EFFECTS OF CONCEPT MAPPING AND INQUIRY STRATEGIES ON ACHIEVEMENT AND CREATIVITY AMONG COLLEGES OF EDUCATION PHYSICS STUDENTS IN NORTH-EAST NIGERIA

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DECLARATION

I declared that the Study entitled "Effects of Concept Mapping and Inquiry Strategies on Achievement and Creativity among Colleges of Education Physics Students in North-EastNigeria" has been written by me in the Department of Science Education, Ahmadu Bello University, Zaria. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

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CERTIFICATION

This thesis entitled "Effects of Concept Mapping and Inquiry Strategies on Achievement and Creativity among Colleges of Education Physics Students in North-EastNigeria"has been written *by* Ali AUTA Reg, No. Med/EDUC/15304/2007-08, meets the regulations governing the award of the degree of Master in Science Education (M.Ed Science Education) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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OPERATIONAL DEFINITION OF TERMS AS USED IN THIS STUDY

Concept Map: Are diagrammatic representation of knowledge from known to unknown to provide meaningful learning

Inquiry Strategy: Is a student-centred teaching strategy in which the learner is allowed to discover learning experiences with a minimum guidance from the teacher.

Creativity: Is the translation of unique gifts, talents and vision into an external reality that is useful and new.

Fluency: Ability to generate a large number of ideas.

Flexibility: Ability to generate many solutions to a particular problem

Originality: Ability to create something new and unique

Motivation: Having abundant energy for work and solve many problems.

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ABBREVIATIONS USED

B.Ed Bachelor of Education

Cmaps: Concept maps

C.O.E College of Education

E_1 Experimental Group 1

E_2 Experimental Group 2

F.C.E Federal College of Education

FME: Federal Ministry of Education

I.C.A.S Ibadan Creativity Assessment Scale

NCCE: National Commission for Colleges of Education

N.C.E Nigeria Certificate in Education

NRC: National Research Council

N.S.E.S National Science Education Standard

STAN: Science Teachers Association of Nigeria

PAT: Physics Achievement Test

ABSTRACT

This study investigated the comparative effects of concept mapping and inquiry methods of teaching on the academic achievement and creativity of Colleges of Education physics students in the North-East Nigeria. The study was a pretest-posttest experimental match group design. The population of the study consisted of two hundred and forty-seven (247) physics students from seven state Colleges of Education in the North-East Zone. Two out of the seven colleges were sampled using simple random sampling technique by flipping a coin, the two colleges were designated experimental group 1 (E_1), and experimental group 2, (E_2). Intact class were used for the study. The two groups were subjected to a treatment for six weeks each. Thirty-three (33) students were used in experimental group (E_1) and thirty-four (34) were used in experimental group 2 (E_2). Physics Achievement Test (PAT) was used to measure their academic achievement while Ibadan Creativity Assessment Scale (ICAS) was used to measure their creativity. two (2) research questions and a corresponding two (2) null hypotheses were raised with a view to finding out if there was any significant difference in the academic achievement and creativity of the students taught physics concepts using concept mapping and inquiry strategies of teaching respectively. The first hypothesis was tested using t-test statistic while the second hypothesis was tested using two-ways analysis of variance. Both hypotheses were tested at $P \leq 0.05$ level of significance. The findings of the study showed that there was no significant difference between both groups in their academic achievement after treatment. The study also found no significant difference between the two groups in their creativity traits. It was concluded that innovative teaching strategies enhances students' academic achievement and creativity, and teachers should be trained in the use of learner-centred instructional strategies such as concept mapping and inquiry strategies of teaching is one of the recommendations made.

CHAPTER ONE

THE PROBLEM

1.1**Introduction**

Recent changes in science curricula around the world emphasize higher students' creativity and performance using various teaching methods and innovations. With this, attempts have been made to shift instructions from mere rote learning to making it more meaningful to the learner.Ausubel(1963) maintained that meaningful learning occurs only when the learner consciously and explicitly ties new knowledge to relevant concepts and expressions.Therefore, the responsibility of teachers in schools and colleges is not only to teach students the particular content of knowledge needed for their professional discipline but also to help them develop successful lifelong skills of acquiring knowledge. A number of factors have been identified as militating against students' attainment of the objectives of science instruction, and the most pronounced factor identified by researchers is the inappropriate and uninspiring teaching methods adopted by science teachers, (Nwagbo,2001; Odell, 2005; Cheema & Mirza, 2013).

Science comprises the basic disciplines such as Physics, Chemistry, Mathematics and Biology. Many investigations have shown that secondary school students are exhibitingdwindling interest in Science(Oladejo, Olusunde, Ojebisi & Ishola, 2011). Besides, Physics as one of the Science subjectsremain one of the most difficult subjects in the school curriculum(Ishola, 2010). According to Ogunleye and Babajide, (2011), Nigeria has witnessed persistent poor students' performance in Physics at the Senior School Certificate level. This has been linked to the adoption of instructional strategies which did not give enough consideration to learners' previous knowledge and how they reasoned in order for learners to construct their knowledge based on these.

In order to improve students' academic achievement,researches into science teaching and learning methods such as problem solving ,inquiry method, demonstration method, lecture method, concept mapping and many others have been developed with the aim of making learning more meaningful and less complex. Students experience difficulties in learning physics because they must fully understand concepts and principles of the physical world that are sometimes impossible to see (as in heat and energy, electromagnetism, conservation of energy and mass) and often difficult to comprehend (Bauman, 1992; Odell, 2005). In addition to these difficulties, there are the requirements to master quantitative and formulaic representations of scientific phenomena in order to teach new concepts and they also maintained thatteachers' views of what constitutes effective teaching and learning influence their choice of instructional strategies and whatever method is used, the students prior knowledge is important.Prior knowledge have been shown to influence the quality of learning and students' achievement in a significant manner (Hailikar, 2009). Ultimately, the aim of higher education is to promote high-quality learning which can serve as sound basis for individuals to build on later in life. It is generally agreed that learning outcome is determined by many factors interacting with each other. When teaching science concepts, teachers must ascertain the prior knowledge of students about the new concept meant for teaching because it is an important factor in influencing learning (Ausubel, 1968, Lakpini, 2006).

Using strategies such as problem solving, concept mapping and inquiry strategies of teaching to motivatestudents' prior knowledge were considered equivalent to preparing for a learning experience. The use of activating strategies have produced significant gains in learning potential by recognized prior knowledge as the basis for familiarity with concepts, and have provided students with a context that argues strongly for new learning to occur.Studies have clearly shown that meaningful learning is more efficient and lasting (Novak & Gowin, 1984; Novak, 1991) because of

the integration and linkages made. In contrast to rote learning, the outcome of meaningful learning is that the new information is transferred into long term memory in a relevant linkage with prior knowledge.This study therefore employed the use of students' prior knowledge to aid in the construction of concept maps.

Abimbola & Danmole (1995) asserted that to reduce the difficulty students' face in learning concepts, teacher must analyze concepts meant for learning and specifying its level of complexity, abstractness and sophistication. This analysis would enable teachers to lead students to know the relationships between concepts. They maintained that concept mapping techniques is useful in that it helps teachers in knowing what to teach, how to teach it and how to evaluate students.

In considering knowledge based problems encounter by pre-service teachers, one of the approaches that has been found helpful in facilitating and identifying individual needs is the use of concept mapping. White & Gunstone, (1992)believe that the effective strategy designed to promote efficient and meaningful learning rely upon connecting prior knowledge to new concepts. Ausubel,(1963)and Novak,(1990)assert that the mental ability of students to enhance their credible standard and good performance relies on the understanding,proper application of an acquired skill and successfully relating them with new ones. The extents to which the students interrelate concepts can be assessed using concept mapping technique.

Mintze, Wandersee, & Novak(1998) defined concept maps as tools used for organizing and representing knowledge. Pellegrinno,Chudowsky & Glasser(2001) identified concept mapping as a method of arranging conceptual nodes, and labels of nodes and links to show relationship among multiple concepts in a domain. Concept maps are therefore tools that help organize knowledge for meaningful learning. The linking words that are used to connect concepts provide meaning for the preposition and the domain of the knowledge.When concept maps are used to represent scientific

concepts, they help to resolve ambiguities, inconsistencies and rigors of representing scientific knowledge (Kharatmal & Nagarjuna 2006). According to Marzano & Kendall, (2007), concept maps are made towards enriching conceptual understanding of different instructional contents regarding topics, identifying prior understanding, bridging gaps in knowledge, removing misconception, and can be designed to detect changing in understanding thereby enhancing the performance of the students. Marzano & Kendall (2007) also maintained that good concept maps that move from teacher-generated to student-generated help students imagine new gaps in knowledge,and also help refine their thinking to pure unadulterated facts of their lives into real creativity. Concept mapping helps meaningful learning in several other ways. For example, concept mapping is an activity that provides the student with an opportunity to organize, summarize, analyze and evaluate many different ideasand also promotes the development of critical thinking skills, which can then be used to enhancing meaningful learning (Novak & Canas 2006). Furthermore, because the concept mapping process externalizes the concepts in the student's existing knowledge structure, it is possible to identify misconceptions, incongruities and weaknesses in that existing knowledge structure. Therefore, this study usedconcept mapping strategy with a view to finding how it can enhance students' academic achievement and creativity in physics.

Science teaching around the globe is encouraged through experiment, simulation and debate,and other participatory activities where students discover concept on their own. This type of learning motivates students and increases group participation. According to Sola & Ojo,(2007)defined inquiry or guided inquiry as a style or method of teaching where the learner with minimum guidance from the teacher seeks to discover and create answers to a recognized problem through a procedure of making a diligent search.Inquiry, as a term used in science teaching refers to a way of questioning,seeking knowledge or information about a phenomenon,it also involves

investigating,searching,defining a problem, formulating hypothesis,gathering and interpreting data and arriving at a valid and acceptable conclusion. Students with minimum guidance by teacher make their own observation develop basic scientific concepts, use and interpret different forms of scientific representation.Scientific inquiry method brought new developments in the field of education. According Hussaini, Azeem & Shakoor (2011), scientific inquiry method implies involvement of students that leads to understanding. Furthermore, students' involvement in learning leads to acquisition of skills and attribute of seeking resolutions to questions and issues while learners construct new knowledge. There are three types of inquiry, which differ by the amount of student involvement at the planning stage (Andi, 2010). The most common type of inquiry is structured inquiry. In structured inquiry, the teacher states the problem, formulates the question and hypothesis, as well as develops the working plan. The students implement the plan, gather the data, and draw the conclusions. The second type of inquiry is guided inquiry. In this type of inquiry, the teacher poses the problem and then the students determine the processes and solution. The third and final type of inquiry is open inquiry. In open inquiry, the students state the problem, formulate the hypotheses, and develop theirprocedures as well as follow through with the procedure and collect the data (Andi, 2010). Therefore, in this study, the structured type of inquiry was used as a teaching strategy to find out the academic achievement and creativity of NCE students in Physics in Eastern Nigeria.

This research study grew out of a programme aimed to helping NCE students in Physics to develop their ideas of Physics concepts and how to interrelate them using concept mapping and inquiry teaching strategies. According to Afuwape, (2004), concept mapping promotes the development of critical thinking skills which are embedded in creativity that can be used to ensure meaningful learning for enhancing academic achievement. In the same vain, the inquiry strategy

involves critical thinking to arrive at logical conclusion to problems; this process of thinking generates meaningful learning and creativity traits in the learner (Wakili 2007). This study therefore investigated the comparative effects of the two teaching strategies on the academic achievement and creativity of NCE physics students in North Eastern Nigeria. The concept of Physics used in the study is PHY 121(Introduction to Thermal Physics I). From the investigation conducted by the researcher in two (2) out of the seven (7) Colleges of Education namely; (C.O.Es Azare, Waka) results of this course have not been encouraging, remarkable failures were recorded in students' examinations (appendix xii). Therefore, this study desired to improve teaching of physics (PHY 121).

Creativity skills have been identified as one of the most distinct human attribute.These skills include curiosity, exploring,wondering and the art of questioning (Onu, 2007). According to Sambo(2002), creativity is a combination of flexibility,originality and sensitivity to ideas which enable the thinker to break away from usual sequences of thought into different and productive sequences, the result of which gives satisfaction to himself and possibly to others. Hence, creativity can be seen as a mental and social process involving the generation of the ideas or concepts and new associations of creative mind between existing ideas or concepts. It can be conscious or unconscious, and the end product is the act of making something new, it can also be a process and a product. Afuwape,(2004)maintained that the process component of creativity involves skills which are employed in the science processes; these skills are the foundation of both scientific inquiry and development of intellectual skill.Based on this, several attempts have been made to investigate the effectiveness of science teaching methods. Results from the investigations of Nwagbo(2001)indicated that innovative teaching methods such as guided discovery,cooperative learning and inquiry methods were more effective than the traditional method in enhancing students'

achievement and creativity.Novak & Canas (2004)have shown that the act of concept mapping is a creative activity in which the learner must exert to clarify meanings by identifying important relationships concepts, relationships and structure within a specified domain of knowledge. Therefore,this study sought to compare the effects that concept mapping and inquiry strategies would have on academic achievement and creativity of prospective physics students in North Eastern Nigeria.

1.1.1Theoretical Framework

Concept mapping is a meta-cognitive learning strategy based on the Ausubel-Novak-Gowin theory of meaningful learning (Ausubel, Novak, & Hanesian 1978; Novak & Gowin, 1984). It has its origins in a research done at Cornell University with a view to studying changes in students' understanding of science concepts over a 12-year span of schooling (Novak, 1990). The research group led by Novak worked with the idea that new concept meanings were acquired through assimilation into existing concept/propositional frameworks. This idea of hierarchical representation of concepts/propositional frameworks was eventually described as "cognitive maps" or "concept maps".

Inquiry-based strategy of instruction is a constructivist based approach to education and according to Mayer (2004), it is supported by the work of learning theorists and psychologists such as Jean Piaget, Jerome Bruner and since then it has gained a lot of popularity. Martins & Oyebanji (2000) maintained that inquiry based activities are designed to enhance the development of skills among the learners. The inquiry based strategy is a child-centered activity oriented teaching method in which the teacher directs students through problem solving approach with the aim of discovering answers to instructional topics at hand (Nwagbo 2001).

