohen, Manion & Marrison (2007) was used. The Researcher used systematic observation kind to collect supplementary data on students‟ attitude and interest towards physics as well as their abilities to perform laboratory practical activities on their own. Systematic observation involves a situation were the researcher records only what he/she wants while unsystematic observation is a situation where the researcher records everything happening during the event or class.

3.11 Data Collection Procedure

Data collection is a technique for physically obtaining data to be analysed in a research study (Johnson & Christensen, 2008). Data collection involves the process in which data of the study is gathered. Data of this study were collected in three stages. The first stage was the collection of teaching and assessment information from the students‟ workbooks. The student‟s workbooks were examined to find out the frequency of tasks performed in the previous term, how many times they were taken through laboratory practical activities during the previous terms. Teaching and learning record form will be used to collect data from these activities.

The second stage involved collection of data on the pre-intervention class activities. Before the implementation of the intervention, concepts learnt by students in the previous term were revised and at the end of the revision period, students were given assignments, class exercises and practical work in groups. These pre-intervention exercises were marked and data collected with the use of students‟ learning evaluation form.

The final stage involved collection of data on student‟s outputs on regular class and practical activities. Students were taught in class for four weeks with practical activities in the laboratory alongside in groups. The teaching methods which included practical demonstrations with activity groups were geared at using science process skill to facilitate the understanding of the concepts been taught both in the classroom and the laboratory practical work. After the intervention stage, students were made to understand that the activities were designed to help them learn to improve their process skills in physics theory and practical examinations.

All assignments were marked and the data collected on students responses were used to answer some of the research questions. After the intervention activities post-test exercises were administered to students to enable the Researcher evaluate the effects of the intervention exercises on facilitating student‟s performance in physics. The data collected on students‟ responses were again recorded using students learning evaluation form.

3.12 Data Analysis

Data analysis is the process of converting raw data collected into usable information (Joseph, 2009). This study used both quantitative and qualitative methods of data analysis. Data from pre-intervention exercises were analysed qualitatively and quantitatively. Students‟ responses to questions, weekly intervention exercises and the post-test were analysed to determine whether they reflected correct acquisition of skills learnt. Responses with correct explanations or accurate performance showing the development of the needed skills were classified as "correct acquisition of skills".

Responses that were related to the questions but with incorrect demonstration of the needed skills were classified as "partial acquisition of skills" and those responses that did not relate to the question and did not demonstrate the needed skills were classified as "no acquisition of skills". These categories of evaluation scheme used to measure students‟ level of acquisition of skills were indicated in Table 1 expressed in percentages and tabulated. Data from the observation schedule, students‟ work books were analysed quantitatively.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

In this chapter, data gathered were presented, analysed and discussed. Data collected from students" workbooks; pre-test exercises, weekly intervention exercises, post-tests exercises and weekly class tests which were conducted along-side were analysed quantitatively and qualitatively. The analysis covered: when laboratory practical lesson started; how many times it is organised per week; students" ability to set up and manipulate apparatus, measure physical quantities correctly, draw table of values, plot graphs, find slopes and intercepts of graphs drawn. The responses were mainly presented in the form of frequencies and percentages. Descriptive analyses of results were done to provide the basis for the findings, conclusion and recommendations.

4.1 Pre-intervention Exercise

The participants were taken through pre-intervention exercises and a class test at the end of the pre-intervention week to enable the Researcher determined students" levels of science process skills which is necessary for laboratory practical works and to enable the Researcher acquire a fair knowledge of students" understanding of the physics concepts taught in the previous term. Students" responses to the demands of the items in the pre-test were analysed and presented as follows:

Item 1: You are presented with rectangular glass block, drawing paper, optical pins. Set up the apparatus for an experiment to determine the refractive index of the glass block using the diagram shown on the question paper as a guide. Use your set up to carry out experiment to determine the refractive index of the glass block using Figure 3 below as a guide.

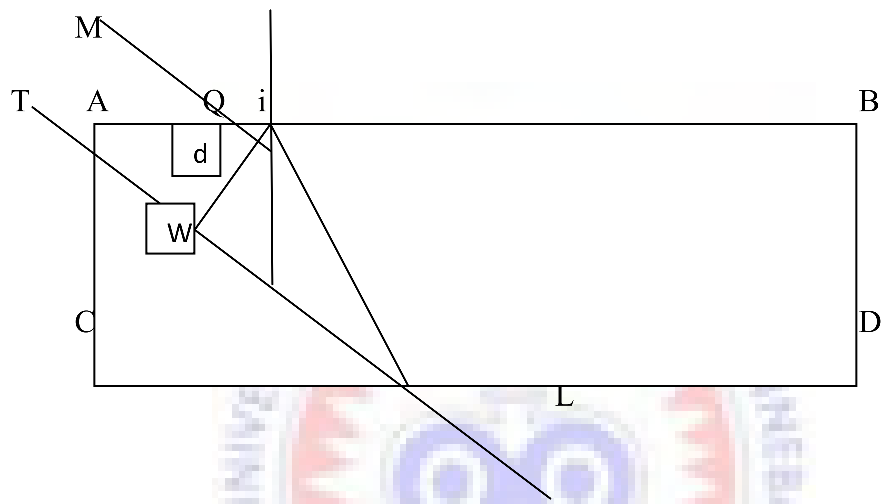

Figure : A diagram of the outline of a rectangular glass prism

Students' responses

The demands of this question included acquisition of six process skills: (1) tracing the outline of the glass block; (2) drawing of normal to a straight line TL and also another to meet the surface AB; (3); construction of given angles (s) of incidence; (4) erecting object and search pins; (5) drawing of refracted and emergent rays; (6) calculation of the refractive index of the glass block. Depending on the correctness of the answers to the questions, students‟ responses to pre-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 1 were analysed and presented in Table 2 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 1 correct or wrong in pre-intervention practical exercises

Process Skills	n	Correct	Incorrect
Tracing outline	55	1(1.8)	54 (98.2)
Constructing normal	55	0(0.0)	55 (100.0)
Constructing angles	55	0 (0.0)	55 (100.0)
Erecting pins	55	0 (0.0)	55 (100.0)
Drawing rays	55	0(0.0)	55 (100.0)
Calculations	55	0(0.0)	55(100.0)

Note: Figures in brackets are percentages

Data from Table 2 showed that most of the responses students provided did not reflect correct usage of science process skills needed for physics laboratory practical works. Only, 1(1.8%) student exhibited the „correct" usage of the process skills needed for tracing outline whilst no students (0.0%) exhibited the correct usage of process skills for constructing normal, constructing angles, erecting pins, drawing rays and calculations required for physics practical work.

On the other hand, majority of students‟ responses reflected incorrect usage of each process skill. As many as 54(98.2%) students exhibited „incorrect‟ usage of the observation skill needed whilst all the students (100%) exhibited „incorrect‟ usage of the process skills for constructing normal, constructing angles, erecting pins, drawing rays and calculations required for physics practical work.

Finding 1

Only 1 student (1.8%) exhibited correct usage of the process skill for tracing outline.

Item 2: Using the apparatus provided, measure and record the values of the angles of incidence and angles of refraction and also the length of the perpendicular line QW = d in each of the traces made. Each measured values should be recorded in their correct units of measurement.

Students' responses

The demands of this question included acquisition of five process skills: (1) measurement of angles of incidence; (2) measurement of angles of refraction; (3) measurement of the length of the line QW = d in each of the traces made; (4) recording measured values in appropriate units of measurement and (5) recording the measured values into a suitable table of values when necessary. Depending on the correctness of the answers to the questions, students‟ responses to pre-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 2 were analysed and presented in Table 3 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 2 correct or wrong in pre-intervention exercises

Process Skills	n	Correct	Incorrect
Measurement of incidence angles	55	5(9.1)	50(90.9)
Measurement of angles of refractions	55	5(9.1)	50(90.9)
Measurement of length	55	4(7.3)	51(92.7)
Appropriate units	55	4(7.3)	51(92.7)
Table of values	55	4(7.3)	51(92.7)

Note: Figures in brackets are percentages

Data from Table 3 showed that most of the responses students provided did not reflect correct usage of science process skills needed for physics laboratory practical works. Only, 5(9.1%) student exhibited the „correct" usage of the process skills for measurement of incidence and refracted angles whilst 4(7.3%) students exhibited the „correct" usage of process skills for measurement of length, appropriate units and table of values required for physics practical work.

Conversely, majority of students" responses reflected „incorrect" usage of each science process skill. As many as 50(90.9%) students exhibited „incorrect" usage of the process skills for measurement of incidence and refracted angles whilst as many as 51(92.7%)

students exhibited „incorrect" usage of process skills for measurement of length, appropriate units and table of values required for physics practical work.