Historically, the early paths of science instruction followed the philosophyof exercising student's minds through rote memorization of information. Duringthe 1960's however, research done by Jean Piaget and Jerome Bruner, as well asothers, began to change this approach of thinking about science instruction. Thesenewly developed philosophies of learning styles and learning environmentssupported the assumption that "learners actively construct individual world viewsbased on personal observations and experiences, and that learner's respond to instruction in terms of pre-existing intuitive perspectives (Andi, 2010).

The theory of creativity begins with the creative process, and according to Wakili (2007), agreeing in total with the creative process is the process of becoming aware of problem deficiencies, gaps in knowledge, missing element disharmonies, bringing in new relationship and formulating hypotheses.Wakili (2007) maintained that science and creativity are sensitive to reducing gaps in knowledge, deficiencies, missing elements, identifying difficulties and search for solutions to problems. They also asserted that creativity is related to many aspects of science when confronted with unfamiliar events including generating relevant and unique questions, identifying possible explanations, testing such ideas and predicting probable effects. Science should therefore produce students who are experienced in understanding the world and also generating novel scientific ideas which require a lot of creativity. The importance of students' learning to put their latent skills to optimal use is self-evident as education inculcates decision-making abilities. Learning of different subjects may not yield similar results as there are many factors that affect students' achievement but teaching methods almost have same effect on students learning. Teaching of physics is facing dilemma for teachers as well as students. Physics curricula should inculcate creative thinking and critical analysis in students.

It was on this premise that the theory of meaningful learning by (Ausubel, Novak, & Hanesian 1978; Novak & Gowin, 1984) on concept mapping and the constructivist theory on inquiry strategy that this study employed to find out the academic achievement and creativity of NCE students in physics in the North Eastern Nigeria.

1.2 Statement of the Problem

Nigeria is facing problems in the teaching of physics at both secondary and tertiary levels of education (Ishola, 2011). It has also been observed that the teaching of Physics suffers due to limited resources, equipment, latest physics books and teaching methods(Oladejo, Olusunde, Ojebisi & Ishola, 2011).From the investigations conducted by the researcher in two (2) out of the seven (7) Colleges of Education namely; (C.O.Es Azare and Waka), the results of PHY 121 (Thermal Physics I) have been very poor and discouraging (Appendix xii).Using concept maps in different fields of Science Education, such as Biology Chemistry, geology, Economics, and Physics, have had positive results. Research findings indicate that Inquiry teaching strategy may be very effective in enhancing student achievement and motivation to learn science as well as development of scientific process skills (Sola & Ojo, 2007; Njoroge, Changeiywo & Ndirangu, 2014).

This study therefore investigated the effects of two teaching strategies i.e (Concept Mapping and Inquiry) on the academic achievement and creativity of Colleges of Education Physics students in North-East Nigeria.

1.3Objectives of the Study

The objective of this study is to investigate the effects of Concept Mapping and Inquiry Teaching Strategies on the academic achievement and creativity among Colleges of Education physics students in North-East Nigeria. The specific objectives of the study are:

(i) To investigate the effects of concept mapping and inquiry teaching strategies on the academic achievement of Colleges of Education physics students in North-East Nigeria;

(ii) To investigate the effects of concept mapping and inquiry teaching strategies on creativity traits i.e

(a) Fluency

(b) Flexibility

(c) Originality, and

(d) Motivation

among Colleges of Education physics students.

1.4Research Questions

The following are the research questions for the study:

i) What is the difference between the mean score of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy?

ii) What is the difference in the creativity traits of

(a) Fluency

(b) Flexibility

(c) Originality and

(d) Motivation

of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

1.5Null Hypotheses

The following null hypotheses weretested at $p \leq 0.05$ level of significance.

$H0_1$:There is no significant difference between the academic achievement of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

$H0_2$:There is no significant difference in the creativity traits of

(e) Fluency

(f) Flexibility

(g) Originality and

(h) Motivation

of Colleges of Education students taught physics concepts using concept mapping and those taught the same concepts using inquiry strategy.

1.6The Significance of the Study

This study aimed at comparing concept mapping and inquiry strategies of teaching on academic achievement and creativity of NCE students in North Eastern Nigeria.It is hoped that the findings from the study would help teachers, curriculum planners, students and researchers and professional bodies in the following ways:

a) Physics Teachers: To select different and appropriate tools, apparatus and materials to

promoting their teaching in investigations by ensuring a save working environment,

make available physics teaching tools, materials and if possible making available other media and technological tools at their disposal.

b) Curriculum planners: In designing and developing curriculum for N.C.E. students in physics, since it will help the curriculum planners to recommendthe most suitable teachingstrategy to achieving the objectives of physics at the N.C.E level.

c) Students: In framing and solving problems associated with concept mapping and inquiry and also relating physics conceptswith a view to ensuring meaningful learning and lifelong challenges through developing self competence.

d) Researchers:To initiate further studies into other teaching strategies not only in physics, but other sciences with a view to equipping professionals on how to enhance academic achievement and creativity of students at all levels of education.

e) Professional bodies: In service training for science teachers in form of seminars, workshops and conferences should focus more on how to use concept mapping and inquiry strategies for the teaching of Physics concepts. The government or relevant professional bodies like Science Teachers' Association of Nigeria (STAN), National Institute of Physics (N.I.P) should take up this responsibility.

f) Open up a new frontier in Nigerian schools especially the North-East zone where the researches on these strategies of teaching are not only new as it intends also to find out their effects on academic achievement and creativity on NCE students in physics.

1.7Scopeof the Study

The study was delimited to only NCE1 students studying Physics in College of Education Jalingo Taraba State and College of Education Waka-Biu both in Eastern Nigeria. The topics selected for

the study were based on the content and objectives of PHY 121, titled"Introduction to Thermal Physics I" which contains heat and temperature, thermal energy development, heat transfer and kinetic theory. Based on the researcher's investigation from two (2) out of the seven (7) Colleges of Education in the North-East zone, the performance of students was poor and hence remarkable failure were recorded and this is therefore a source of concern, hence warranted the choice of PHY 121. The methods of instruction to be used in this study are concept mapping and inquiry strategies of teaching. NCE I Physics students were used as the subjects for the study due to the fact that it is their first contact in a higher level physics course and to introduce different strategies to teaching physics concepts.

1.8 Basic Assumptions.

The following assumptions were made for the purpose of this study:

i) The students used in this study have similar experiences in learning since all of them have attended secondary school and also have some background knowledge of thermal physics.

ii). The studentsused in this study have some elements of creativity.

CHAPTER TWO

LITERATURE REVIEW

2.0Introduction

This study sought to investigate the Effects of Concept Mapping and Inquiry Teaching Strategies on Achievement and Creativity among Colleges of Education Physics Students in North-East Nigeria.This chapter examined the works of others on teaching strategies and students' creativity and how they are related to the present study. Therefore, the following related topics to this research work were studied.

- Teaching Physics at NCE Level
- Concept Mapping
- Kinds Of Concept Maps;
- Concept Mapping As An Instructional Strategy;
- Evaluation /Analysis Of Concept Maps;
- Inquiry Method;
- Creativity
- Creativity and Academic Achievement in Physics
- Academic Performance in Relation to Science Teaching;
- Students Performance in Physics at S.S.C.E. And N.C.E. Levels;
- Academic Achievement In Relation to Teaching Strategy;
- Overview of Literature Reviewed.

- Implication of Literature Reviewed to the Present Study.

2.1Teaching Physics at NCE Level

The philosophy of the Nigeria Certificate in Education, (N.C.E.), and physics is inspired by the desire to help students become intellectually informed in physics, and by the need to produce competent and effective teachers with good mastery of content and method, and knowledge of the development of the learner.

One of the objectives of science is the understanding of nature; this understanding is not based on the possession of absolute truth, but rather on the ability to explain and predict event and phenomenon. Science explores matter and the meaningful structures and descriptions. The knowledge about the world is all centered on facts, principles and theories discovered from the various scientific disciplines. It is within this scenario that warrants all scientific processes to become an integral part of physics programmes at all levels of education and all with the view to enhancing high level performance in the academics and advance research. Some of the objectives of teaching physics at the N.C.E level include:

i) Have basic knowledge of the organizational concepts and techniques in practical physics and laboratory management.

ii) Be aware of the fact that the fundamental ideas of physics evolved from a process of inquiry, which will enable them to develop scientific attitudes which are transferable to other life situations.

iii) Have sound basic knowledge of the physics concepts and principles to equip them for further studies in physics and physics- related courses.

v) Explain the nature of science.

vi) Use science resources effectively.

Physics programmes center around the process of science including observing, classifying, measuring, inferring, using space and time relationship, numbers, controlling variables, interpreting data, forming operational definitions, experimenting and formulating hypothesis. All these are towards understanding the process of inquiry in physics and which has practical importance in educational decisions (Adebisi 2008). The important of physics cannot be overemphasized as it forms the basis of technological advancement of any nation. Apart from this, the knowledge of physics plays a very significant role in the economic development of any nation. In the realization of its numerous advantages, physics has been introduced in Nigerian secondary schools at the senior level in order to achieve the following objectives:

(i) To provide basic literacy in physics for functional living in the society;

(ii) To acquire basic concepts and principles of physics as a preparation for further studies;

(iii) To acquire essential scientific skills and attitudes as a preparation for technological application of physics and;

(iv) To stimulate and enhance creativity (FME, 2004).

The above mentioned objectives look realistic and to the needs of Nigerians, but their realization remain vague as physics education is confronted by numerous constraints at higher level. Omosewo (1999) identified some problems associated with physics at the secondary school level to include:

(i) Inadequate training of teachers at the university level:

(ii) Poor attitude of student to physics.

(iii) Inadequate laboratory facilities.

(iv) Poor teaching method.

(v) Lack of instructional material specifically designed to aid the teaching of physics.

(vi) In adequate motivation for teachers.

Of these factors, the one of most interest to the author is the inadequate training of physics teachers Omosewo (1999) maintain that developing countries such as Nigeria where science education receives little or no political support, the most important resource in the physics classroom is the physics teacher. He also showed that prospective physics teachers should be well grounded in physics content be it at any level, they should also learn different methods of teaching as well as practical ways of imparting physics education to students. He argued that the training programmes for these prospective teachers should also be expanded to allow for more sufficient exposure to relevant subject matter content so that the product of such teaching would have more sense of belonging to physics as well as relate their knowledge to the secondary school physics curriculum. Institutions such as colleges of education, faculties of education of universities should cooperate to produce common curriculum guidelines for the physics component of the teacher education propramme in other to ensure a uniform preparation for teachers of the same secondary school physics curriculum. Omosewo (1999) revealed that if these are done these teachers will be exposed to different aspect of physics and consequently will be able to impart the knowledge with the little or no difficulty at all levels of education.Hence, concept mapping and inquiry strategies of teaching were used on NCE students in this study with a view to measuring their academic achievement and creativity traits.

2.2 Concept Mapping

In recent years, concept mapping has become a powerful tool which is frequently applied in different context in science education. Teachers ask their students to describe their knowledge by means of specific terms and explain the connection between (as a means of self monitoring and evaluation). Researchers ask students to construct concept maps to gain information about students'

conception of various topics in science. Concept maps also meets the demands for short and well structured description of students' ideas often needed for the purpose of assessment and self monitoring in studying science concepts. According to Novak & Canas (2006), concepts maps are graphical tools used for organizing and representing knowledge. Novak & Gowin (1984) observed that concepts maps are knowledge representation about a particular idea in form of graph comprising of boxes connected with labeled lines, words or phrases that denotes concepts which are placed inside boxes and the relationship between them are specified on each line. Concepts are perceived regularities in events, objects or record of event or object designated by a label, (Novak & Canas 2006). Concepts according to Navak & Gowin (1984) are mental representation of objects or events with the following characteristics:

(i) Correspondence among concepts and what it represents.

(ii) Absence of ambiguity.

(iii) Optional use of language involved.

In concepts maps, concepts are not isolated, they are written in boxes or cells connected by labeled lines or arrows called links which consist of words, phrases or verbs that explains,meaningful relationships between them. Arrows if used designate direction of the relationship, sometimes they are arranged in hierarchical way, from the most abstract on top of the graph to the most concrete and specific, the direction of relationship is usually downwards.This facilitates the reading and understanding of such concept as a whole. Concept mapping can therefore be seen as a graphical technique of representing ideas, helping to think, solving a problem, planning a strategy or developing a process, connecting different concepts of the subjects and relation by compiling the maps, (Dahncke & Reiska 2008). The concept mapping technique is base on the theory of meaningful learning on the assumption that knowledge is savedin the human brain

(Dahncke & Reiska 2008). They also maintained that the generated concepts maps represent the knowledge saved in the brain. Olusola & Hammed (2008) defined concept mapping as a process or technique of representing concepts and their inter relationship in a two dimensional structure, showing the concept in a topic/units in their aches and interconnections. It provides a technique for representing knowledge in graphical or diagrammatical form with lines and phrases. It is also based on the modern theory of learning that knowledge is not isolated, rather knowledge are linked in a "web" form through words and concepts (Novak 1990). According to Mintze, Wandersee & Novak (1998), concepts maps is a two dimensional hierarchical node-link diagram that depicts the structure of knowledge within a scientific discipline as viewed by a student, an instructor or an expert in the field. Novak & Gowin (1984); Wandersee (1990); White & Gunstone (1992) view concepts map as a two or three dimensional spatial or graphic display that make use of labels to represent concept and lines or arcs to represent relationship between the pair of concept.

Therefore, concepts maps can be seen as a diagrammatic representation of idea which helps to solve problems of learning, while concept mapping is a technique of presenting ideas, planning a strategy and developing a process of providing meaningful learning. By this, concept maps were used in this study with a view to helping students understand how concepts are linked, how one develops out from another, all of which enabled the students to extend and deepen their knowledge of physics concepts contained in PHY 121 and to understand its wholeness.

2.2.1 Types of Concepts Maps

There are four major categories of maps these are distinguished by their different format for representing information (Novak & Gowin, 1984). They are presented as follows:

(i) Spider Concept Maps

The spider concept map is organized by placing the central theme or unifying factor in the center of the map, outwardly radiating the sub-themes.

(ii) Hierarchy Concept Map

The hierarchy concept map presents information in a descending order of importance. The most important information is placed on the top. Distinguishing factors determine the placement of the information;

(ii) Flow-Chart Concept Map

The Flow-Chart Concept Map organizes information in a linear format;

(iv) System Concept Map

The System Concept Map organizes information in a format which is similar to a flow chart with the addition of 'INPUTS' and 'OUTPUTS'. It is also known as Data Flow Diagram.

There are also special concepts maps that are based on the type of format they follow:

(i) Multidimensional /3-D concept maps;

(ii) Mandala concept maps;

(iii) Fishbone concept Maps;

(iv) Storyboard concept map;

(v) Venn Diagrams;

(vi) Picture landscape concepts maps.

Novak (1998) emphasized the importance of hierarchical structures in concept mapping. Thus, concept maps should have more inclusive, general concepts at the top of the hierarchy with progressively reducing generality at the lower levels, which consist of less inclusive, and more specific concepts. Based on this principle, concept maps are generally read from the top to the bottom, it is then on this premise that hierarchical concept map was used in this study.

2.2.2 Concept Mapping as an Instructional Strategy

Following the definition of concept mapping given in section 2.1, concept mapping can serve as an instructional tool that is currently gaining popularity in the field of science education. It is seen as a product of recent advances in cognitive science and a new philosophy of science. The new philosophers of science reject the traditional cumulative view of scientific knowledge and replace it with a conceptual change, as reflected in the works of (Abimbola & Bello 1997). The theoretical foundation of concept map rest upon the constructivist views on education, Ausebel's theory of meaningful learning on one, hand and rote learning on the other, (Heize-Fry& Novak 1990). Iuli & Helled (2004) assert that concept maps were developed as a met-cognitive tool that helps students understand the science they study by revealing gaps in understanding, identifying misconceptions, promoting reflective thinking and facilitating shared understanding. Concepts maps usually represent an individual's knowledge within the framework of concept relationships thereby allowing assessment of an individual's understanding.

An instructional format with concept map components can provide teachers on training with the opportunity to reflect on their own misconception, and refine their own understanding by listening to one another's justifications and seeking clarifications(Himangshu, Iuli, & Venn 2008). Teacher candidates can therefore learn to construct their maps which can help them identify and define structural concepts based on their curriculum content. A research by Iuli & Himangshu (2007) suggests that the efficacy of using students' approaches to learning through concept mapping technique strongly correlates with a conceptual approach to learning. Olusola & Hammed (2008) maintained that concept mapping as an instructional technique can be useful in the following ways:-

(i) To facilitate meaningful learning as an evaluation tool:

(ii) As a learning device, teacher can use concept maps to enable student learn the meaning of concepts and their relationships.

(iii) Learner-created concept maps can be used to summarized articles or chapters of textbooks read.

(iv) It can be used to summarize a lesson and as a tool to find out how learners understand and relate concepts.

Concepts maps can be used to make explicit the relationships between principles, processes and their conceptual contents; they can also be used to bridge the gap that exists between prior knowledge and new knowledge with the aim of providing the teacher candidate with a safe environment and the flexibility to probe, monitor, control and reflect their own learning (Himangshu, Iuli & Venn 2008). It is in this regard that concept maps was used in finding out the students academic achievement and creativity in physics.

2.2.3 Analysis and Evaluation of Concept Maps.

The main focus of this section is concerned with the analytical procedure and evaluation of concept maps. Bandiera & Vicentini (2001) assert that the analysis in a concept map is done at a qualitative level with two identifications namely:

(i) What is explicit in the maps (concepts and links).

(ii) What is missing from the map.

The first identification involves the key concepts and the use of prepositions which provides linkages between the concepts on the maps, while the second identification needs a reference map. Therefore, in the diagnosis of the initial knowledge of students before a learning session, the reference map is of course the map that the teacher is planning to communicate during the activity. When comparing the different maps of each students at the same time and defining the level of shared knowledge, these two activities simulate discussion among students thus triggering peer interaction, and the end of these learning activities, the new maps may be compared with the initial ones thus leading to a qualitative evaluation of the conceptual changes activated (Bandiera & Vicentini, 2001).

In other to evaluate and analyze concept maps in a way that attempts to relate the scores of physics students understanding of concept maps, Austin & Shore (1997) devised two new quantitative ways of evaluating concept maps, namely;

(i) linkages- this is the total numbers of links, it is also referred to by Novak (1979) as the number of relationships;

(ii) coding the Maps- this involves coding the maps with the purpose of taking into account the quality of links. The coding is done on a three point scale such that good explanation was coded three (3), medium codes are coded two (2)and links which has no labels are coded one (1).

Austin & Shore (1997) maintained that the use of linkages has the disadvantage that no account is taken of the validity of the labels on the links. Other various methods of analysis of concept maps have been described by a series of researchers including Novak & Gowin (1984) and White & Gunstone, (1992). A commonly adopted scoring procedure is that proposed by Novak (1984); and it consists of the following rules:

(i) Any relationships that are valid attracts one mark each;

(ii) Every valid level of hierarchy attracts five marks each;

(iii) Cross links if valid attracts ten marks each. If the cross link is valid but does not illustrate synthesis between sets of related concepts and preposition score two marks each;

(iv) Examples score one mark each.

The total scores that can be obtained from evaluation of concept maps are subjects to marker variation but the main attributes of concept maps such as links, concepts, prepositions and hierarchical levels should be taken into consideration.

In this study therefore, an investigation was made on the effect of concept mapping strategy on Colleges of Educationstudents' academic achievement and creativity in physics.

2.3 Inquiry Strategy

According to the National Science Education Standard (NSES 2001), an inquiry is "central to science learning" and rests on the premise that science is an active process. Therefore, students that engage in science inquiry are propelled along making their own discoveries and fuelling the desire to learn. Inquiry is a process by which children actively investigate their world through questioning and seeking answers to their questions, and this process is characterized by actions such as probing, searching, exploring and investigating (Mcbride, Bhatti, Hannan & Feinberg, 2012).

Inquiry-based strategyof instruction is a constructivist based approach to education and according to Mayer (2004), it is supported by the work of learning theorists and psychologists such as Jean Piaget, Jerome Bruner and since then it has gained a lot of popularity. Martins & Oyebanji (2000) maintained that inquiry based activities are designed to enhance the development of skills among the learners. The inquiry based strategy is a child-centered activity oriented teaching method in which the teacher directs students through problem solving approach with the aim of discovering answers to instructional topics at hand (Nwagbo 2001). Inquiry based strategy of teaching focuses on the scientific method. The students start from their observations, develop their basic scientific concepts, use and interpret different forms of scientific representation and construct explanatory models with predictive capabilities. The students develop scientific reasoning skills and gain experience in relating scientific concepts, representation to real world phenomena. Wolf (2001) maintained that inquiry method of teaching provide the students with direct experience in the process of science. According to Hensley (2004), inquiry strategy of teaching is a response to an environment of exploration that is expressed through actions and attitudes that manifest themselves in wanting to know why. The first change that researchers can incorporate then is to foster inquiry in teaching and learning so as to create an environment rich in inquiry. Wakili, (2007) showed that teachers who use inquiry method possess five (5) attributes, namely

(i) Nudge conversation with new ideas.

(ii) Take pleasure in learning about new things and solve it.

(iii) Focus on the activities that are activity-based.

(iv) Use jokes, humor and patience to liven things up.

(v) Accentuate the positive about what they found out and think deeply when in conversation with other people.

Hensley (2004) asserted that the heart of this; is an inquiry and creative individual student who can sustain an ongoing appreciation for what learning is and how it can promote awareness ability, self confidence and contribution in the teaching and learning process.Successful teaching and learning encounters have one element in common, and that is the objectives. Performance in teaching and learning has to do with the attainment of set of objectives of instruction. In science instructions for instance, if a learner accomplishes a task successfully and attains the specified goal for a particular learning experience, he is said to have achieved (Nwagbo 2001). The attainment of the goal of science education is a major concern of education policy makers and one of such goal is the inculcation of scientific literacy (FME 2004). Nwagbo, (2001) maintained that the foundation of scientific literacy is laid in schools through the use of teaching method such as the inquiry strategy. Martins & Oyebanji (2002), in their work showed that students taught with inquiry method and allowed to interact and carry out activities in group perform better than those taught with the traditional method. They also maintained that inquiry method in their study is activity oriented and encourages student-teacher, student-student and student-material interactions. Therefore, performance and creativity are clearly two components of an inquiry method when teaching and learning are involved.Harwood (2004) in Wakili (2007) developed a model for inquiry strategy of teaching with the following essential components:

(i) Defining a problem.

(ii) Carrying out a plan.

(iii) Making observations.

(iv) Forming questions.

(v) Asking questions.

(vi) Investigating the unknown.

(vii) Articulating an expectation.

(viii) Reflecting findings.

(ix) Communicating with others. .

This model is not unique to science alone; it is also applicable to other disciplines like the social science, arts, geography and agriculture. Wakili (2007) maintained that inquiry strategy is another method of teaching that can help in enhancing the creativity and performance of students especially in the sciences. This suggestion agrees with the N. C. C. E. recommendation which emphasized on learning science by students using the heuristic approach for total development of the child. For using the inquiry method, he listed the following advantages:

(i) Encourages realism;

(ii) Problem solving abilities;

(iii) Application of principles.

These, minimize any arm chair rhetoric teacher, therefore, based on these studies, the inquiry strategy was adopted in finding out the students academic achievement in physics.

Another instructional strategy that supports inquiry-based science instruction is the 5E learning cycle model, which includes five specific components: engage, explore, explain, elaborate,

and evaluate (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes, 2006). Similar to the motivation component of a non-science lesson plan, the *engage* stage of the model is meant to elicit questions and prior knowledge from students and, of course, to motivate them to learn. During the *explore* stage students carry out the lab activity or experiment by collecting data, making observations, etc., and these explorations are given formal names in the *explain* stage. In the *elaborate* stage students have the opportunity to extend their learning to other topics or to satisfy previously held questions. Seemingly self-explanatory, the *evaluate* stage provides both teachers and students with the chance to both formally and informally reflect upon what was learned. For this study, Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes, (2006) will be used.

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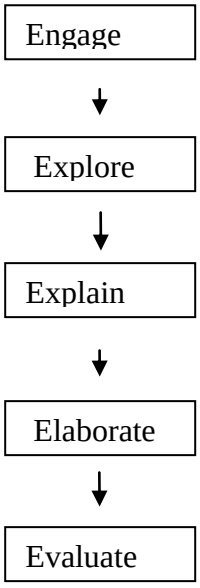


Fig.2.1 Inquiry Flow Chart Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes, (2006) Model.

2.4 Creativity

The theory of creativity begins with the creative process, and according to Wakili (2007), agreeing in total with the creative process is the process of becoming aware of problem deficiencies,

gaps in knowledge, missing element disharmonies, bringing in new relationship and formulating hypotheses.Creativity is believed to be a combination of abilities, skills, motivation, attitudes and other factors (Cheng 2004). Even so, the most popular techniques for enhancing creativity over the past 50 years have involved the teaching of divergent thinking and general problem-solving heuristics (Cheng, 2004). Cheng (2004) also defined the core components of divergent thinking are fluency (generating a large number of ideas), flexibility (generating ideas of different categories or approaches), novelty (generating unusual or rare ideas) and elaboration (generating ideas in detail).

Several scholars have defined creativity differently. Alaba (2007) described creativity as essentially a form of problem solving where there are no easy answers to problems for which popular or conventional responses do not work, it also involves adaptability and flexibility of thoughts. Cheng (2001), stated that creativity is the ability to produce work that is both novel i.e. (original, unexpected) and appropriate i.e. (useful, adaptive concerning task constrains). According to Bolaji (2007), creativity involves the translation of our unique gifts, talents and vision into an external reality that is useful and new. Generally, creativity can be seen as a mental process involving generation of new ideas, concepts or new association that agrees with existing ideas or concepts. Akinboye (2001) summarized the major creative traits to include the following:

1. Fluency:-

   The idea of the individual to come up with different ideas related to a given problem. This means that the individual should be self sufficient in idea generation, make good observation and report accurately.

2. Flexibility:-

   This involves having the ability to generate many solutions to a particular problem. It is also the ability to adapt to new unfamiliar situations and then adjust quite easily

especially to novel situations. An example is the conversion of the resources of the environment for different purposes or being able to apply an idea for various purposes.

3. Originality:-

   This is the creation of something new and unique, asking questions that are relevant, unique and capable of providing new suggestions to many problems, ability to conducting experiments in order to verify facts already known or unknown.

4. Motivation:-

This involves having abundant energy for work of interest in relation to all problems that comes your way. Sometimes it involves emotionally sensitive to new ideas or performing a challenging task on your own will.

Many scholars have suggested that creativity development is inherited in scientific processes. Cheng (2004) considered engaging students in active thinking in the open ended scientific discovery and inquiry process as means of fostering students' creativity. Cheng(2004) also maintained that instead of asking students to follow a fixed set of directions in doing experiments, educators should encourage students to form their own hypothesis and then develop their own experimental design. Therefore, the inquiry approach isa fundamental way to foster creativity in science; and should be incorporated into creativity-enhancing course in science education. Besides the inquiry approach to learning, problem solving are also included in science learning curricular all with the purpose of enhancing creativity (Cheng 2004). He also maintained that educators have tried to integrate other common creativity-enhancing methods of teaching.

Creativity skills if well developed are capable of producing individuals who can take some responsibilities for shaping positively not only their own lives, but also that ofthe society (Onu 2007). Skills that can make students think logically, ask reasonable questions and seek appropriate answers will not only solve daily problems but are also useful in non-scientific situations (Onu2007). Science taught with a variety of teaching methods will help impart quality scientific information and then produce learners that will be self reliant. Therefore, science teaching in our schools should be modeled in such a way that can enhance performance and creativity. Though there are a number of researchers suggesting some specific instructional strategies for developing creativity and performance in science, other sets of activities for focusing creativity and performance can also be source of concern.

Therefore, this research study used the major creativity traits of fluency, flexibility, originality and motivation as pointed out by Akinboye (2001) on NCE I physics students taught physics concepts using concept mapping and inquiry strategies of teaching.

2.4.1 Creativity and Academic Achievement in Physics

The acquisition of creative skills by the science teacher is an important factor in the teaching profession and being creative is an element in the psychology and development of a person and also one of the objectives of teaching. According to Afuwape, (2004) the intervention of the teacher variable in the instructional setting is a major prediction of any learning outcome. For a teacher to inspire creativity in students, he must be creative, and to be creative he must develop the skills for initiating new approaches for better academic achievement.