Finding 2

Only 5 students (9.1%) exhibited correct usage of the process skills for measurement of angles of incidence and refraction. While, 4 students (7.3%) exhibited the correct usage of process skills for measurement of length, appropriate units and table of values.

Item 3: Using the values obtained in (2) above plot a graph with angle of incidence (i) as ordinate and deviation (d) as abscissa. Record the slope of your graph. Find also the intercept (s) of the graph drawn.

Students' responses

The demands of this question included acquisition of six process skills: (1) clearly showing title and starting point of the graph; (2) proper labelling of axes with appropriate units; (3) choosing of suitable scales for both axes; (4) plotting of measured points correctly on the graph; (5) drawing the line of best fit through at least three of the plotted points; (6) finding slope and intercepts of the graph drawn. Depending on the correctness of the answers to the questions, students" responses to pre-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 3 were analysed and presented in Table 4 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 3 correct or wrong in pre-intervention exercises

Process Skills	n	Correct	Incorrect
Title	55	10(18.2)	45 (81.8)
Axes labeling	55	10(18.2)	45 (81.8)
Scales	55	10 (18.2)	45 (81.1)
Plotting of points	55	8 (14.6)	47 (85.4)
Line of best fit	55	8(14.6)	47 (85.4)
Slope and intercepts	55	8(14.6)	47 (85.4)

Note: Figures in brackets are percentages

Data from Table 4 showed that most of the responses students provided did not reflect correct usage of science process skills needed for physics laboratory practical works. Only, 10(18.2%) student exhibited the „correct" usage of process skills for labelling title, axes and scales whilst 8(14.6%) students exhibited the „correct" usage of the process skills for plotting points, drawing line of best fit and finding slope and intercepts of the graph required for physics practical work.

Conversely, majority of students" responses reflected „incorrect" usage of each science process skill. As many 40(81.8%) students exhibited „incorrect" usage of process skills for labelling title, axes and scales whilst as many as 42(85.4%) students exhibited „incorrect" usage of the process skills for plotting points, drawing line of best fit and finding slope and intercepts of the graph required for physics practical work.

Finding 3

Few students 10(18%) exhibited correct usage of process skills for labelling title, axes and scales. While, 8 students (15%) exhibited the correct usage of the process skills for plotting points, drawing line of best fit and finding slope and intercepts.

Item 4: Classify the following forces into contact forces and force fields: frictional force, drag force, upthrust, intermolecular forces, centripetal force, gravitational force and electrostatic force.

Students' responses

The demands of this question included acquisition of one process skill: (1) classifying the forces into contact forces and force fields appropriately.. Depending on the correctness of the answers to the questions, students" responses to the pre-test question were classified as "correct" and "incorrect" for the process skill. This item served as the pre-intervention class test. The marking scheme of this question was developed and used to mark students" responses and can be found in appendix A.

The responses given by the students to Item 4 indicated that 12 students representing 22% were able to classify the forces correctly.

Finding 4

Only 22% of students exhibited correct usage of the process skill for classification of forces.

4.2 Intervention Results

To help students utilise the science process skills needed for physics class and laboratory practical work, students were instructed for four weeks with class and practical exercises using the group activity approach. At the end of each week students were made to answer few questions based on the skills developed within the week and the previous weeks. The test results were given to students before the next week‟s lessons started. This enabled students to have enough time to do remediation on the areas they could not do well.

Descriptive feedback in the form of written comments was provided against each incorrect response presented. This helped students to know of their mistakes and how to correct them in subsequent exercises. Feedback on each exercise was discussed with students so that they could identify what went wrong and what were expected as responses to the questions asked. This strategy helped students to develop the needed skills for laboratory practical works and hence overcome the difficulty they hither to face during physics class work and in performing physics laboratory practical experiments. Data collected on students‟ output in the weekly laboratory practical exercises and class test were analysed and presented as follows:

Week one – lesson 1

The first lesson was centred on tracing rays through a glass prism. The following process skills were required: tracing the outline of the glass block, drawing of normal, construction of given angles (s) of incidence, erecting object and search pins, drawing of refracted and emergence rays, measurement of angles of refractions, construction of perpendicular line from point of incidence and calculating refractive index of the glass block.

Secondly, the lesson focussed on a pendulum experiment. The following process skills were required: attaching thread to bob, measurement of the length of the thread, attaching the thread to the retort stand using split corks and sketching a labelled diagram of set up.

Materials used in lesson one

Glass prism, four optical pins, pencil, protractor, metre rule, plane sheet, drawing board, compass, four tomb nails, stop watch, retort stand, string, metre rule, G-clamp, split cork, boss.

Using group activity approach of instruction, students were instructed on content knowledge in class under the topic „simple harmonic motion" whilst in the laboratory they were given instructions to identify some basic apparatus provided after which they were put into their respective groups of five. These apparatus served as the appropriate Teaching and Learning Materials (TLMs) for both class and practical lessons organised. Students were then instructed to set up apparatus for a series of physics laboratory practical experiments. Students were given instructions to set up apparatus for series of experiments including: - acceleration due to gravity using simple pendulum; refractive index of glass and verification of principle of moments. These activities allowed students to observe, measure, record and manipulate apparatus and by so doing their process skills were developed.

Also, students participated in class room activity group discussions which enabled their ability to state, explain and perform calculations to further be developed. Students actively participated in the lesson and were able to set up series of apparatus for different experiments with little or no assistance from the Researcher. At the end of the week students were given simple laboratory practical exercise similar to that of the pre-test to perform. The Researcher went round and observed as students performed activities. After the period students" responses were collected and marked. Descriptive feedbacks were provided and then discussed with students. The analyses of students" responses were presented as follows;

Item 1: You are provided with regular glass block, drawing board, drawing paper, optical and thumb pins. Set up the apparatus for an experiment to determine the refractive index of the glass block using Figure 4 below as a guide.

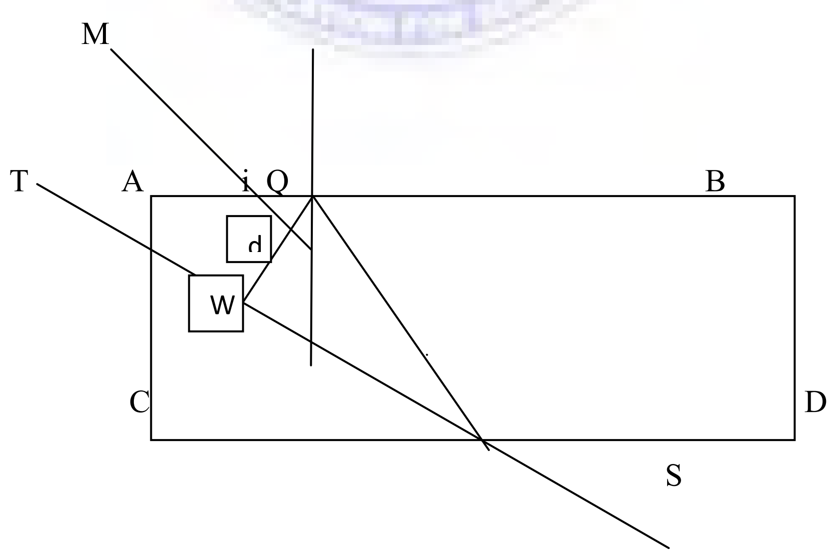

Figure : A diagram of the outline of a rectangular glass prism

Use your set up to carry out experiment to determine the refractive index of the glass block.

Students' responses

The demands of this question included acquisition of seven process skills: (1) tracing the outline of the glass block; (2) drawing of normal; (3) construction of given angles (s) of incidence; (4) erecting object and search pins; (5) drawing of refracted and emergence rays, (6) construction of perpendicular line from point of incidence to meet line TL and (7) calculating the refractive index of the glass block using the data obtained. Depending on the correctness of the answers to the questions, students" responses to intervention-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 1 were analysed and presented in Table 5 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 1 correct or wrong in intervention week one.

Process Skills	n	Correct	Incorrect
Tracing outline	55	43(78.2)	12 (21.8)
Constructing normal	55	41(74.6)	14 (25.4)
Constructing angles	55	41 (74.6)	14 (25.4)
Erecting pins	55	41 (74.6)	14 (25.4)
Drawing rays	55	40 (72.7)	15 (27.3)
Drawing perpendicular	55	40 (72.7)	15(27.3)
Calculations	55	40(72.7)	15 (27.3)

Note: Figures in brackets are percentages

Data from Table 5 showed that most of the responses students provided reflected correct usage of science process skill needed for physics laboratory practical works. As many 43(78.2%) students exhibited „correct‟ usage of the process skill for tracing outline whilst 41(74.6%) students exhibited „correct‟ usage of the process skills for constructing normal, constructing angles and erecting pins. Additionally, 40(72.7) students exhibited the „correct‟ usage of the process skills for drawing rays, drawing perpendicular and calculations required for physics laboratory work.