In physics class, being creative imply students are given the chance to venture answers which the teacher would have provided. The teacher pose questions whose answers are not in textbooks and the students are allowed to do something which has never been done before, something traditional

and the teachers must not insist on precise answers. In a study conducted regarding student learning in Physics, Cheng, (2004) found out that in the student evaluation, consistent with the nature of most creative activities, most students felt that these Physics creative activities are interesting, playful and quite different from normal learning activities. Some students agreed that these activities make them think more, wider, andenhance their creativity, whereas other students who were aware that their creativity is not enough, need to put effort on this area. Besides learning outcomes in creativity domain, these activities also have impact on students' academic achievement and creativity in physics learning. They discovered that Physics is more interesting, and more related to daily-life and creativity than they think before. To some students, these activities made them think more deeply in Physics and realized that their physics knowledge is not enough. In short, the creative thinking activities in Physics are not merely useful in fostering creativity of students, but also for promoting "better" Physics learning which subsequently enhances students' academic achievement. It is on this basis that concept mapping and inquiry strategies of teaching were used in this research study since both strategies involve critical thinking.

2.5Academic Achievement in Relation to Teaching Strategies

A teaching strategy is the overall plan developed by the teacher to satisfy his instructional objectives. Every teacher uses a variety of methods and technique in order to obtain a high level performance from his students. This is done at all levels of education. According to Akinbobola (2006), the selection of the appropriate and most effective strategies of instruction is very important to the success of any lesson. According to Lakpini (2006), the failures of the curriculum planners of 1970s were due to the fact that there was neglect of human construct and use of meaning to guide their actions on instructional strategies. The need to improve instructional strategies in science is those of the constructivists' views that allow students personal experiences in the construction of

their knowledge that were neglected in the previous learning strategies. Lakpini, (2006) maintained that there is the need to have a shift from teaching strategies that are teacher-centered to student-centered strategies that recognize the role of personal construction in the development of science education.

For any teaching strategy to be effective, Lakpini, (2006) asserted that the most important single factor influencing learning is the learner's prior knowledge. This is based on the constructivist theory of learning based on the idea that the conceptions the learner holds have a considerable influence in the learning process. This theory argues that knowledge is constructive. In combination with new knowledge, learners generate knowledge and meaning from their past experiences. At first, learners assign simple meanings to objects and phenomena. Knowledge becomes more complicated as learners become more experienced (Hsu and Chang 2011). Essentially, constructivism says that:

(1) Learners are the center of learning, and knowledge is constructed based on their past Experiences.

(2) New knowledge is constructed based on experience or old knowledge.

(3) Learning incorporates andgives meaning to the old and the new.

(4) Knowledge is complicated and contextual, and learners must exhibit their understanding in complex situations.

Constructivism is about building new ideas on old knowledge,creativity and thinking are emphasized, and learners can therefore flexibly construct their own mental modes and cognition.

It is to this end that this study was conducted to expose students to student-centered mode of teaching by using concept mapping and inquiry strategies to find out the academic achievement and creativity of Colleges of Education students in physics in North Eastern Nigeria.

2.6 Overview of Similar Studies

Few topics have captured as much attention from policymakers and practitioners as the connection between creativity and student achievement. The research has clearly shown that instructional strategy is important to student creativity and academic achievement. Teaching strategy has been consistently identified as the most important school-based factor in student achievement (Ogunleye & Babajide 2011).

Lawal (2004), in a study on the effects of The effect of Concept Mapping Strategy on Cognitive Preference and Academic Achievement in Genetics of 95 undergraduate students in genetics, it showed that there was a statistical difference in cognitive preference grouping of the subjects (students) after the treatment in concept mapping technique. It also discovered that there was a correlation between the achievement scores in genetics and concept map grades of the subjects.

In a study conducted by Aishana, (2007) on concept mapping instructional strategy and expository method in a mathematics class, the studywas conducted on 300 Junior Secondary school students(JSS 2) from five (5) schools in the Federal Capital Territory used t-testand concluded there was no significant difference between students that were exposed to concept mapping those exposed to expository method. However, there was significant difference in performance between boys and girls; the boys performed better than the girls, but concluded that concept mapping is effective in concept acquisition and capable of stimulating students resulting from their interactions and discussions of the topics.

Hsu and Chang (2011) examined forty students in the Design Department at a Technical University to analyze whether computer-based concept mapping and applications improved students' video production and creative performance. The instrument used for the collection of the data was a

questionnaire, descriptive statistics and correlation analysis were used for the data analysis, and the results showed that:

(1) The application of computer-based concept mapping received approval from students.

(2) Students' concept mapping performance is directly related to academic performance.

(3) students' concept mapping performance can effectively predict their creative performance.

The study also examined whether concept mapping helps students create digital films and it concluded thatcomputer-based concept mapping benefits students' creative and thinking abilities.

Carroll, (2012) investigated the influence concept mapping and inquiry methods in creativity on 60 secondary schools students in Integrated Science and confirmed that giving students hands-on experiences and opportunities to construct their own meaning through inquiry achieve much in both cognitive and creativity. The results of the study also revealed that the student creativity traits of fluency, flexibility, originality and motivation were better enhanced through inquiry than in concept mapping.

Ajewole (1991) found the effect of guided discovery and expository instructional methods on the attitude of students to biology. He used 240 SSI students of biology randomly drawn from six schools in Oyo State, Nigeria. He used a 40-item scientific attitude questionnaire with a five-point scale. He found out that, the experimental groups i.e those taught using guided discovery method had a significantly more favorable attitude to biology than the control group, in addition the study revealed a non significant difference in attitude between male and female students exposed to the two teaching methods.

McDermott and Shaffer (2000), studied on teaching physics and physical science by inquiry learning strategy and problem solving and its effects on students' academic achievement in

secondary school physics. A total of 280 students took part in the study and the result showed that inquiry learning strategy enhanced students' achievement in physics more than problem-based learning strategy. The study also concluded that when students are allowed to discover problems and work together cooperatively in a small group to find solutions to them through joint intellectual effort; resourcefulness, innovation, creativity, student -centeredness, respect for other people's view, problem solving skills, initiative, curiosity and critical thinking can be created, developed and sustained in physics classroom.

Cheng, (2004), investigated the use of inquiry method of teaching in developing students learning abilities for fostering students' creativity in Hong Kong, he used 120 secondary school students in a physics class and concluded that the use on inquiry strategy can foster students creativity in physics.

In another development Agboghoroma (2005), in trying to ascertain the knowledge acquisition of urban and rural subjects in integrated science, used 360 JSS III students exposed to the guided-inquiry method as well as students not exposed to the inquiry method and, with the use of covariance adjustment, found that there was a significant difference (improvement) in the knowledge acquisition of the exposed urban students exposed to inquiry method.

In a study conducted on the influence of guided discovery approach on creativity traits of 187 Integrated Science students at the Junior Secondary school in Kafanchan, Wakili, (2007) used t-test and concluded that students taught using guided discovery approach performed better in terms of creative idea generation when considering all the creativity traits of fluency, flexibility, originality and motivation. The study also concluded that when appropriate teaching method like guided discovery is employed in teaching and learning science, it influences creative traits and the application of these skills in solving scientific problems becomes effective.

Afuwape, (2004) maintained that inquiry allows learners to operate independently and find out facts on their own using known techniques of investigations to explore the environment. According to the study, Afuwape, (2004) concluded that inquiry teaching strategy helps develop students' academic achievement and creativity towards science since it is activity-centered and provides opportunity in the real world of science.

Hussain, Azeem & Shakoor (2011), in a research on inquiry and traditional method of instruction in a secondary school physics class; the inquiry class was divided into three levels—guided scientific inquiry, unguided scientific inquiry and combination or mixed (guided & unguided) scientificinquiry. The major objective of the study was "to study the effect of three levels of scientific inquiry method and traditional method of teaching physics on students' performance and their proficiency to apply the physics knowledge in real life situations. One of the experimental groups was taught by guided scientific inquiry; Second group was taught by unguided scientific inquiry and third was taught by combination scientific inquiry and fourth group was taught by traditional method. Using ANOVA, the research explored that there is significant effect of guided, unguided and combination scientific inquiry on the students' achievement than traditional physics teaching method and their proficiency to apply the concepts of chemistry in real situations. The research concluded that students who weretaught by inquiry methods of teaching were better in applying the concepts of physics to real life situations.

Alaba (2007) investigated the use of educational cartoons and comics in enhancing creativity on 420 primary school pupils in Ile-Ifeand acknowledged that creative teaching strategies coupled with a creative environment can enhance progressive and creative growth in students.

This study therefore compared concept mapping and inquiry strategies on academic achievement and creativity of NCE students in physics in the North Eastern Nigeria.

2.7Implications of Literature Review on the Present Study

Related literature on concept mapping and inquiry strategies on students' academic achievement were reviewed. Apart from studies which solely determined the effects of concept mapping on students' academic achievement along with other instructional strategies and their combined effects, some of these studies showed significant improvements on students' academic achievements. For example, Lawal (2004), investigated the effects of concept mapping on cognitive preference and students academic achievement in genetics and the results showed a significant difference in favour of concept mapping strategy. Similarly, Aisahana (2007) studied the effects of concept mapping on mathematics achievement of Junior Secondary school students. Hsu & Chang (2011)investigated the relationship between computer-based concept mapping and creative performance among university students and discovered that concept mapping has direct effect on both students' academic achievement and creativity. In the same vain, Caroll (2102) investigated the effects of concept mapping and inquiry strategies as tools for measuring creativity in Integrated Science.

Similarly, literature on the effects of inquiry on students'academic achievement and creativity were also reviewed.Ajewole (1991) studied the effect of guided discovery and expository instructional method on the attitude students to biology. McDermott & Shaffer (2000) investigated the effects of teaching physics by inquiry teaching strategy and problem solving on secondary school students and their academic achievement. In the same vain Wakili, (2007) found out the influence of guided discovery approach on the creative traits of Integrated Science students at the junior secondary school level in Kaduna state. Alaba (2007) investigated the use of educational cartoons and comics in enhancing creativity in school pupils in Ile-Ife acknowledged that creative teaching strategies coupled with a creative environment can enhance progressive and creative growth in

primary school pupils. Hussain, Azeem & Shakoor (2011) conducted a research on physics teaching methods: Inquiry vs traditional on secondary school students and concluded that students who were taught by inquiry were better in applying the concepts of physics to real life situation.

Thepresent study therefore sought to find the effects of concept mapping and inquiry modes of instruction onstudents' academic achievement and creativity in physics. The uniqueness of the present study was that it was conducted at the NCE level among Colleges of Education physics students in North Eastern Nigeria. It is expected to add to existing literatureon concept mapping and inquiry strategies.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The aim of this study is to ascertain the effects of concept mapping and inquiry strategies on the academic achievement and creativity of Colleges of Education students in North-Eastern Nigeria. This chapter therefore described the procedure used for the study under the following sub-headings:

- Research Design
- Population for the Study
- Sample and Sampling Technique
- Selection of Topic to be Taught
- Instrumentation
- Validation of the Instrument
- Pilot Study
- Reliability of Instrument
- Data Collection Procedure of Physics Achievement Test
- Data Collection Procedure of Ibadan Creativity Assessment Scale
- Item analysis of Physics Achievement Test
- Treatment of Experimental Groups
- Data Collection Procedure
- Procedure for Data Analysis

3.1Research Design

This study is a pretest-posttest experimental matched group design. According to Lawal (2004), the matched group design could be used when the groups compare favorably. The academic achievement and creativity traits of both groups were measured using Physics Assessment Test (PAT) and Ibadan Creativity Assessment Scale (ICAS) during the pretest. The schools from which the subjects were derived were assigned randomly to experimental group E_1 and experimental group E_2. Both groupswere taught using concept mapping and inquiry strategies of teaching respectively in six contacts or lessons which lasted for six weeks. A posttest PAT and ICAS were administered to both groups at the end of the treatment. The PAT was used to measure their academic achievement in physics concepts, while ICAS test was used to measure their creativity traits of fluency, flexibility, originality and motivation. The illustration is represented in figure 3.1.

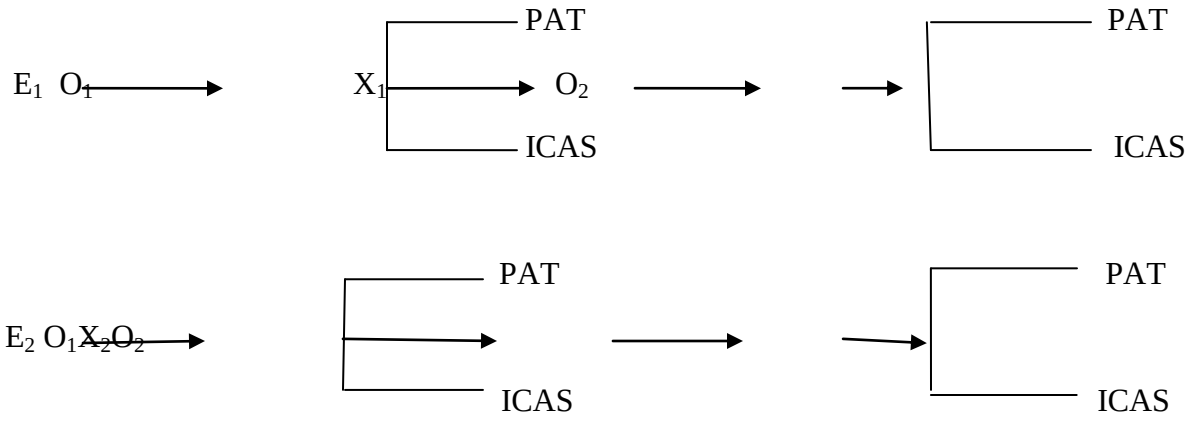


Figure 3.1 Research Design illustrations:

Where E_1 and E2 arethe Experimentalmatched groups

X_1……Concept mapping strategy

X_2…….Inquiry strategy

O_1…….Pre test

O_2……..Post test

PAT…… Achievement test

ICAS ……...Creativity test

3.2 Population of the Study

The study comprised all NCE I students in all the seven state Colleges of Education studying in the North Eastern Nigeria studying PHY 121 (Thermal Physics), a second semester course offered by all NCE I physics students.There are 247 physics students in NCE I of Colleges of Education in the North-East Zone; comprising 155 male and 92 female as shown in table 3.1

Table 3.0 Population of the Study

S/No	Name of School	Location	NCEI Population		Total
			Male	Female	
1.	C.O.E Azare	Azare, Bauchi State	21	14	35
2.	C.O.E Gashua	Gashua, Yobe State	15	8	23
3.	C.O.E Bama	Bama, Borno State	18	17	35
4.	C.O.E Jalingo	Jalingo, Taraba State	21	12	33
5.	C.O.E Hong	Hong, Adamawa State	27	19	46
6	Sir Kashim Ibrahim C.O.E Maiduguri	Maiduguri,Borno State	27	14	41
7.	C.O.E Waka, Biu	Waka, Borno State	26	8	34
	Total		155	92	247

Source: Admission Office of the Colleges(2012)

3.3 Sample and Sampling Technique

In a study such as this, it is not practically possiblefor the whole population to be involved directly. Therefore, a sample was drawn from the population. Out of the seven (7) state Colleges of Education in North Eastern Nigeria, four were selected using simple random sampling technique through pick from a hat method. Pretest was conducted with a view to finding out their group equivalence by conducting a pretest. Analysis of variance was used to find out the statistical difference between the schools and it revealed that $P \leq 0.282$; which showed that there is no significant difference between the schools at $P \leq 0.05$ levels of significance. (Appendix x)Hence, the two schools selected as the samples were College of Education Waka and College of Education Jalingo. The sampled schools were obtained using picking from a hat method.By flipping a coin, C.O.E Jalingo and CO.E Waka were assigned to concept mapping strategy and inquiry strategy of teaching respectively.The sampled schools for the study are shown in the table 3.2.