On the other hand, a few students‟ responses reflected incorrect usage of each science process skill. Only, 12(21.8%) student exhibited the „incorrect‟ usage of the process skill for tracing outline whilst 14(25.4%) students exhibited the incorrect usage of the process skills for constructing normal, constructing angles and erecting optical pins. Also, only 15(27.3%) students‟ exhibited the process skills for drawing rays, drawing perpendicular and calculations required for physics laboratory work.

Finding 5

Most students (72.7%) exhibited correct usage of process skills for drawing rays, drawing perpendicular and calculations while majority of students representing (78.2%) were able to correctly trace the required outline. Additionally, most students representing (74.6%) exhibited the process skills for constructing normal, constructing angles and erecting pins. Ray tracing equipment such as glass block, optical pins, protractor and compass enabled most students to acquire the skill of ray tracing through a glass block.

Item 2: You are provided with retort stand, clamp with boss, thread and pendulum bob, metre rule and split cork. Manipulate these apparatus to obtain experimental set up for an experiment to determine acceleration due to gravity using simple pendulum. Sketch a labelled diagram of the set up.

Students' responses

The demands of this question included acquisition of seven process skills: (1) attaching the thread to the bob; (2) measurement of the length of the thread; (3) attaching the thread to the retort stand using split cork and (4) sketching a labelled diagram of the set up. Depending on the correctness of the answers to the questions, students‟ responses to the intervention-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 2 were analysed and presented in Table 6 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 2 correct or wrong in intervention week one.

Process Skills	N	Correct	Incorrect
Attachment of thread to bob	55	50(90.9)	5(9.1)
Measurement of length	55	48(87.3)	7(12.7)
Attachment of thread to retort stand	55	48(87.3)	7(12.7)
Sketching diagram	55	48(87.3)	7(12.7)

Note: Figures in brackets are percentages

Data from Table 6 showed that most of the responses students provided reflected correct usage of science process skills needed for physics laboratory practical works. As many 50(90.9%) students exhibited „correct" usage of the process skill for attachment of thread to bob needed whilst 48(87.3%) students exhibited „correct" usage of the process skills for measurement of length, attachment of thread to retort stand and sketching diagram required for physics laboratory work.

On the other hand, a few students" responses reflected incorrect usage of each science process skill. Only, 5(9.1%) students exhibited the „incorrect" usage of the process skill for attachment of thread to bob needed whilst 7(12.7%) students exhibited incorrect usage of the process skills for measurement of length, attachment of thread to retort stand and sketching diagram required for physics laboratory work.

Finding 6

Most students (87.3%) exhibited correct usage of process skills for measurement of length, attachment of thread to retort stand and sketching diagram whilst majority of students representing (90.9%) were able to attach the thread correctly to the bob.

Item 3: 1. (i) Explain simple harmonic motion.

(ii) State two factors on which the period of oscillation of a simple pendulum depend.

(iii) Calculate the length of a simple pendulum corresponding to a periodic time 1.60s. [Take g = 10ms^2]

Students' responses

The demands of this question included acquisition of seven process skills: (1) explaining correctly simple harmonic motion; (2) stating the factors on which the period of a simple pendulum depend; and (3) correctly calculating the length of the simple pendulum for which the periodic time is 1.60. Depending on the correctness of the answers to the questions, students‟ responses to the intervention-class test questions were classified as “correct” and “incorrect” for each process skill. The marking scheme of this question was developed and used to mark students‟ responses and can be found in Appendix A.

The responses given by the students to Item 3 were analysed and presented in Table 7 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 3 correct or wrong in intervention class test 1 of week one.

Process Skills	N	Correct	Incorrect
Explaining S.H.M	55	40(72.7)	15(27.3)
Stating factors	55	38(69.1)	17(30.9)
Calculations	55	38(69.1)	17(30.9)

Note: Figures in brackets are percentages

Data from Table 7 showed that most of the responses students provided reflected correct usage of science process skills needed for physics class works. As many as 40(72.7%) students exhibited „correct‟ usage of the process skill for explaining S. H. M needed whilst 38(69.1%) students exhibited „correct‟ usage of the process skills for stating factors and calculations required for physics class work.

On the other hand, a few students‟ responses reflected incorrect usage of each science process skill. Only, 15(27.3%) students exhibited „incorrect‟ usage of the process skill for explaining S. H. M needed whilst 17(30.9%) students exhibited incorrect usage of process skills for stating factors and calculations required for physics class work.

Finding 7

Most students (72.7%) were able to explain S. H. M while majority of students representing (69.1%) correctly stated the factors affecting the period of a simple pendulum and were able to calculate the period.

Week Two – Second lesson

The lesson was centred on a pendulum experiment. The following process skills were required; attaching string rigidly to the retort stand, taking time for 20 oscillations, measuring the length of the string and creating table of values with average time and period T.

Secondly, the lesson focussed on techniques of reading scales on venire callipers, micrometre screw gauges, beam balance, thermometers, voltmeters and ammeters.

Materials/equipment Used in second lesson

Stop watch, retort stand, string, metre rule, G-clamp, split cork, boss.

Using group activity approach of instruction, the lesson started with revision of students‟ relevant previous knowledge. Students were instructed on the main topic „light energy‟ and under the sub-topic „transparent, translucent and opaque objects‟ to enhance students‟ ability to state, explain and perform calculations in physics concepts learnt. Also, in the physics laboratory, students were given instructions to take measurement of some physical quantities using the basic measuring equipment provided. These equipments served as the appropriate Teacher and Learning Materials (TLMs) needed for the practical work.

The responses provided showed that students had acquired the skills for measurement and recording. Students were then taken through series of activity to revise their knowledge on manipulation and setting up of apparatus for finding the acceleration due to gravity using a simple pendulum which was studied the previous week to increase their manipulative skill. The topic for discussion was then introduced. In their activity groups, students were taken through series of very short exercises designed to provide familiarity with the most common measuring devices used in the laboratory. These exercises engaged students in taking measurement of quantities such as length, mass, time, temperature, voltage and current using appropriate measuring instruments. Students were guided to look for situations in which the precision of measured values can be improved. Students suggested multiple measuring of the quantity and averaging as a suitable means for improving accuracy of measured values.

Techniques of reading scales on micrometre screw gauges were then discussed and students allowed ample time to practice their usage. Initially most students could not read the scales on these devices correctly but with consistent and regular practice majority of them were able to read values on the scales of these instruments correctly.

After this, students were taken through process of recording measured values into suitable table of results to increase their process skills. Sample practical questions were used to guide students deduce the column headings for the table of values. Students were then given series of practical questions and asked to construct suitable table of values for each question. Students were able to perform each of the given activities correctly.

At the end of the lesson, students answered few practical exercises and their responses were analysed and presented as follows:

Item 1: You are provided with a bob attached to a string. Rigidly clamp the string so that the length of the bob L = 90cm. Displace the bob to one side and determine and record the time t_1 for 20 oscillations. Repeat the experiment for length L = 80cm, 70cm, 60cm and 50cm each time measuring the corresponding t_1 for 20 oscillations. Now increase L starting from L = 50cm up to L = 90cm, each time recording the corresponding time, t_2 for 20 oscillations. Find the average time, t and hence evaluate the period T = t/20. Tabulate your results.

Students' responses

The demands of this question included acquisition of seven process skills: (1) attaching the string rigidly to the retort stand; (2) taking the time for 20 oscillations with the required lengths and (3) creating a table of values with average time and period T. Depending on the correctness of the answers to the questions, students" responses to the intervention-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 1 were analysed and presented in Table 8 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 1 correct or wrong in intervention week two.

Process Skills	n	Correct	Incorrect
Attachment of thread to retort stand	55	52(94.6)	3(5.4)
Time for 20 oscillations	55	50(90.9)	5(9.1)
Table of values	55	45(81.8)	10(18.2)

Note: Figures in brackets are percentages

Data from Table 8 showed that most of the responses students provided reflected correct usage of science process skills needed for physics laboratory practical works. As many as 52(94.6%) students exhibited „correct" usage of the process skill for attachment of thread to retort stand needed whilst 50(90.9%) students exhibited „correct" usage of process skill for time taken for 20 oscillations required. Also, 45(81.8%) students exhibited the „correct" usage of process skill for constructing table of values required for physics laboratory work. On the other hand, a few students" responses reflected incorrect usage of each science process skill. Only, 3(5.4%) students exhibited the „incorrect" usage of the process skill for attachment of thread to retort stand needed whilst 5(9.1%) students exhibited incorrect usage of process skills for time taken for 20 oscillations needed. Also, 10(18.2%) students exhibited the incorrect usage of the process skill for constructing table of values required for physics practical work.