Table 3.1 Sample for the study

S/no	**Name of school**	**Location**	**No. NCE I selected**		**Total**
			Male	**Female**	
1	C.O.E Waka Biu	Biu, Borno State	26	8	34
2.	C.O.E Jalingo	Jalingo, Taraba State	21	11	33
	Total		47	19	67

Source: Admission office of the Colleges (2012).

3.4Selection of Topic to be Taught

The topics for the study were the ones obtained in PHY 121 (Introduction to Thermal physics), it is a two credit unit course at the NCE one level. The Physics content chosen for this study mainly deals with thermal physics which is one of the domains of physics, it defines laws of energy, thermal energy development and conservation laws and it is applicable to laws of conservation of mass (Odell, 2005).The choice of the course isdue to the fact that the organizational concepts and techniques contain the basic knowledge needed by students in an introductory physics class.

3.5 Instrumentation

The instruments that were used for data collection in this study were:

(i) Physics Achievement Test (PAT). Appendix i.

(ii) Ibadan Creativity Assessment Scale (ICAS). Appendix iv

3.5.1 Physics Achievement Test (PAT)

The Physics Achievement Test (PAT) was constructed by the researcher and comprised thirty multiple choice items with options A-E. The test comprised questions on concepts drawn from the topics selected in PHY 121 which were heat and temperature, change thermal energy development heat transfer, and kinetic theory of gases.(See appendix x)

Table 3.2 Table of Specification for PAT based on Topics selected

Topics selected	Items	Total
Concepts of Heat and Temperature	1,2,8,19,20,26,2807	
Thermal Energy Development	3,15,21,27 04	
Heat Transfer	4,5,9,10,11,13,14,22,24,30	10
Kinetic Theory	6,7,8,12,16,17,23,25,29	09
Total	30	

3.5.2 Validation of Physics Achievement Test (PAT)

The content validity of PAT and the marking scheme were assessed by five (5) experts drawn from Science Education and Physics Departments of Ahmadu Bello University, Zaria. These experts who were senior lecturers and above in rank were requested to critique the items and options for the test. The experts were requested to examine and assess the entire test items with reference to the following:

i. The validity of PAT that is whether it conforms to the objective of the content and specifications it is to test.
ii. Are the items clear, precise and free from ambiguity?

The items final in the test that were carefully selected and agreed with those of the experts, hence the final set of the test items were made to conform with the course PHY 121 as contained in the NCE I minimum standard.

3.5.3 Validation of Ibadan Creativity Assessment Scale (ICAS)

The Ibadan creativity Assessment scale (ICAS) is a creativity assessment scale that was created by Akinboye (1977) and was adopted for this study. It was constructed based on a 9-Likert scale –rating items which attempts to describe the creativity of an individual in order of magnitude i.e 1,2,3…….,9 with zero as least descriptive of the individual. It has a total of eighty nine (89) items across individual's fluency, flexibility, originality and motivation. The creativity measuring instrument (ICAS) was given to a Senior Lecturer in Psychology Department of Abubakar Tafawa Balewa University Bauchi, and a principal Lecturer in the English Department of and Federal College of Education (Technical), Gombe with a view to critically examine its clarity, readability, suitability and standard at the NCE level.

3.6 Pilot Testing

The Instruments Physics Achievement Test (PAT) and Ibadan Creativity Assessment Scale (ICAS) were pilot- tested on NCE I physics students of Federal College of Education (Technical), Gombe. This school is not part of the population used for the study. The aim of this pilot study was to determine the characteristics of the test items, which include their facility and discrimination indices and the reliability coefficient. Thirty students comprising 21 male and 9 female participated in the pilot testing. The students were subjected to the achievement test (PAT) i.e PHY 121 which covered the topics, concepts of heat and temperature, thermal energy development, heat transfer and kinetic theory. After PAT and ICAS were administered, the data generated were analyzed with a view to determining the characteristics of the test items of PAT and the reliability coefficient of PAT and ICAS. The results of the item analysis are shown in Appendix v. The results of the pilot test were then used to:

(i) test the workability of the instruments.

(ii) find out the characteristics of PAT and ICAS items through item analysis, difficulty level and facility indices of the items.

(iii) determine suitable time duration for each item administered.

(iv) test run the instruments and to

(v) determine the reliability of the instruments

3.7 Reliability of Physics Achievement Test (PAT)

The reliability coefficient of PAT was obtained using Kuder-Richardson formula. It was found to be 0.62. The K_r-21 formula was adopted because it is more suitable for teachers, requires less computation and is useful when items are multiple responses (Lawal, 2004). The formula is shown below

$$K_r - 21 = \frac{n}{n-1}\left[1 - \frac{(n^2 - X)}{ns^2}\right]$$

Where n = number of items in the test, s^2 variance of the total test, x = normal mean,

X is the raw of the test. The split half coefficient was obtained then the Kuder- Richardson formula.

3.7.1 Reliability of ICAS

The data obtained from the pilot study revealed a reliability coefficient of 0.66 using split-half Hence from these results, the instrument can be said to be reliable and adequate for the study.

3.8 Item Analysis

Item analysis was carried out on all the items in the test (PAT) with a view to determining the facility index (difficulty index) and also to estimate the discrimination index. (See appendix v). The facility index of each of the items in the achievement test is meant to find out how easy or difficult the test may be. Fernandez etal, (2007) recommended that the range from 0.30 – 0.70 for a good test,

hence adopted for the study. For this study, the facility index (FI) form 0.25 0.75 was obtained for the study. The formula is given as:

$F.I = \frac{R}{T}\ X\ 100,$

Where R = number of candidates that got the item correct,

T = number of candidates that attempted the item.

The discrimination index was also determined with a view to distinguishing between the high and low rankings of the learners in the achievement test. The calculation was done by using the scores of the top twenty-seven percent (27%) and the top twenty-seven (27%) of the total respondents (Lawal 2004). The formula is given as

$$d = \frac{(R_u - R_l)}{N}$$

$\frac{1}{2}N = N_0$ number of respondents in each of the upper and lower 27%.

3.9 Treatment of Experimental Groups

The researcher taught the two experimental groups using Concept Mapping and Inquiry Strategies respectively for six (6) weeks. During this period, the course PHY 121 (Introduction to Thermal Physics) was taught by the researcher in which Concept Map construction technique was taught and practiced with experimental group E_1 and lasted for two hours in each contact and Inquiry strategy was used on experimental group E_2 using the same course PHY 121 (Thermal Physics I). See lesson plans in appendixes viii and ix.

The hierarchical concept map by Novak, (1990) was adopted for this study. The prior knowledge of the subjects was consciously and purposely exposed by asking the students to define work, energy, power, state the conservation law of energy and mass and other forms/types of energy and by so doing the new concepts were linked. The concepts and propositions relating to PHY 121 were outlined and written on cardboards. The subjects were then required to pick a concept and link it to

the most relevant proposition. Similar training sessions were conducted for six weeks, and each session last for two hours (2hrs). Every training session has a planned procedure shown in figure 3.2.

Concepts	**Propositions**
Physics	Explains
Energy	Results
Motion	Can be
Newton's Law	Follows
Unbalance	Study of
Acceleration	Change in
Force	Describes
Position	Causes
Speed	To produce

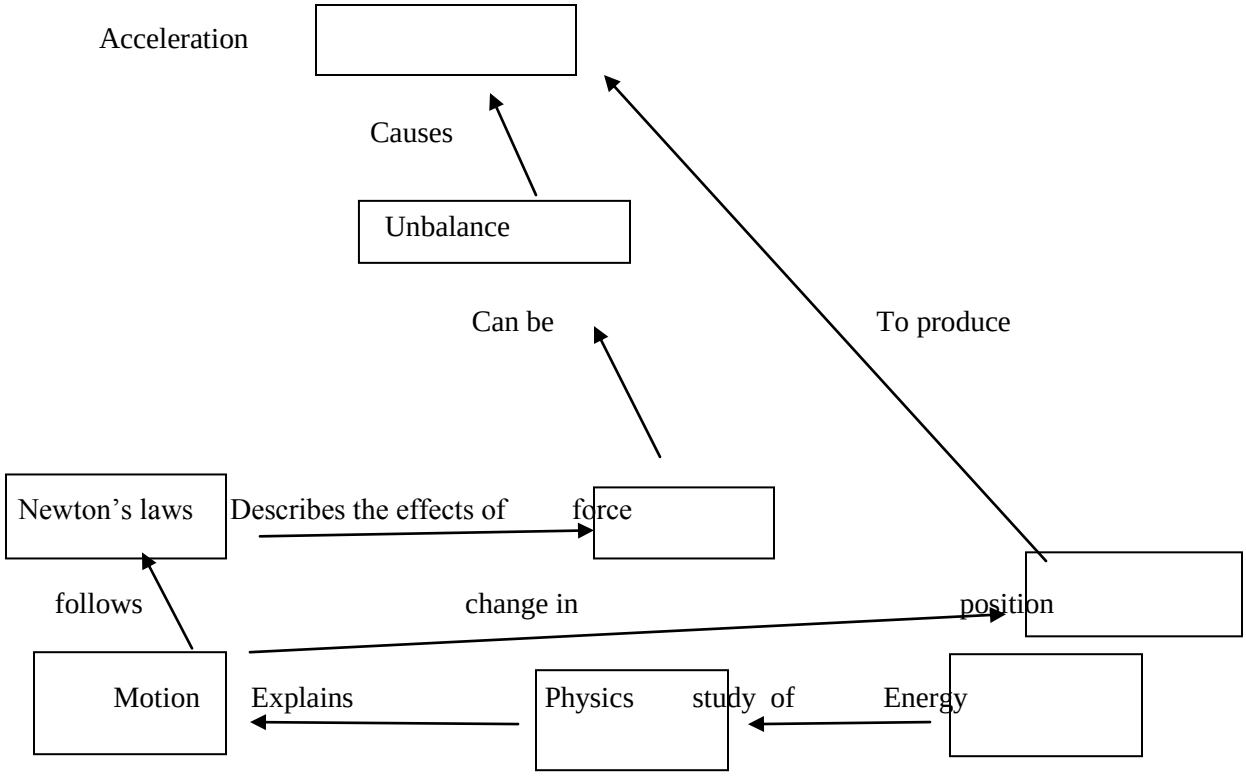
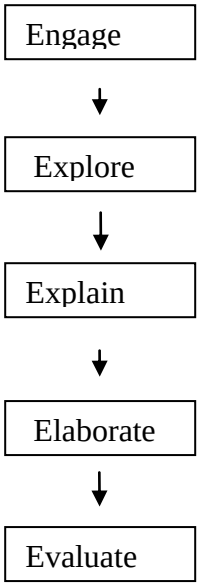


Fig. 3.2 A plan procedure of a Concept Map

The Inquiry Strategy used was adapted fromBybee, Bloom, Philips, Knaaps, Zander &Pence (2006) which is based on the science by inquiry model using the 5E learning cycle model, comprising engaging, exploring, explaining, elaborating, and evaluating the activity performed. The flow chart is described in figure 3.3

Fig.3.3 flow chart of Bybee *et al* (2006) model.



The students were divided in small groups and allowed to explore the concepts through practical activities, exploration of the concepts and ask questions that are meant to lead them to observe and discuss their experiences. The teaching lasted for six weeks consisting of double period/week lasting for 2 hours each.

Based on the above model, each of the activities was explained in the table below.

Inquiry-based ExercisesUnit Activity	
Heat and temperature	Use thermometer to find out the difference same type of liquid at different temperatures, and use solids to find out how heat flows.

Heat transfer	Make solid naphthalene to determine it's specific heat capacity
Thermal energy development	Determination of thermal conductivity of solids
Kinetic theory	Heating a closed empty container to record an increase in its volume.

After the treatment both experimental groups E_1 and E_2 were exposed to a posttest using the Physics Achievement Test (PAT) and Ibadan Creativity Achievement Scale (ICAS), at the end of which their academic achievement and creativity were measured using PAT and ICAS respectively.

3.10Procedure for the Administration of PAT

Before treatment, the sampleswere classified as experimental groups E_1 and E_2 respectively. A pretest was conducted on both groups using PAT with a view to finding the groups equivalences before treatment. After the pretest, both were subjected to a six (6) weeks lesson of 2 hours/week for the treatment. Theexperimental group E_1 was taught PHY 121 using Concept Mapping Strategy and the same course was taught to the other experimental group E_2using Inquiry Strategy. At the end of the treatment both groups were post tested using PAT. The test was marked out of 30, ie 1 mark for each question using the marking scheme (see appendix iii). The scores were recorded and grouped into experimental group E_1 and E_2, with a view to finding out the significance difference in their academic achievement after treatment.