Finding 8

Most students (94.6%) were able to attach thread correctly to the retort stand whilst majority of them (90.9%) were able to record time accurately for 20 oscillations. Also, most students representing (81.8%) constructed good tables for recording measurements taken. Measuring equipment such as stop watch and metre rule enabled the students to acquire the skills of the pendulum experiment.

Item 2: (a) State the uses of micrometer screw gauge.

(2b) Explain briefly how the reading is done on a micrometer screw gauge.

Student's responses

The demands of this question included acquisition of two process skills: (1) stating the uses of the micrometer screw gauge and (2) explaining how to read a micrometer screw gauge. Depending on the correctness of the answers to the questions, students" responses to the intervention-test question were classified as "correct" and "incorrect" for the process skill.

The responses given by the students to Item 2 indicated that 52 students representing 94.6% were able to use correctly the micrometer screw gauge and recorded the readings correctly.

Finding 9

Most students (94.6%) were able to use correctly the micrometer screw gauge and recorded the readings correctly.

Item 3: 1. (i) State the principle of reversibility of light.

(ii) Classify the following examples into transparent, translucent and opaque objects: block, tree, cloth, air, piece of paper, frosted louver, milk in glass, clean water, mirror and human being.

(iii) A man 1.5m tall stands at a distance of 6.0m from the pinhole of a pinhole camera. The distance of the screen from the pinhole is 0.3m. Find the length of the image of the man formed.

Students' responses

The demands of this question included acquisition of four process skills: (1) stating the principle of reversibility of light; (2) classifying the examples appropriately into transparent, translucent and opaque objects; and (3) calculating the length of the image of the man correctly. Depending on the correctness of the answers to the questions, students‟ responses to the intervention-test questions were classified as "correct" and "incorrect" for each process skill. This item served as the intervention class test two. The marking scheme of this question was developed and used to mark students‟ responses and can be found on Appendix A.

The responses given by the students to Item 3 were analysed and presented in Table 9 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 3 correct or wrong in intervention class test 2 of week two.

Process Skills	N	Correct	Incorrect
Stating principle	55	50(90.9)	5(9.1)
Classifying examples	55	46(83.6)	9(16.4)
Calculations	55	45(81.8)	10(18.2)

Note: Figures in brackets are percentages

Data from Table 9 showed that most of the responses students provided reflected correct usage of science process skills needed for physics class works. As many as 50(90.9%) students exhibited „correct‟ usage of the process skills for stating principle needed whilst 46(83.6%) students exhibited „correct‟ usage of the process skill for classification of examples required. Also, 45(81.8%) students exhibited the „correct‟ usage of the process skill for calculations required for physics class work.

On the other hand, a few students" responses reflected incorrect usage of each science process skill. Only, 5(9.1%) students exhibited the „incorrect" usage of the process skills for stating principle needed whilst 9(16.4%) students exhibited incorrect usage of the process skill for classification of examples required. Also, 10(18.2%) students exhibited the incorrect usage of the process skill for calculations required for physics class work.

Finding 10

Most students (90.9%) were able to state science principles and also about (84%) of the students were able to classify the objects given while (81.8%) of them were able to calculate correctly the problem given.

Week three

The lesson was centred on the following science process skills; analysis, interpretation, communication, evaluation and presentation and group activity approach was used in instruction. Students were instructed in class on the main topic „light energy" and under the sub-topic „reflection of light" which was intended to enhance students" usage of the communication and evaluative skills. The topic for the laboratory practical lesson was on „interpretation of graph work" which was geared towards enhancing students" usage of the analysis, interpretation and presentation skills. To introduce the lesson the Researcher asked students to construct a Table of values for a given practical exercise on simple pendulum. Students were able to construct the required table of values with appropriate column headings. The Researcher discussed with the students how to display the data from the table of results on graphs. The Researcher used activity group discussion strategy to introduce students to techniques of choosing and labelling axes of graphs; how to choose suitable scales for axes; plotting of points on graph and drawing line of best fit through plotted points.

Students were then given instructions to use the data provided to plot and interpret graphs after they had been given the appropriate Teaching and Learning Materials (TLMs) with the right activity methods chosen and their responses exhibited correct usage of analysis, presentation and interpretation skills for plotting graph.

To find the gradient and intercepts of graphs, the Researcher again gave instructions to students to draw triangles which were at least half of the length of the line drawn on their graphs and from these triangles values of change in y and change in x were read. The Researcher went round to observe, making sure students do not use the plotted points to draw the triangle, instead of two points on the line of best fit and also change in y over change in x values are calculated correctly.

Students were taken through the process of finding the intercepts of their graphs with the right activity methods which included dividing students into activity groups and given them instructions and tasks to perform. Sample graphs were used to explain to students how to read the intercept directly from a straight line graph. The substitution of co-ordinates of a point (x, y) on graph, into the equation y = mx + c in order to find the value of „c‟ which is the y-intercept as well as the unit of the gradient and intercept were also discussed in students activity groups.

Students‟ participation in the lesson and their responses to questions during the lesson showed that they have understood the concept of the graph works being taught.

At the end of the lesson students were made to answer few laboratory practical exercises to demonstrate their level of acquisition of interpretation skills for graph works. Samples of responses students provided to exercises were analysed and presented as follows:

Item 1: The Table below shows the data obtained in an experiment to determine acceleration due to gravity using simple pendulum.

i. Use the values from the Table to plot a graph with T^2 as ordinate and h as abscissa.

ii. Determine the slope, s and hence find the value of g

Table for item 1 can be found on Appendix B

Students' Responses

The demands of this question included: drawing and labelling the axes correctly; plotting the points correctly; drawing a straight line passing through at least three of the plotted points; determining the slope and finding the acceleration due to gravity g. This activity was meant to determine students‟ usability of the following science process skills; (1) presentation, (2) analysis and (3) evaluation. Depending on the correctness of the answers to the questions, students‟ responses to the intervention-test questions were classified as "correct" and "incorrect" for each process skill.

To determine „correct‟ usage of presentation skills, students should be able to draw and label the axes correctly, plot the points correctly, draw a straight line passing through at least three of the plotted points. Also, for „correct‟ usage of analysis skill, students should be able to determine the slope of the graph. Finally, for „correct‟ usage of evaluation skills, students should be able to find the acceleration due to gravity g.

Responses were classified as „incorrect" if respondents were not able to perform the given task in each skill. The responses given by the students to Item 1 were analysed and presented in Table 10 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 1 correct or wrong in intervention week three.

Process Skills	N	Correct	Incorrect
Presentation	55	51(92.7)	4(7.3)
Analysis	55	50(90.9)	5(9.1)
Evaluation	55	50(90.9)	5(9.1)

Note: Figures in brackets are percentages

Data from Table 10 showed that most of the responses students provided reflected correct usage of science process skills needed for physics laboratory practical works. As many 51(92.7%) students exhibited „correct" usage of the presentation skill needed whilst 50(90.9%) students exhibited „correct" usage of both the analysis and evaluation skills required for physics laboratory work.

On the other hand, a few students" responses reflected incorrect usage of each science process skill. Only, 4(7.3%) students exhibited the „incorrect" usage of the presentation skill needed whilst 5(9.1%) students exhibited incorrect usage of science process skills for both analysis and evaluation.

Finding 11

Most students (90.9%) were able to use correctly both analysis and evaluation skills

while majority of students representing (92.7%) exhibited correct usage of the presentation skill required.

Item 2: Below is a Table of results constructed during an experiment conducted using a plane mirror. Using the data from the Table:

Instructions and Table of results can be found on Appendix B

Student's Responses

The demands of this question included: drawing and labelling the axes correctly; plotting the points correctly; drawing a straight line passing through at least three of the plotted points; determining the slope, analysing the slope and finding the intercepts on both axes. This activity was meant to determine students" usability of the following science process skills; presentation, analysis and interpretation. Depending on the correctness of the answers to the questions, students" responses to the intervention-test questions were classified as "correct" and "incorrect" for each process skill.

To determine „correct" usage of presentation skills, students should be able to draw and label the axes correctly, plot the points correctly, draw a straight line passing through at least three of the plotted points. Also, for „correct" usage of the analysis skill, students should be able to determine the slope of the graph. Finally, for „correct" usage of the interpretation skills, students should be able to determine the implication of the slope and be able to find the intercepts on both axes.

Responses were classified as „incorrect" if respondents were not able to perform the given task in each skill. The responses given by the students to Item 2 were analysed and presented in Table 11 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 2 correct or wrong in intervention week three.

Process Skills	N	Correct	Incorrect
Presentation	55	53(96.4)	2(3.6)
Analysis	55	51(92.7)	4(7.3)
Interpretation	55	50(90.9)	5(9.1)

Note: Figures in brackets are percentages

Data from Table 11 showed that most of the responses students provided reflected correct usage of science process skills needed for physics practical works. As many as 53(96.4%) students exhibited „correct" usage of the presentation skill needed whilst 51(92.7%) students exhibited „correct" usage of the analysis skill required. Also, 50(90.9%) students exhibited the „correct" usage of the interpretation skill for physics practical work.

On the other hand, a few students" responses reflected incorrect usage of each science process skill. Only, 2(3.6%) students exhibited the „incorrect" usage of the presentation skill needed whilst 4(7.3%) students exhibited incorrect usage of science process skills for analysis. Also, 5(9.1%) students exhibited the incorrect usage of the interpretation skill for physics practical work.

Finding 12

Most students (96.4%) were able to use the presentation skill correctly while majority of students representing (92.7%) exhibited correct usage of the analysis skill required. Also, most students (90.9%) were able to use the interpretation skills correctly.

Item 3: 1. (i) Define the following terms: diffuse reflection, mirror, normal, point of incidence and an image.

(ii) State the laws of reflection

(i) An object of height 5mm is placed at a distance 3mm in front of a pinhole camera from the pinhole. It forms an inverted image of height 5cm. Calculate a) the magnification b) the image distance.

Students' responses

The demands of this question included: defining all the terms required correctly; stating the laws of reflection; and calculating correctly the magnification and the image distance of the given object. This activity was meant to determine students‟ usability of the following science process skills; (1) communication and (2) evaluation. Depending on the correctness of the answers to the questions, students‟ responses to the intervention-class test questions were classified as "correct" and "incorrect" for each process skill. The marking scheme of this question was developed and used to mark students‟ responses and can be found in Appendix A.

For „correct‟ usage of communication skill, students should be able to define all the terms required correctly; they should also be able to state the laws of reflection. Also, for „correct‟ usage of evaluation skill, students should be able to calculate correctly the magnification and the image distance of the given object.

Responses were classified as „incorrect" if respondents were not able to perform the given task in each skill.

The responses given by the students to Item 3 indicated that 51 students representing 92.7% were able to use correctly the communication skill and 50 students representing (90.9%) were able to use the evaluation skill correctly. .

Finding 13

Most students (92.7%) were able to use correctly the communication skill while majority of students representing (90.9%) exhibited correct usage of the evaluation skill.

4.3 Post- Intervention Exercise

To evaluate the effect of the intervention strategy implemented on the development of science process skills of students, post-intervention exercise were administered two weeks after the intervention period. Data collected on students output in the post-test were analysed and presented in Table 15.

Item 1: Suspend the simple pendulum from the support provided such that the length L of the pendulum, measured from the point of support to the centre of the bob is 90cm. Set the pendulum swinging gently and determine the time of 20 oscillations of the pendulum. Calculate the periodic time T for one oscillation of the pendulum and hence determine T^2. Repeat this experiment for the values of L = 80cm, 70cm, 60cm, and 50cm. In each case determine T and T^2.

i. Plot a graph with L on the vertical axis and T^2 on the horizontal axis.
ii. Calculate the slope of the graph drawn.

iii. State two precautions taken to obtain accurate result.

Students' Responses

The demands of this question included acquisition of eight process skills: (1) manipulation and setting up of the apparatus, (2) measurement of length; (3) recording of table of values; (4) drawing and labelling the axes correctly; (5) plotting the points correctly; (6) drawing a straight line passing through at least three of the plotted points; (7) determining the slope and predicting the implication of the slope; (8) finding the intercepts on both axes and (9) stating the precautions taken during the experiment. Depending on the correctness of the answers to the questions, students" responses to the post-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 1 were analysed and presented in Table 12 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 1 correct or wrong in post-intervention practical test.

Process Skills	N	Correct	Incorrect
Manipulation and setting up	55	55(100.0)	0(0.0)
Measurement of length	55	54(98.2)	1(1.8)
Table of values	55	51(92.7)	4(7.3)
Drawing and labelling axes	55	51(92.7)	4(7.3)
Plotting points	55	51(92.7)	4(7.3)
Drawing line of best fit	55	50(90.9)	5(9.1)
Determining slope	55	50(90.9)	5(9.1)
Finding intercepts	55	50(90.9)	5(9.1)

Stating precautions	55	50(90.9)	5(9.1)

Note: Figures in brackets in the table of the previous page are percentages

Data from Table 12 showed that most of the responses students provided reflected correct usage of science process skills needed for physics laboratory practical works. All the students (100%) exhibited „correct" usage of the process skills for manipulation and setting up of apparatus needed. As many as 54(98.2%) students exhibited „correct" usage of the process skills for measurement of length of thread needed whilst 51(92.7%) students exhibited „correct" usage of the process skills for recording of table of values, drawing and labelling axes and plotting of points required. Also, 50(90.9%) students exhibited „correct" usage of the process skills for drawing of line of best fit, determining slope, finding intercepts of the graph and stating precautions required for physics laboratory work.

On the other hand, a few students" responses reflected incorrect usage of each science process skill. No student (0.0%) exhibited „incorrect" usage of the process skills for manipulation and setting up of apparatus needed. Only, 1(1.8%) student exhibited the „incorrect" usage of the process skills for measurement of length of thread needed whilst 4(7.3%) students exhibited the „incorrect" usage of the process skills for recording of table of values, drawing and labelling axes and plotting of points required. Also, only 5(9.1%) students exhibited the „incorrect" usage of the process skills for drawing of line of best fit, determining slope, finding intercepts of the graph and stating precautions required for physics practical work.

Finding 14

All the students (100.0%) were able to use correctly manipulate and set up the apparatus. Majority of students representing (98.2%) correctly measured the length of thread. Also, most students representing (92.7%) were able to construct good tables for recording measurements taken, drew and labelled the axes correctly and plotted the given points. Also, majority of students representing (90.9%) exhibited „correct" usage of the process skills for drawing of line of best fit, determining slope, finding intercepts of the graph and stating precautions.

Item 2: Using Figure 5 below as a guide carry out the following instructions:

Instructions can be found on Appendix B

Diagram of set up

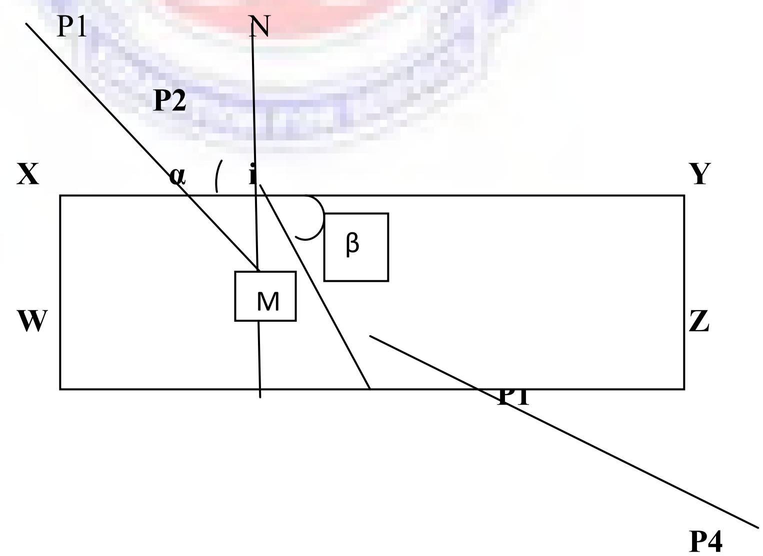

Figure : A diagram of the outline of a rectangular glass prism

Students' Responses

The demands of this question included acquisition of thirteen process skills: (1) tracing the outline of the glass block; (2) drawing the normal; (3) drawing the incident angles; (4) placing the glass block back and using the search pins be able to determine the refracted and emergent rays; (5) measuring the glancing angles α and β; (6) presenting table of values; (7) drawing and labelling the axes correctly; (8) plotting the points correctly; (9) drawing a straight line passing through at least three of the plotted points; (10) determining the slope; (11) determining the implication of the slope; (12) finding the intercepts on both axes and (13) stating the precautions taken during the experiment. Depending on the correctness of the answers to the questions, students" responses to post-test questions were classified as "correct" and "incorrect" for each process skill.

The responses given by the students to Item 2 were analysed and presented in Table 13 as numbers and percentages of students at each skill.

Table : Number of students' acquiring Item 2 correct or wrong in post-intervention practical test.