3.11Procedure for the Administration of ICAS

Ibadan Creativity Assessment Scale (ICAS)was administered on both groups before and after treatment. This instrument was used to find out if there was a significant difference in their creativity traits of fluency, flexibility, originality and motivation between the two groups before and after

treatment. Itwas given to each member of the sample to respond and was retrieve within a period of seven days.

3.12Data Analysis

The data collected on the students' academic achievement using Physics Achievement Test (PAT) wasanalyzed using descriptive statistics in answering the research questions while independent t-test statistic for testing the research hypothesis.The data collected on their creativity traits were collected using Ibadan Creativity Assessment Scale (ICAS), and were analyzed using descriptive statistic for answering the research questions and two-way analysis of variance was used in testing the research hypothesis.

All hypotheseswere tested at a level of significance $P \leq 0.05$. The hypotheses are restated with their respective statistical tool as follows:

$H0_1$: There is no significant difference in the academic achievement of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

Independent t-test was for this hypothesis

$H0_2$: There is no significant difference in the creativity traits of

(a) Fluency

(b) Flexibility

(c) Originality and

(d) Motivation

of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

Two-way analysis of variance was used for this hypothesis.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the analysis of data and the results obtained from the study are presented. Also, the research questions raised were answered using descriptive statistics and the formulated hypotheses for the study were tested using independentt- test for the first hypothesis and two-way analysis of variance for the second hypothesis. The chapter also provided a brief summary of the findings. Each hypothesis was tested at a significant level of $P \leq 0.05$, which formed the basis of rejecting or accepting the null hypotheses.

4.2 Analysis and Results Presentation

The analysis and presentation of the results were conducted using descriptive statistics in responding to the research questions and t-test was used to test research hypothesis one, while two ways analysis of variance was used to test the second hypothesis..

Research question one

i) Is there any significant difference in the mean score of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy?

To answer research question one, the mean score between the two groups was determined using descriptive statistics and the result is presented in Table 4.0

Table 4.0Descriptive Statistics Results of Difference Between Academic Achievements of Experimental Groups E_1 and E_2

Group	N	Mean	Std Dev.	Mean Score Difference
Experimental group E_1	33	19.79	2.71	
				0.44
Experimental group E_2	34	19.35	2.39	

The results in Table 4.0 showed that experimental group E_1 has a mean of 19.79 while the mean of experimental group E_2 is19.35;the difference in mean was observed to be 0.44 and to test whether the difference is significant or not, null hypothesis one was formulated and tested using independent t-test statistic, the hypothesis reads:

Research Hypothesis One

$H0_1$: There is no significant difference in the academic achievement of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

Table 4.1:Comparison of the Academic Achievement Between the ExperimentalGroup E_1 and Experimental group E_2.

Group	N	Mean	Std Dev	S.E	Df	t_{cal}	t_{crit}	Decision
ExperimentalGroup E_1	33	19.79	2.71					
				0.472	65	0.69	1.67	accepted
Experimental Group E_2	34	19.35	2.339	0.409				

$p \leq 0.05$

The results shown in Table 4.1 revealed that t-calculated has a value of t_{cal}0.69, while t-critical has a value of 1.67 for df = 65 at $P \leq 0.05$ and since t_{crit} is greater than t-calculated, the null hypothesis is therefore accepted, this signifies that there is no significant difference on the academic achievement of students taught PHY121 using Concept Mapping Strategy and those taught the same course using Inquiry Strategy of teaching.

Research question two

iii) What is the difference in the creativity traits of

(i) Fluency

(j) Flexibility

(k) Originality and

(l) Motivation

of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

To answer research question two, the meanbetween the two groups was determined using descriptive statistics and the result is presented in Table 4.2

Table 4.2 Descriptive Statistics Results of Difference in Creativity Traits Between Experimental Groups E_1 and E_2.

Experimental Groups	Creativity Traits	N	Mean	Std Dev	Mean Score difference
Experimental Group E1		33	131.57	17.44	
	Fluency				1.99
Experimental Group E2		34	129.58	45.78	
Experimental Group E1		33	113.18	18.97	
	Flexibility				19.39
Experimental Group E2		34	93.79	25.55	
Experimental Group E1		33	122.91	26.89	
	Originality				2.85
Experimental Group E2		34	120.06	30.31	
Experimental Group E1		33	95.18	21.34	
	Motivation				5.44
Experimental Group E2		34	100.62	22.40	

The descriptive statistics in Table 4.2 showed that among the Concept Mapping experimental group E_1, their creativity traits mean scores were 131.57, 113.18, 122.91 and 95.18 in fluency, flexibility, originality and motivation respectively. Among the inquiry strategyexperimental group E_2, their creativity traits mean scores were 129.58, 93.79, 120.06 and 100.62 in fluency, flexibility, originality and motivation respectively. The mean score difference in creativity traits between the two

experimental groups were found to be 1.99, 19.39, 2.85, and 5.44 in fluency, flexibility, originality and motivation respectively. To test whether there is any significant difference in creativity traits between the two experimental groups E_1 and E_2, a null hypothesis was formulated and tested using two-way analysis of variance and it reads:

$H0_2$: There is no significant difference in the creativity traits of

(a) Fluency

(b) Flexibility

(c) Originality and

(d) Motivation

of Colleges of Education students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy.

Table 4.3:Two-ways analysis of variance on the significant difference in the creativity traits of Experimental group (E_1) and Experimental group (E_2)

Source of Variation	**Type III sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Experimental Groups	1814.60	1	1814.60	2.40	0.123
Creativity Traits	44538.464	3	14846	19.636	0.000
ExperimentalGroups Creativity Traits	5386	3	1793.707	2.372	0.071
Error	196580.459	260	756.079		
Total	3674727.00	268			
Corrected Total	248339	267			

Table 4.3 showed the two-way analysis of variance statistics indicating that there is no significant difference in the creativity scores of students of varied traits of fluency, flexibility, originality and motivation taught physics concepts using concept mapping and those taught the same concepts using inquiry strategy. Reason being that the P-value for varied traits versus experimental groups is 0.071, which was found to be higher than the 0.05 alpha level of significance. The significant P value for varied abilities levels was 0.000 and that of the experimental groups was 0.123 was found to be higher than the alpha level of 0.05. This means that between the experimental groups, the varied creativity traits showed no significant difference. Therefore, the null hypothesis which states that there is no significant difference in the creativity traits of fluency, flexibility, originality and motivation of students taught physics concepts using Concept Mapping and those taught the same concepts using Inquiry Strategy is hereby accepted and retained.

4.3 Summary of Findings

In this study, the following findings were made:

(i) There is no significant difference between the posttest mean scores of the experimental group E_1 taught physics concepts using concept mapping strategy and experimental group E_2 taught the same concepts using inquiry teaching strategy.

(ii) There is no significant difference between the creativity traits of fluency, flexibility, originality and motivation after the post-test of the experimental group E_1 taught physics concepts using concept mapping strategy and experimental group E_2 taught the same concepts using inquiry strategy of teaching.

4.4 Discussion of the Results

In this section, the results of the research findings were discussed based on the outcome of the responses obtained from the research hypotheses.

The study compared concept mapping and inquiry strategies of teaching on the academic achievements and creativity of Colleges of Education physics students in the North Eastern Nigeria. To this effect, the data of the posttest were collected from Taraba State college of Education Jalingo and Borno State College of Education Waka-Biu. Both schools were post tested via an experimental matched group design E_1 and E_2 after being taught the same physics concepts. The samples from both schools were taught for six weeks and the data collected after the treatments were analyzed using descriptive statistics for the research questions and independent t-test for the first hypothesis, while two-way analysis of variance was used to test the second hypothesisboth at$P \leq 0.05$ levels of significance.

Null Hypothesis One

The results in Table 4.1 indicated that there is no significant difference in the academic achievement of those taught physics concepts using concept mapping strategy and those taught the same concepts using inquiry strategy of teaching. This finding is in agreement with the fact thatconcept maps help students to organize their knowledge and think in a logical manner (Cheng, 2001). Concept maps also help students to organize their knowledge around the most important concepts and principles of the subject content (Nousiainen & Koponen, 2010). On the other hand, students who were taught by the guided, unguided and combination scientific inquiry strategies of teaching always perform well; since the teaching method is activity oriented and also allow students to interact with the first hand information of whatever they discovered and are in a better position in

applying the concepts of physics to real life situations (Hussaini, Azeem &Shakoor 2011).The results obtained indicated that both Concept Mapping and Inquiry Strategies are students centered strategies and this have resulted in their academic achievement

Null Hypothesis Two

In Table 4.3, the result indicated that there is no significant difference between the experimental groups E_1 andE_2 in terms of the creativity traits of fluency, flexibility, originality and motivation of Colleges of Education students taught physics concept using Concept Mapping and those taught the same concepts using Inquiry StrategyThe results indicated that Concept Mapping and Inquiry teaching Strategiespositively influenced students' creativity. These findings agree with the results of Wakili (2007) who reported that inquiry teaching approach increases students' abilities to come up with divergent views on issues/human activities and hence increases students' creativity. Similarly, Sisovic and Bojovic, (2000) revealed that a concept map can help students: to analyze a problem from different angles, helping to develop a divergent way of thinking. It also helps to develop and enlarge their network of knowledge, as well as their abilities to make use of it. Also, concept maps can help the teacher to recognize the causes of students' eventual misconceptions, which is valuable information for further planning and performing of the teaching process.

In the same vain, Hsu and Chang (2011)maintained that Concept Mapping Strategies can help students learn to organize and symbolize knowledge through activity oriented instructions,and also asserted thatit can facilitate students' attainment of the goals of meaningful learning and increasing effective knowledge, which expands thinking ability, stimulates creativity and arouses inspiration. This is due to the fact that in creativity, students are explicitly asked to give more different categories of answer, to change directions, or to give more details and elaborations of the answers. This is in agreement with the findings of Cheng (2004) who maintained that creativity

traitscan foster divergent thinking abilities, and provides additional qualities to creative individuals in responding to critical scenarios.The result was obtained because in concept mapping, students were flexible in their thinking as they were allowed to choose and think of a suitable proposition that can link physics concepts.

The finding from this study is also in agreement with the findings of Sisovic and Bojovic, (2000); who reported that when concept maps are combined with demonstration experiments to help students to apply their knowledge of concepts and their interrelations, as well as to formulate theoretical explanations for the observed changes, they then engage in activities which promotedifferent creativity traits in them. Many scholars have suggested that creativity development is inherited in scientific processes for instance, Cheng (2004) considered engaging students in active thinking and scientific inquiry process as means to foster students' creativity, they also maintained that instead of asking students to follow a fixed set of directions in doing experiments, educators encourage students to form their own hypotheses and their own experimental design and concluded inquiry method is considered as a fundamental way to foster creativity in science, and is most widely incorporated into creativity-enhancing course in science education.The result was obtained due to the fact that both teaching strategies are activity oriented and allow for the development of the scientific processes inherited in the students to be explored.

Similarly, Nousian & Koponen (2010) which showed that structured and well connected concepts that are properly arranged can foster creativity traits especially when students' desire for knowledge.Wakili (2007) maintained that more than anything else, teaching strategies affects the response of students and determines whether they are interested, motivated and involved in the lessons in a way as to be engaged in good learning. This research also signified that the students who are taught by the scientific Inquiry Strategy of teaching were better in applying the concepts of

physics to real life situations. This is supported by (Hussain, Azeem & Shakoor, 2011) that any inquiry strategy involving individual and cognitive constructivism is a highly effective method of teaching in which all students can benefit from since collaboration and social interactions are incorporated. Student centered teaching strategies allow students to provide solution to problems and by so doing, the students become motivated in their learning tasks, that was why this result was obtained from the study.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The study compared effects of Concept Mapping and Inquiry Strategy of teaching on academic performance and creativity of N.C.E physics students in the North Eastern Nigeria. The entire study is organized under the following headings:

- Summary
- Summary of Findings
- Conclusion
- Recommendations
- Limitations
- Contribution to Knowledge
- Suggestion for Further Studies

5.2 Summary

The study was an investigation into the comparative effects of Concept Mapping and Inquiry Strategies of teaching on the academic achievement and creativity of Colleges of Education physics students in the North Eastern Nigeria. It also looked at how these two teaching innovations can help facilitate teaching and learning in the classroom, and related the experiences of the students in promoting their creativity traits of fluency, flexibility, originality and motivation. Most of the literature reviewed in the study so far revealed that both teaching strategies when properly handled can facilitate students' academic achievement and their creativity.

The study was a pretest-posttest experimental matched group design. The population of the study comprised of all seven Colleges of Education in North Eastern Nigeria studying PHY 121

(ThermalPhysics I). A total of two hundred and forty seven (247) students were found to be the population of the N.C.E I in the schools. Two schools namely; College of Education Waka, Biu and College of Education Jalingo were sampled based on simple random sampling procedure, and the number of students in these schools were purposely selected because of their manageable size, (thirty four students in C.O.E Waka, Biu and thirty-three in C.O.E Jalingo) making a total of sixty-seven students in the two sampled schools. Concept mapping strategy was used during the treatment in C.O.E Jalingo as experimental group one (E_1) while, C.O.E Waka, Biu as experimental group (E_2) and inquiry strategy was used during treatment. In the course of the research, relevant literature were reviewed which guided the study.

Two instruments were used for the study, namely; Physics Achievement Test(PAT) which was constructed by the researcher and consist of thirty (30) multiple questions based on the course outline of PHY 121 (Introduction to Thermal Physics). See appendix xi. I has a reliability coefficient of 0.62. While the second instrument Ibadan Creativity Assessment Scale (ICAS) was adopted from Akinboye (1977). Itconsists of eighty-nine items distributed to measure the creativity traits of fluency, flexibility, originality and motivation, and the reliability coefficient was 0.66. A total of six weeks were used for the treatment, after which the mentioned instruments were administered. Descriptive statistic was used to answer the research questions while t-statistic was used to testthe first hypothesis, while the second hypothesis was tested using two-way analysis of variance.Two research questions and twohypotheses were raised; bothwere accepted at 0.05 level of significance.

5.3 Summary of Findings

In this study, the following findings were made:

(i) Concept Mapping and Inquiry strategies of teaching enhance the academic achievement of NCE students taught physics concepts.