Process Skills	N	Correct	Incorrect
Tracing outline	55	55(100.0)	0(0.0)
Drawing of normal	55	55(100.0)	0(0.0)
Drawing incident angles	55	54(98.2)	1(1.8)
Erecting search pins	55	54(98.2)	1(1.8)
Measurement of glancing angles	55	54(98.2)	1(1.8)
Table of values	55	54(98.2)	1(1.8)
Drawing and labelling axes	55	54(98.2)	1(1.8)
Plotting points	55	53(96.4)	2(3.6)
Drawing line of best fit	55	53(96.4)	2(3.6)
Determining slope	55	53(96.4)	2(3.6)
Implication of slope	55	53(96.4)	2(3.6)
Finding intercepts	55	53(96.4)	2(3.6)
Stating precautions	55	53(96.4)	2(3.6)

Note: Figures in brackets are percentages

Data from Table 13 showed that most of the responses students provided reflected correct usage of science process skills needed for physics laboratory practical works. All the students (100%) exhibited „correct" usage of the process skills for tracing outline and drawing of normal needed for practical work. As many 54(98.2%) students exhibited „correct" usage of the process skills for drawing incident angles, erecting search pins, measurement of glancing angles, construction of table of values and drawing and labelling of axes needed whilst 53(96.4%) students exhibited „correct‟ usage of the process skills for plotting points, drawing of line of best fit, determining slope, implication of slope, finding intercepts and stating precautions required for physics laboratory work.

On the other hand, a few students‟ responses reflected incorrect usage of each science process skill. No student (0.0%) exhibited „incorrect‟ usage of the process skills for tracing outline and drawing of normal needed. Only, 1(1.8%) student exhibited the „incorrect‟ usage of the process skills for drawing incident angles, erecting search pins, measurement of glancing angles, construction of table of values and drawing and labelling of axes needed whilst 2(3.6%) students exhibited the „incorrect‟ usage of the process skills for plotting points, drawing of line of best fit, determining slope, implication of slope, finding intercepts and stating precautions required for physics practical work.

Finding 15

All the students (100.0%) were able to trace correctly the outline and drew the normal required. Majority of students representing (98.2%) correctly drew the incident angles, erected search pins, measured the glancing angles, constructed the table of values and drew and labelled the axes. Also, most students representing (96.4%) were able to plot points, drew the line of best fit, determined slope, determined the implication of slope, found the intercepts and stated the precautions.

Item 3: 1. (i) Define the following terms: annular eclipse, umbra and penumbra.

(ii) Tabulate four differences between eclipse of the sun and eclipse of the moon.

Students' responses

The demands of this question included acquisition of two process skills: (1) defining the required terms correctly and (2) tabulating four differences between eclipse of the sun and eclipse of the moon. Depending on the correctness of the answers to the questions, students" responses to the post intervention-class test questions were classified as "correct" and "incorrect" for each process skill. The marking scheme of this question was developed and used to mark students" responses and can be found on Appendix A.

The responses given by the students to Item 3 indicated that 55 students representing 100.0% were able to define the given terms correctly and 54 students representing (98.2%) were able to tabulate correctly the differences.

Finding 16

All the students (100.0%) exhibited correct usage of the process skill for defining of terms needed while majority of students representing (98.2%) exhibited correct usage of the process skill for tabulating of differences.

4.4 Discussion of Results

The findings of this research were discussed in line with the research questions that guided the study and the literature.

4.4.1 Research Question 1

What type of teaching and learning materials could be used in practical demonstration to develop scientific principles and facts behind particular concepts?

This question is answered by Findings 5 and 8. In Finding 5 the glass block, optical pins, protractor and compass were used by students to acquire the skill of ray tracing through a glass block. In finding 8, equipment such as stop watch and metre rule were used by students to acquire skills of performing pendulum experiment.

It could be realised from Finding 5 that most students (72.7%) exhibited correct usage of process skills for drawing rays, drawing perpendicular and calculations while majority of students representing (78.2%) were able to correctly trace the required outline. Additionally, most students representing (74.6%) exhibited the process skills for constructing normal, constructing angles and erecting pins. Thus, ray tracing equipment such as glass block, optical pins, protractor and compass enabled most students to acquire the skill of ray tracing through a glass block. The implication was that there were some students who were able to draw the outline correctly but could not construct the normal, construct the angles and erect the optical pins. Also, some students were able to construct the normal, the angles and erect the optical pins but could not draw the rays, draw the perpendicular and perform the required calculations. This was in line with the format for tracing rays through a glass prism though the first challenge would be to acquire some basic knowledge and skill in using geometric, trigonometry and algebra (Katz & Kata, 2002).

Also, it could be realised from Finding 8 that most students (94.6%) were able to attach thread correctly to the retort stand whilst majority of them (90.9%) were able to record time accurately for 20 oscillations. Also, most students representing (81.8%) constructed good tables for recording measurements taken. Thus, measuring equipment such as stop watch and metre rule enabled the students to acquire the skills of the pendulum experiment. The finding also implied that there were more students who could be able to attach the thread correctly to the retort stand than those who were able to record the time accurately for 20 oscillations. Also, some students were able to take the time for 20 oscillations but could not construct good tables of values. Aggarwal et al. (2005) stated in their work that by doing the pendulum experiment with large angle displacements causes calculations to become complicated and some information has to be filtered out. Thus, the skill of performing the displacements of the bob has to be acquired properly.

Adarman (2003) pointed out that students are motivated to learn if the materials being learnt are of interest and relevant to their previous experience. These were seen in all areas after the intervention activities. There was a good improvement on the science process skills required from them for scientific advancement.

4.4.2 Research Question 2

What activity methods in physics teaching can help students to acquire scientific skills?

This question is answered by Findings 1- tracing outline, Findings 2 and 6 - measurement of length, Finding 3 – labelling diagrams, Finding 4 – classification of objects into groups, and Finding 5 – tracing rays through glass blocks.

It could be realised from Finding 1 that only 1 student (1.8%) exhibited correct usage of the process skill for tracing outline. While, no student (0.0%) exhibited the correct usage of the process skills for constructing normal, constructing angles, erecting pins, drawing rays and calculations. This implies that before the intervention strategy was administered almost all the students could not exhibit the process skills for tracing outline of the glass block, constructing normal, constructing angles, erecting pins, drawing rays and calculations. This could be due to improper activity methods which were used in teaching the students. Thus, they did not acquire the required scientific skills. Ezeife (2003) pointed out that with rectangular glass blocks and optical pins, tracing the outline of the block, the paths of the incident and refracted rays could be observed through the glass block by drawing the normal and measuring the angles of the incidence and refraction for the various traces of the rectangular block. This implies, the students could not exhibit the skill of tracing the outline of the glass block correctly.

In contrast, from Finding 5 during the intervention, it could be realised that most students (72.7%) exhibited correct usage of process skills for drawing rays, drawing perpendicular and calculations while majority of students representing (78.2%) were able to correctly trace the required outline. Additionally, most students representing (74.6%) exhibited the process skills for constructing normal, constructing angles and erecting pins. This could imply that most students could now exhibit the skills of tracing the outline of glass blocks due to the application of appropriate activity methods in teaching the students. Thus their scientific skills have been improved through the intervention strategy adopted.

For Findings 2 which involved measurement of length, it could be realised that only 5 students (9.1%) exhibited correct usage of the process skills for measurement of angles of incidence and refraction while 4 students representing (7.3%) exhibited correct usage of process skills for measurement of length, appropriate units and table of values. This implied that only a few students could measure the length accurately. However, studies by Livingston (2000) have shown that accurate measurement of length during physics practical activities is essential to getting correct data. This implied that most students could not exhibit the skill of measurement of length before the intervention strategy was administered. Therefore, the appropriate activity method may not have been used in teaching students.

In contrast, from Finding 6, it is observed that most students (87.3%) exhibited correct usage of process skills for measurement of length, attachment of thread to retort stand and sketching diagram whilst majority of students. This could imply that most students could now exhibit the skills of measurement of length after the appropriate activity methods were used in teaching students during the intervention stage.

Also, from Finding 3, it is observed that few students 10(18%) exhibited correct usage of process skills for labelling title, axes and scales. While, 8 students (15%) exhibited the correct usage of the process skills for plotting points, drawing line of best fit and finding slope and intercepts. This could imply that majority of students could not exhibit the skill of labelling of diagrams before the intervention strategy was administered.

Additionally, from Finding 4, it could be realised that before the intervention strategy was implemented only 22% of students exhibited correct usage of the process skill for classification of objects into groups. This showed that students did not acquire the required scientific skills yet because they had not been taught using organisation of laboratory practical activities.

Usefulness of the Intervention

The intervention strategy adopted organisation of laboratory practical activities that helped in improving students" scientific skills. However, studies by Jekins (2006) have shown that involving students in laboratory activities with adequate and appropriate apparatus does not only provide scientific literacy as well as preparing students for further study work, but also enable students get good results. This means that the inability of students to exhibit scientific skills were to a large extent, due to lack of appropriate activity method of teaching. Thus students were unable to use the scientific skills needed because of the use of inappropriate activity methods of teaching. The analyses of results of weekly intervention practical exercises and class tests further confirmed that the improvement in students" output was due to the intervention strategy adopted. This agrees with Wehby (2001) assertion that students who are actively engaged and provided with frequent opportunity to respond to academic activities demonstrate improved academic skills. It therefore, became clear, that the activity methods used in teaching physics helped the students to acquire scientific skills.

4.4.3 Research Question 3

How will students' performance improve if group activity approach is applied in teaching? This question is answered by Findings 5 – 16 which were on the Intervention exercises.

The data on the participating students" outputs in the pre-test were compared with those obtained on their outputs in the weekly intervention exercises, class tests and post-test. The students" output in the pre-test clearly showed that their performances in physics laboratory practical works and class works before the intervention were low. The students" performance began to improve when the intervention strategy (group activity approach) was introduced and used in teaching students both in class and laboratory practical activities. Majority of students now exhibited the required skills. These had provided enough evidence to affirm that the use of group activity teaching approach played an important role in improving the performance of the students. This was in line with the new approach of science teaching and learning which emphasises on group activity observations rather than listening to talks and taken down notes (Akimbola, 2008).

The students" output in the post-intervention exercises further attest to the fact that students" ability to perform well were as a result of the group activity approach which was used in teaching (Findings 14, 15 and 16).

Thus, the use of group activity approach in teaching enabled students" performance to improve. Thus group activity approach helped students to perform well in the weekly intervention class tests which they could not do during the pre-test.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMENDATION

5.0 Overview

This chapter discusses the findings of the study. This involves the use of science process skills to help motivate and facilitate student"s" learning of physics in order to enhance students" performance in the subject. It is intended to arouse the interest of students in physics to help them to actively participate during physics lessons. Most of the participating students" responses during the lessons showed correct acquisition of the science process skills needed for laboratory practical activities. The practical exercises that followed each lesson made the students to develop their science process skills. The chapter also includes the implications of the findings for teaching and learning of physics.

5. 1 Summary of Major Findings

The study was an Action Research carried out in Bolgatanga Senior High School, in the Upper East Region of Ghana. The purpose of the study was to use science process skills to facilitate students" learning of physics. It is believed that most students do not acquire the needed science process skills before the commencement of their final examination hence performed incompetently in such examinations. The study, therefore sought to find whether the use of science process skills through organisation of laboratory practical activities and exercises could play a significant role in developing the needed scientific skills of the students. Students were taught for six weeks and at the end of each week made to answer few laboratory practical exercises and class test based on the skills taught and leant. The intervention strategies used helped students develop the required skills as most of them were able to provide the required solutions to the questions asked.

The analyses of data collected from students‟ output in both weekly laboratory practical exercises, class tests and the post-test showed an improvement in the use of science process skills for physics works. The main findings are summarised as follows:

Pre-intervention Findings

1. In using ray tracing equipment such as glass block, optical pins, protractor and compass only 1 student (about 2 %) demonstrated acquisition of process skills of ray tracing through a glass block.
2. Only 4 students (about 7 %) constructed good tables for recording measurements taken during the glass block experiment.
3. In using measuring instruments such as metre rule in the pendulum experiment only 10 students (about 18 %) exhibited correct usage of the process skills of measurement of thread and were able to attach the correct length of thread to a retort stand and to a pendulum bob.
4. With the use of graph sheet only 8 students (about 15 %) drew and labelled the axes correctly and plotted the given points, drew line of best fit, determined slope and intercepts of the graphs.
5. About 22% of the students were able to classify several forces into contact and force fields.

Intervention Findings

1. In using ray tracing equipment such as glass block, optical pins, protractor and compass most of the students (about 73 %) demonstrated acquisition of process skills of ray tracing through a glass block.
2. In using measuring instruments such as metre rule in the pendulum experiment most students (87 %) exhibited correct usage of the process skills of measurement of thread and were able to attach the correct length of thread to a retort stand and to a pendulum bob.
3. In using measuring equipment such as a stop watch majority of the students (about 91 %) were able to record time accurately for 20 oscillations.
4. Most students (about 82 %) constructed good tables for recording measurements taken during the pendulum experiment.
5. The pendulum experiment enabled most of the students (about 73 %) were able to explain Simple Harmonic Motion (SHM) while majority of students representing (69 %) correctly stated the factors affecting the period of a simple pendulum and were able to calculate the period.
6. In doing the pendulum experiment most students (91 %) were able to state science principles underlying the pendulum experiment.
7. About 84% of the students were able to classify the several objects given into transparent, translucent and opaque objects.
8. With the appropriate formulae majority of the students (82 %) were able to calculate correctly the given problems.

9. Given the opportunity to describe their experiments majority of the students (93 %) were able to correctly communicate their ideas about the experiments they undertook.
10. With the use of graph sheet majority of the students (91 %) drew and labelled the axes correctly and plotted the given points, drew line of best fit, determined slope and intercepts of the graphs.

Post-Intervention Findings

1. In using ray tracing equipment such as glass block, optical pins, protractor and compass all the students (100 %) demonstrated acquisition of process skills of ray tracing through a glass block.
2. In using measuring instruments such as metre rule in the pendulum experiment most students (about 98 %) exhibited correct usage of the process skills of measurement of thread and were able to attach the correct length of thread to a retort stand and to a pendulum bob.
3. Most students (about 98 %) constructed good tables for recording measurements taken during the glass block experiment.
4. With the use of graph sheet majority of the students (about 96 %) drew and labelled the axes correctly and plotted the given points, drew line of best fit, determined slope and intercepts of the graphs.
5. About 98% of the students were able to different items into groups.

It may therefore be stated that the Post Intervention Findings were 90 % better than the Pre Intervention Findings hence the intervention has had an impact on students‟ performance.

5.2 Conclusion

Science process skills as means of facilitating students‟ learning of physics is widely acknowledged in journals and other educational literature. It is believed that teachers have been taking their students through physics activities yet students could not perform competently as far as Physics examinations both internally and externally are concerned. The findings of this study revealed that regular organisation of laboratory practical activities and using activity group discussions exerts potent and positive influence on the development of scientific skills of students. These two strategies helped the physics students of Bolgatanga Senior High School to develop the scientific skills needed for physics learning.

Thus as students were exposed to regular laboratory practical activities using group activity method, their ability to learn and understand physics concepts and laboratory practical activities increased dramatically. Group activity method and laboratory practical activities are, therefore, identified as ideal strategies that could help students develop the needed scientific skills for the learning of physics concepts.

5.3 Implication of the finding for classroom Instruction

The findings of the study indicated that regular organisation of laboratory practical activities and using group activity method of teaching enhances the development of scientific skills of students and hence their performance in physics. Regular organisation of laboratory practical activities and using activity group method of teaching will regularly motivate students to learn more. Cumulative assessments which involve frequent exposure of students to laboratory practical exercises may be quite useful in promoting the development of the scientific skills of students. The use of science process skills stimulate students to learn physics concepts in detail that would not otherwise be learned for examination. This makes students see examination questions as one of the usual laboratory practical exercises hence easier to perform.

The use of science process skill for physics teaching should be done throughout the term instead of waiting till final examination time. The task performed by the students in class and in the laboratory should be more challenging since this will enable the Researcher to monitor student‟s‟ performance and give appropriate attention accordingly.

5.4 Recommendations

Based on the findings of the study and the conclusions, the following recommendations are made:

i. Conscious efforts by physics teachers of Bolgatanga Senior High School to use appropriate science equipment for the acquisition of science process skills such as measurement of length and time has the potential to enable students acquire the required skills in physics.

ii. Bolgatanga Senior High School physics students may be given the chance to practice their scientific skills through hands-on activities organised both in the laboratory and in the classroom to enable them carry out physics learning on their own.

iii. Bolgatanga Senior High School physics students may be given the opportunity by their teachers to use results of experiment they perform in the laboratory to explain the underlying scientific principle of the phenomenon being investigated and also state factors that sustain the phenomenon observed in the experiment.

iv. Bolgatanga Senior High School physics teachers may present concrete objects to students for them to classify into groups as this demonstrate their understanding of types of objects in their environment.

v. Bolgatanga Senior High School physics teachers may encourage students to go through calculation appropriate to the experiment that they undertake so that students will sharpen their numeracy skills.

vi. Bolgatanga Senior High School physics teachers should encourage group discussion of laboratory experiment results as this encourages students to sharpen communication skills.

vii. Bolgatanga Senior High School physics teachers should ensure that graph work is done regularly in physics experiments and the physical significance of the results explained so that students will appreciate the reality of physics experiments.

viii. Ministry of Education and the Ghana Education Service are encouraged to endeavour to equip laboratories for schools and train teacher in the use of equipment so that teachers would not feel inadequate in the use of science laboratory equipment for physics experiments.