(ii) Both Concept Mapping and Inquiry strategies of teachingpromote the creativity traits of fluency, flexibility, originality and motivation of Colleges of Education students taught physics concepts.

5.4 Conclusion

This study further strengthens that concept mapping is one way to make instructional concepts arranged from known to unknown in a more organized manner and also to acknowledge that knowledge is hierarchical. The study also showed that teaching physics by inquiry develops the learners' ability to observe, ask questions, presume and verify assumptions and to make critical analysis of data. These skills enhance creativity and the role of the teacher as organizer and facilitator of learning is very important.

From the findings of this study the following conclusions are drawn:

(i). Innovative teaching strategies enhances students' academic achievement and creativity;

(ii) Engage students with more pragmatic activity based practical approaches to science instructions without altering the concepts;

(iii). Teachings innovations such as Concept Mapping and Inquiry Strategies are student centered,when properly utilized, they can enhance both creative thinking abilities and knowledgeacquisition.

5.5 Recommendations

On the basis ofthe finding emanating from the study, the following recommendations are made:

(i) Teachers should be trained in the use of learner centered and activity based instructional strategies such as Concept Mapping and Inquiry Strategies of instructions;

(ii). Teachers should pay attention to the training of their students in the development of Concept Mapping and Inquiry based instructional strategies towards enhancing their academic achievement and creativity before the end of the N.C.E programme;

(iii). Exercises should be provided to foster the development of the cognitive domain involved in creativity based activities such as divergent thinking ability, risk taking tendencies;

(iv). Schools should provide an environment that specifically values creative thinking, recognized in students and be promoted through teachers' behaviors in the classroom- creativity needs to be valued at least as much as knowledge acquisition and as part of academic achievement.

5.6Limitations of the Study

This study has some limitations, which include the following;

(i). The present study was conducted in two Colleges of Education in the North Eastern Nigeria namely- C.O.E Waka Biu, and C.O.E Jalingo which showed the restriction of the study, hence the extent to which the results apply to other Colleges of Education is not known ;

(ii). The study also limits itself to a specific course in physics (PHY 121), and physics students alone, if the same study will be conducted in other areas of physics and disciplines, it is possible that the findings will appear otherwise.

5.7 Contribution to Knowledge

The results obtained from the Effects of Concept Mapping and Inquiry Teaching Strategies on Academic Achievement and Creativity of Colleges of Education Students in North-Eastern Nigeria has been found to be effective in enhancing students' academic achievement in acquisition of physics concepts at the NCE level. Both teaching strategies also enhance students' creativity traits of fluency, flexibility, originality and motivation. In the same vain, the study also add to the number of existing literature in the areas of concept mapping and inquiry strategies of teaching on academic achievement and creativity of students.

5.8 Suggestions for Further Studies

There is the need to carry out further studies on similar teaching methods/strategies in other parts of the country and on all levels of education and disciplines as well with a view to finding out their effectiveness as well as relevance within the learning circle. It is also suggested that similar studies be carried out in other parts of Nigeria and beyond in other subjects

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Appendix 1

Physics Achievement Test (PAT)

INTRODUCTION: this is purely a research work and all the information that will be collected shall be for the purpose of the research only and with confidence. There are thirty (30) multiple choice questions with options lettered a-e, choose the correct answer by circling.

You should also provide the information below:

Name:- ……..

Name of School:-……..

Course Combination:- ……

Level:- ……

1. Heat can be described as

   (a). Transfer of power from one point to another

   (b). Degree of hotness or coldness of a place.

   (b). Transfer of energy due to temperature difference

   (d). Energy expended in a given time.

   (e). When the temperature of an object remain constant.

2. The lower fixed point on the Kelvin scale is given as

   (a). 212^oF (b). 100^oC (c). 32^oF (d). 273K (e) 373K

3. Change of state is accompanied by change of

   (a). Temperature (b). Volume (c). Heat content (d). Temperature and volume

   (e). Temperature and heat content.

4. The radiator of a motor car is cooled by

   (a). Radiation (b). Conduction (c). Convection (d). Sublimation (e). Evaporation.

5. Which of the following best describes energy changes which takes place when a steam engine drives a generator which lights a lamp?

   (a). Heat → Light → Sound → Kinetic

   (b). Kinetic → Light → Heat → Electricity

   (c). Heat → Kinetic → Electricity → Heat and light

   (d). Electricity → Kinetic Heat Light

   (e). Heat → Sound → Kinetic → Electricity

6. A gas occupies a volume of $40cm^3$ at a temperature of 27^oC, and a pressure of $80cm^3$ of mercury. What volume does it occupy at 87^oC and pressure of 120cm of mercury?

   (a). $32cm^3$ (b). $42cm^3$ (c). $22cm^3$ (d). $52cm^3$ (e). $12cm^3$

7. The work done on a gas at constant volume is known as

(a) Isobaric process (b). Adiabatic process (c). Isochoric process (d). Isothermal process (e). Isomeric process.

8. If 500J is added to a gas it expands and does 200J of work. What is the change in the internal energy of the gas?

(a). 400J (b). 200J (c). 100J (d). 500J (e). 300J

9. What is the SI unit of specific heat capacity?

(a). JK^{-1} (b). JKg^{-1} (c). $JKg^{-1}K^{-1}$ (d). $JKgK^{-1}$ (e). $JKg^{-1}K$

10. How much heat is absorbed when a temperature of a piece of iron of mass 0.1kg and specific heat capacity $2.0 \times 10^{2} Jkg^{-1}K^{-1}$ is raised from $25^{o}C$ to $75^{o}C$?

(a). 0.1J (b). $1.0 \times 10^{3}J$ (c). $2.0 \times 10^{3}J$ (d). $10^{4}J$ (e). $10^{5}J$

11. The quantity of heat required to raise the temperature of a body by one degree Celsius is defined as

(a). Calorific value (b). Water equivalent (c). Specific heat capacity (d). Thermal capacity (e). Latent heat.

12. Which of the following statement is false?

(a). Brownian motion is a continual random motion

(b). Brownian motion cannot be due to convection.

(c). An increase in temperature slows down Brownian motion

(d). Diffusion occurs in liquids

(e). The molecules in a liquid move faster when heated.

13. The silvery walls of a vacuum flask minimize heat loss due to

(a). radiation only (b). conduction only (c). convection only (d). conduction and convection

(e). convection and radiation

14. The first law of thermodynamics is stated mathematically as

(a). $dQ = dW + du$ (b). dS = $\frac{dQ}{dT}$ (c). du = dw + p d V (d). dQ = p d V (e). du = $\frac{dQ}{dT}$

15. If a solid changes directly into gas when heat is supplied, the process is known as

(a). Sublimation (b). Vaporization (c). Evaporation (d). Ionization (e). Conversion

16. The volume of a given mass of gas varies inversely as the pressure provided that the Temperature is constant is known as

(a). Charles's law (b) Pressure law (c). Graham's law (d). Boyle's law (e). Gay-Lussac's law

17. The volume of dry air at 27^{o}C is 100cm^{3}. Its volume at 57^{o}C when the pressure is kept constant is (a). 100cm^{3} (b). 110cm^{3} (c). 120cm^{3} (d). 101cm^{3} (e). 150cm^{3}

18. Normal body temperature of human body is

(a). 64.8^{o}C (b). 100^{o}C (c). 36.9^{o}C (d). 54^{o}C (e). 32^{o}C

19. Which of the following thermometer can be used to measure a range of temperature from

I. A clinical thermometerII. A mercury in-glass thermometer III. Alcohol in-glass thermometer

(a). I only (b). II only (b). (c) III only (d). I and II only (e). II and III only.

20. A heater marked 60W evaporates 6.0 X 10^{-3}kg of water in 60 seconds. What is the specific latent heat of vaporization of water in Jkg^{-1}.

(a). 6.0 X 10^{5} (b). 6.0 X10^{6} (c). 3.0 X10^{-5} (d). 6.0 X 10^{-5} (d). 3.0 X 10^{5}

21. The amount of heat per unit mass that must be transferred when a substance completely undergoes a phase change is known as

(a). Heat of fusion (b). Latent heat (c). Heat capacity (d) Heat of vaporization

(e). Heat of transformation

22. Highly polished silvery surfaces are

(a) Poor absorbers but good emitters of radiation

(b). Good absorbers and good emitters or radiation

(c). Poor absorbers and poor emitters of radiation

(d). Good absorbers but poor emitters of radiation

(e). None of the above

23. One is able to perceive the odour of food from a distance because

(a). The molecules of food travel by diffusion

(b). The molecules of air are in constant motion

(c). The ingredients travel by capillarity

(d). Osmosis is operative

(e). The food molecules are carried to the nose by capillarity.

24. Which of the following does not need medium for heat transfer?

(a). Conduction (b). Radiation (c). Convection (d). Emission (e). Absorbtion.

25. The r,m.s. of a molecule of a gas is given as

(a) $\bar{v}_{rms} = \frac{3KT}{m}$ (b) $\overline{v}_{rms} = \sqrt{\frac{3mT}{k}}$ (c) $\overline{v}_{rms} = \sqrt{\frac{3mk}{T}}$ (d). $\overline{v}_{rms} = \sqrt{\frac{3m}{kT}}$ (e). $\overline{v}_{rms} = \sqrt{\frac{3}{kT}}$

26. In thermometric conversion of 72^oC to the Fahrenheit scale is equivalent to

(a). 112^oF (b). 212^oF (c). 161^oF (d) 373.15^oF (e). 273.15^oF

27. The quantity of heat required to change the temperature of a unit mass of a substance by 1^oC is called

(a). Specific heat of fusion (b). Specific heat capacity of vaporization (c). Heat capacity

(d). Specific heat capacity (e). Specific latent heat.

28. Which of the following thermometers responds best to changing temperature?

(a). Mercury in-glass thermometer (b). Alcohol in-glass thermometer

(c). Resistance thermometer (d). Thermoelectric thermometer (e). Gas thermometer

29. A fixed mass of gas of volume 600cm^3 at a temperature of 27^oC is cooled at constant pressure to a temperature of 0^oC. The change in volume is

(a). 54cm^3 (b). 273cm^3 (c). 300cm^3 (d). 546cm^3 (e). 600cm^3

30. A tungsten filament of an electric lamp has a length of 0.5m and a diameter 6 X 10^{-5}m. the power rating of the lamp is 60W. Assuming the radiation from the filament is equivalent to 80% that of a black body radiator at the same temperature, the steady temperature of the Filament will be (Stefan constant = 5.7 X $10^{-8}Wm^{-2}K^{-4}$).

(a). 1900K (b). 1933K (c) 1833K (d). 1800K (e) 1733K

Appendix ii

MARKING SCHEME FOR PHYSICS ACHIEVEMENT TEST (PAT)

1. C
2. D
3. E
4. C
5. C
6. A
7. A
8. B
9. C
10. C
11. D
12. C
13. A
14. C
15. E
16. D
17. D
18. D
19. D
20. B
21. C
22. C
23. C
24. B
25. B
26. D
27. B
28. C
29. C
30. B

One mark for each correct answer. Total = 1 X 30 = 30 marks

Item Analysis of PAT

S/No	Facilit Index (FI) = $\frac{R}{T}$X 100	Discrimination Index (DI) = $R_u - R_L / N$
1	0.33	0.36
2	0.54	0.18
3	0.44	0.36
4	0.71	0.36
5	0.45	0.09
6	0.48	0.27
7	0.40	0.36
8	0.43	0.73
9	0.58	0.73
10	0.52	0.45
11	0.43	0.55
12	0.53	0.91
13	0.35	0.18
14	0.30	0.27
15	0.39	0.36
16	0.43	0.55
17	0.30	0.18
18	0.25	0.18
19	0.36	0.27
20	0.32	0.36
21	0.31	0.55
22	0.50	0.82
23	0.33	0.36
24	0.53	0.36
25	0.52	0.73
26	0.50	0.09
27	0.40	0.18
28	0.38	0.27
29	0.75	0.73

Appendix iv

CREATIVITY ASSESSMENT QUESTIONNAIRE

SECTION A

Dear Respondents,

Please kindly read this questionnaire and respond based on the items provided. This is purely a research work and shall be treated with outmost confidentiality. Thank you.

School……..Level……..

Date……

Sex……..

Age……..

Instructions

Please use the ten (10) point scale below to rate yourself on each of the following items. Rate the items from most descriptive of you high in the increasing order of magnitude, i.e 6,7,8,9. Rate items least descriptive of you low in the decreasing order of magnitude i.e 4, 3,2,1,0. Zerobeing your rating for an item that is totally unlike you. Those items that you are not sure about, rate five (5).

(Totally unlike me)0…1…2…3…4…5…6…7…8…9 (very much like me)

Just circle the number that describes the the magnitude of your personal.

Example: I am dull at generating new ideas

(Totally unlike me) 0…1… (2).3…4…5…6…7…8…9 (very much like me)

My rating is 2 because it is very much unlike me.

Use the same method to fill section B,C,D and E.