5.5 Suggestion for Further Study

Since we are in an educational reform era, there is room for further research on any aspect of the physics concepts studied at senior high school level. It is, therefore, recommended that:

1. Studies may be undertaken to investigate the effects of students‟ attitude towards practical lessons on the development of science process skills of students.
2. Again, further studies may be undertaken to establish the effects of the sole use of improvised materials/equipment in teaching laboratory practical lessons in relation to the development of the skills needed for laboratory practical works.
3. A research could also be carried out to find out whether the qualifications and area of specialisation of the teacher has any influence on teaching of physics concepts so that an appropriate decision could be taken.
4. More works need to be done to find out whether students and teacher motivation could have any influence on the teaching and learning of science at the senior high school level.

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APPENDIX A

Questions for weekly class tests

Pre-intervention class test question

Question

Classify the following forces into contact forces and force fields: frictional force, drag force, upthrust, intermolecular forces, centripetal force, gravitational force and electrostatic force.

Intervention class test week one questions

Question

1. (i) Explain simple harmonic motion.

(ii) State two factors on which the period of oscillation of a simple pendulum depend.

Intervention class test two questions

Question

(i) State the principle of reversibility of light.

(ii) Classify the following examples into transparent, translucent and opaque objects: block, tree, cloth, air, piece of paper, frosted louver, milk in glass, clean water, mirror and human being.

Marking scheme for intervention class test three

Question

(i) Define the following terms: diffuse reflection, mirror, normal, point of incidence and an image.

(ii) State the laws of reflection

Post-intervention class test questions

Question

(i) Define the following terms: annular eclipse, umbra and penumbra.

(ii) Tabulate four differences between eclipse of the sun and eclipse of the moon.

APPENDIX B

Data for interventions test questions

Data for item1 of intervention week three

L/cm	L/m	t_1/s	t_2/s	Average time, t/s	T/s= t/20	T^2/s^2
55	0.55	30.41	30.47	30.44	1.52	2.31
15	0.15	16.34	16.47	16.36	0.82	0.67
25	0.25	20.28	20.25	20.27	1.01	1.02
30	0.30	22.50	22.46	22.48	1.12	1.25

Instructions for item 2 of intervention week three

(i) Plot a graph of x as ordinate and tan (θ/2) as abscissa and state the nature of the graph drawn.

(ii) Determine the slope of the graph drawn and its implication.

(iii)Find also the intercept on the x-axis of your graph.

Data obtained during the experiment for item 2 of intervention week three

X/cm	X/m	Θ	θ/2	Tan(θ/2)
6.2	0.062	103	51.5	1.257
6.7	0.067	105	52.5	1.303
7.2	0.072	107	53.5	1.351
7.7	0.077	109	54.5	1.401

8.2	0.082	111	55.5	1.455

Instructions of item 2 of post-intervention exercise

i. Fix the sheet of paper provided on the drawing board. Place the rectangular glass prism on the paper and trace its outline WXYZ.

ii. Remove the prism. Select a point on XY close to the middle, and draw a normal NM through it.

iii. Draw a straight line OA making an angle $i = 25^0$ with the normal at O.

iv. Replace the prism on its outline.

v. Place two pins P_1 and P_2 vertically on AO.

vi. Looking through side WZ, place two other pins P_3 and P_4 such that they fall on the same straight line with the images of P_1 and P_2.

vii. Remove the prism. Draw a straight line through the pin holes of P_3 and P_4 to meet WZ at Q. Join OQ.

viii. Measure and record the angles α and β.

ix. Evaluate cos α and cos β.

x. Repeat the procedure for four other values of $i = 30^o$, 35^o, 40^o and 45^o.

xi. Tabulate your readings.

xii. Plot a graph with cosα on the vertical axis and cosβ on the horizontal axis.

xiii. Determine the slope, s, and its implication.

xiv. State two precautions taken to obtain accurate result.

APENDIX C

Trial Questions

Question 1: You are presented with rectangular glass block, drawing paper, optical pins. Set up the apparatus for an experiment to determine the refractive index of the glass block using the diagram shown on the question paper as a guide. Use your set up to carry out experiment to determine the refractive index of the glass block.

Question 2: Using the apparatus provided, measure and record the values of the angles of incidence and angles of refraction and also the length of the perpendicular line QW = d in each of the traces made. Each measured values were to be recorded in their correct units of measurement.

Question 3: Using the values obtained in (2) above plot a graph with i as ordinate and d as abscissa. Record the slope of your graph. Find also the intercept (s) of the graph drawn.

Question 4: You are provided with regular glass block, drawing board, drawing paper, optical and thumb pins. Set up the apparatus for an experiment to determine the refractive index of the glass block using the diagram below as a guide.

Question 5: You are provided with retort stand, clamp with boss, thread and pendulum bob. Manipulate these apparatus to obtain experimental set up for an experiment to determine acceleration due to gravity using simple pendulum. Sketch a labelled diagram of the set up.

Question 6: You are provided with a bob attached to a string. Rigidly clamp the string so that the length of the bob L = 90cm. Displace the bob to one side and determine and record the time t1 for 20 oscillations. Repeat the experiment for length L = 80cm, 70cm, 60cm and 50cm each time measuring the corresponding t1 for 20 oscillations. Now increase L starting from L = 50cm up to L = 90cm, each time recording the corresponding time, t2 for

20 oscillations. Find the average time, t and hence evaluate the period T = t/20. Tabulate your results.

Question 7: (a) State the uses of micrometer screw gauge.

(2b) Explain briefly how the reading is done on a micrometer screw gauge.

Question 8: The table below shows the data obtained in an experiment to determine acceleration due to gravity using simple pendulum.

i. Use the values from the table to plot a graph with T^2 as ordinate and h as abscissa.

ii. Determine the slope, s and hence find the value of g

Table of values

L/cm	L/m	t_1/s	t_2/s	Average time,t/s	T/s= t/20	T^2/s^2
55	0.55	30.41	30.47	30.44	1.52	2.31
15	0.15	16.34	16.47	16.36	0.82	0.67
25	0.25	20.28	20.25	20.27	1.01	1.02
30	0.3	22.5	22.46	22.48	1.12	1.25

Question 9: Below is a table of results constructed during an experiment conducted using a plane mirror. Using the data from the table:

(i) Plot a graph of x as ordinate and tan (θ/2) as abscissa and state the nature of the graph drawn.

(ii) Determine the slope of the graph drawn and state its importance.

(iii)Find also the intercept on the x-axis of your graph.

Table of values obtained during the experiment

X/cm	X/m	Θ	θ/2	Tan(θ/2)
6.2	0.062	103	51.5	1.257
6.7	0.067	105	52.5	1.303
7.2	0.072	107	53.5	1.351
7.7	0.077	109	54.5	1.401
8.2	0.082	111	55.5	1.455

Question 10: Suspend the simple pendulum from the support provided such that the length L of the pendulum, measured from the point of support to the centre of the bob is 90cm. Set the pendulum swinging gently and determine the time of 20 oscillations of the pendulum. Calculate the periodic time T for one oscillation of the pendulum and hence determine T^2. Repeat this experiment for the values of L = 80cm, 70cm, 60cm, and 50cm. In each case determine T and T^2.

i. Plot a graph with L on the vertical axis and T^2 on the horizontal axis.
ii. Calculate the slope of the graph drawn.
iii. State two precautions taken to obtain accurate result.

Question 11: Using the diagram below as a guide carry out the following instructions:

i. Fix the sheet of paper provided on the drawing board. Place the rectangular glass prism on the paper and trace its outline WXYZ.
ii. Remove the prism. Select a point on XY close to the middle, and draw a normal NM through it.
iii. Draw a straight line OA making an angle $i = 25^0$ with the normal at O.
iv. Replace the prism on its outline.

v. Place two pins P_1 and P_2 vertically on AO.

vi. Looking through side WZ, place two other pins P_3 and P_4 such that they fall on the same straight line with the images of P_1 and P_2.

vii. Remove the prism. Draw a straight line through the pin holes of P_3 and $P_4$to meet WZ at Q. Join OQ.

viii. Measure and record the angles α and β.

ix. Evaluate cos α and cos β.

x. Repeat the procedure for four other values of i = 30^o, 35^o, 40^o and 45^o.

xi. Tabulate your readings.

xii. Plot a graph with cosα on the vertical axis and cosβ on the horizontal axis.

xiii. Determine the slope, s, of the graph.

xiv. State two precautions taken to obtain accurate result.