SECTION B

Ideative fluency scale

S/No	Items	Ratings									
1	Have easy flowing ideas on certain problems that bother me	0	1	2	3	4	5	6	7	8	9
2	Self sufficient in idea generation	0	1	2	3	4	5	6	7	8	9
3	Versatile	0	1	2	3	4	5	6	7	8	9
4	Rich in terms of the variety of ideas running through my mind	0	1	2	3	4	5	6	7	8	9
5	I can ask a hundred questions on the use of palm tree	0	1	2	3	4	5	6	7	8	9
6	I can explain the consequences of an act fairly and accurately	0	1	2	3	4	5	6	7	8	9
7	I can describe scene as accurately as possible within a limited given time	0	1	2	3	4	5	6	7	8	9
8	If a pictorial scene is supplied, I can vividly supply many ideas describing the cause(s)	0	1	2	3	4	5	6	7	8	9
9	If a painting is supplied in a sequential order, I can generate many ideas about the sequence that will follow	0	1	2	3	4	5	6	7	8	9
10	I can give much information to explain a just purpose question	0	1	2	3	4	5	6	7	8	9
11	If a diagram is incompletely drawn, I can quickly think of many improvement	0	1	2	3	4	5	6	7	8	9
12	I may be dry up of ideas very often	0	1	2	3	4	5	6	7	8	9
13	I can easily drawn an elephant from a big oval or circular drawings	0	1	2	3	4	5	6	7	8	9
14	I have to write poems	0	1	2	3	4	5	6	7	8	9
15	I like objective type examinations	0	1	2	3	4	5	6	7	8	9
16	I prefer to write essay examinations	0	1	2	3	4	5	6	7	8	9
17	Plenty of ideas come to me early in the morning when I am about to take breakfast	0	1	2	3	4	5	6	7	8	9

18	I keep a notebook always in which I write the many ideas that come to me	0	1	2	3	4	5	6	7	8	9
19	I do not quickly see all the sides to an argument because of idea shortage	0	1	2	3	4	5	6	7	8	9
20	At times when I am peacefully alone, myriads of ideas come to me on a long standing problem	0	1	2	3	4	5	6	7	8	9
21	At times when playing a game, I tend to remember many useful ideas to solve a problem bothering me	0	1	2	3	4	5	6	7	8	9
22	I find it difficult to start a discussion	0	1	2	3	4	5	6	7	8	9
23	When a discussion is started, my ideas start flowing like river	0	1	2	3	4	5	6	7	8	9
24	I tend to describe things with few words	0	1	2	3	4	5	6	7	8	9
25	When I start thinking about a problem, I wonder about the way my mind conjure myriads of ideas	0	1	2	3	4	5	6	7	8	9
26	It is interesting to put one's ideas on record	0	1	2	3	4	5	6	7	8	9

Section C

Ideative Flexibility Scale

How accurate are the following description of your person

S/No	Items	Ratings									
1	Accept ambiguous situation	0	1	2	3	4	5	6	7	8	9
2	Attracted by mysterious unclear events	0	1	2	3	4	5	6	7	8	9
3	Tend to break health conditions	0	1	2	3	4	5	6	7	8	9
4	Not hostile or aggressive on the whole	0	1	2	3	4	5	6	7	8	9
5	Look for new ways of doing things	0	1	2	3	4	5	6	7	8	9
6	Tend to overlook significant implications of an idea.	0	1	2	3	4	5	6	7	8	9
7	Meticulously curious	0	1	2	3	4	5	6	7	8	9

8	Often a fault finder	0	1	2	3	4	5	6	7	8	9
9	Does not likely constantly	0	1	2	3	4	5	6	7	8	9
10	Manifest odd patterns of behavior	0	1	2	3	4	5	6	7	8	9
11	Sensitive to beautiful things	0	1	2	3	4	5	6	7	8	9
12	Willing to take risk	0	1	2	3	4	5	6	7	8	9
13	Like to propose new approaches to a problem	0	1	2	3	4	5	6	7	8	9
14	Neglect significant facts arising from problem situation	0	1	2	3	4	5	6	7	8	9
15	Never bored	0	1	2	3	4	5	6	7	8	9
16	Can perceive details	0	1	2	3	4	5	6	7	8	9
17	I can easily adapt a thing for other use	0	1	2	3	4	5	6	7	8	9
18	I can adjust quite easily to novel situation	0	1	2	3	4	5	6	7	8	9
19	I can detect small shades of different color from painting that looks one color	0	1	2	3	4	5	6	7	8	9
20	It is easy for me to change my attention from one absorbing duty to another	0	1	2	3	4	5	6	7	8	9
21	If I meet a person once, I'll know him when next I meet him	0	1	2	3	4	5	6	7	8	9

SECTION D

Ideative originality scale

S/No	Items	Ratings									
1	Criticize my mates	0	1	2	3	4	5	6	7	8	9
2	Attracted to difficult jobs	0	1	2	3	4	5	6	7	8	9
3	Can pick out valuable things to me out of many seemingly equally attractive ones	0	1	2	3	4	5	6	7	8	9

4	Like solitary lie	0	1	2	3	4	5	6	7	8	9
5	Not popular with people	0	1	2	3	4	5	6	7	8	9
6	Non-conforming even to intimate friends	0	1	2	3	4	5	6	7	8	9
7	Like to tackle problems that others may avoid	0	1	2	3	4	5	6	7	8	9
8	Follow instructions very closely	0	1	2	3	4	5	6	7	8	9
9	Seek knowledge for its sake	0	1	2	3	4	5	6	7	8	9
10	Like to disagree at times	0	1	2	3	4	5	6	7	8	9
11	Like to question orders of superiors when it is not clear	0	1	2	3	4	5	6	7	8	9
12	Do not like business	0	1	2	3	4	5	6	7	8	9
13	Can be proud and self-satisfied at times	0	1	2	3	4	5	6	7	8	9
14	Differ with friends on opinions at times	0	1	2	3	4	5	6	7	8	9
15	Do not fear to make mistakes	0	1	2	3	4	5	6	7	8	9
16	Reserved, not open like others	0	1	2	3	4	5	6	7	8	9
17	Do not want to be controlled by any person	0	1	2	3	4	5	6	7	8	9
18	May be terribly native in style of life	0	1	2	3	4	5	6	7	8	9
19	Visionary and insightful	0	1	2	3	4	5	6	7	8	9
20	Seek recognition for contributions I make	0	1	2	3	4	5	6	7	8	9
21	Averagely intelligent at least	0	1	2	3	4	5	6	7	8	9
22	Like to do things the way I think right	0	1	2	3	4	5	6	7	8	9
23	I am resolute, I'll change the order of things in the present world	0	1	2	3	4	5	6	7	8	9
24	It is monotonous to see even the most beautiful things without change for many	0	1	2	3	4	5	6	7	8	9
25	Innovation and introduction of the unusual makes one happy and healthy	0	1	2	3	4	5	6	7	8	9

SECTION E

Creativity motivation scale

S/No	Items	Ratings									
1	Have very deep interest in disorderly settings	0	1	2	3	4	5	6	7	8	9
2	Courageous	0	1	2	3	4	5	6	7	8	9
3	Have great determination	0	1	2	3	4	5	6	7	8	9
4	Desire high competence in my endeavours	0	1	2	3	4	5	6	7	8	9
5	Enthusiastic about all problems that come my way	0	1	2	3	4	5	6	7	8	9
6	Fail to let others know my new ideas	0	1	2	3	4	5	6	7	8	9
7	Keep unusually long hours on a problem	0	1	2	3	4	5	6	7	8	9
8	Industrious	0	1	2	3	4	5	6	7	8	9
9	Controlled by an inner force which does not care about what people say	0	1	2	3	4	5	6	7	8	9
10	Have abundant energy for work that interest me	0	1	2	3	4	5	6	7	8	9
11	Emotionally sensitive to new ideas	0	1	2	3	4	5	6	7	8	9
12	Highly persistent on difficult problems	0	1	2	3	4	5	6	7	8	9
13	Discourage at times due to certain situations	0	1	2	3	4	5	6	7	8	9
14	Self-confident	0	1	2	3	4	5	6	7	8	9
15	Resolute	0	1	2	3	4	5	6	7	8	9
16	Humorous	0	1	2	3	4	5	6	7	8	9
17	Can quickly receive and register external stimuli	0	1	2	3	4	5	6	7	8	9

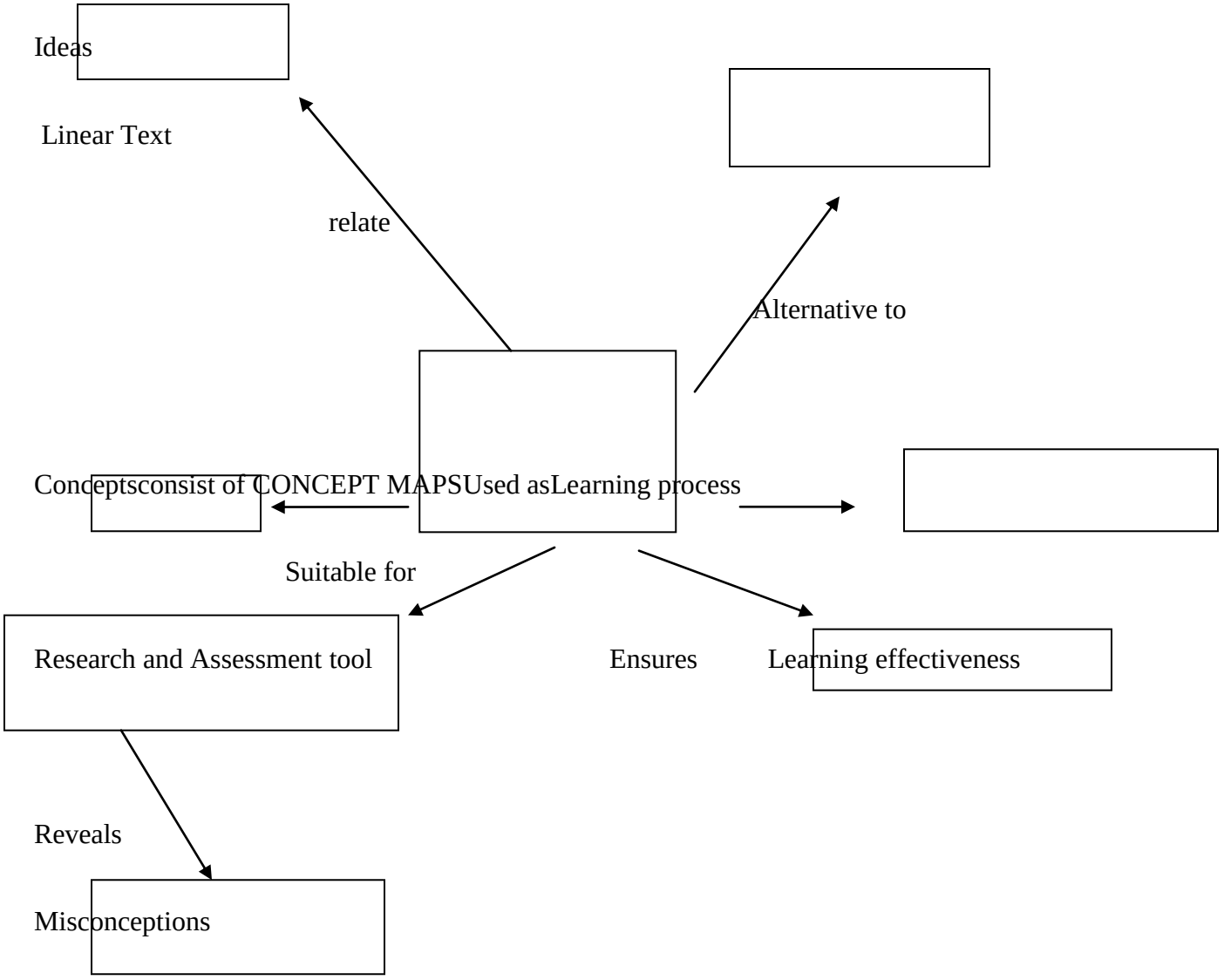
Appendix v

Training Session in Concept Mapping using two guided examples.

Session I (Using Concept Maps)

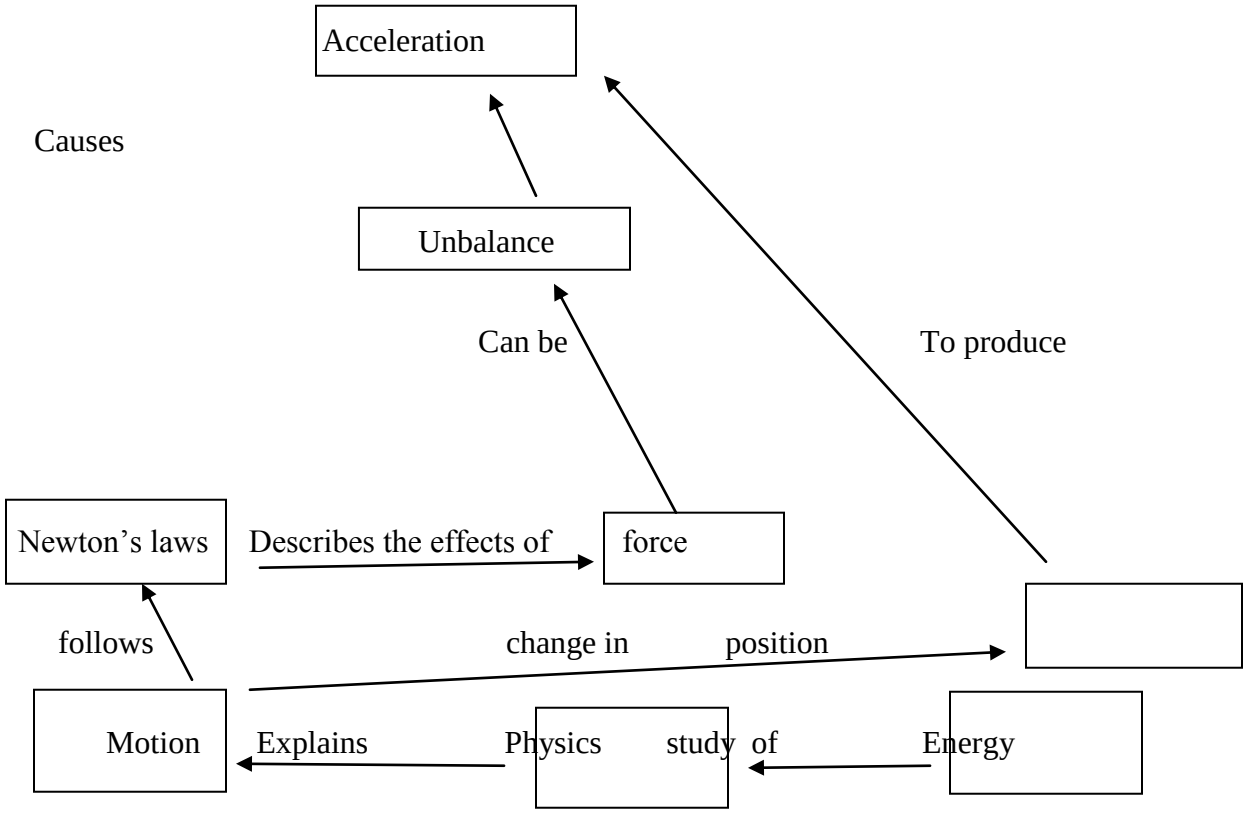
Concepts	Propositions
Concept Maps	Used as
Learning	And
Concepts	Increasing
Propositions	Improving
Ideas	To do with
Research and Assessment tool	Reveals
Misconception	Suitable for
Learning Process	To assess

Training Session I in Concept mapping



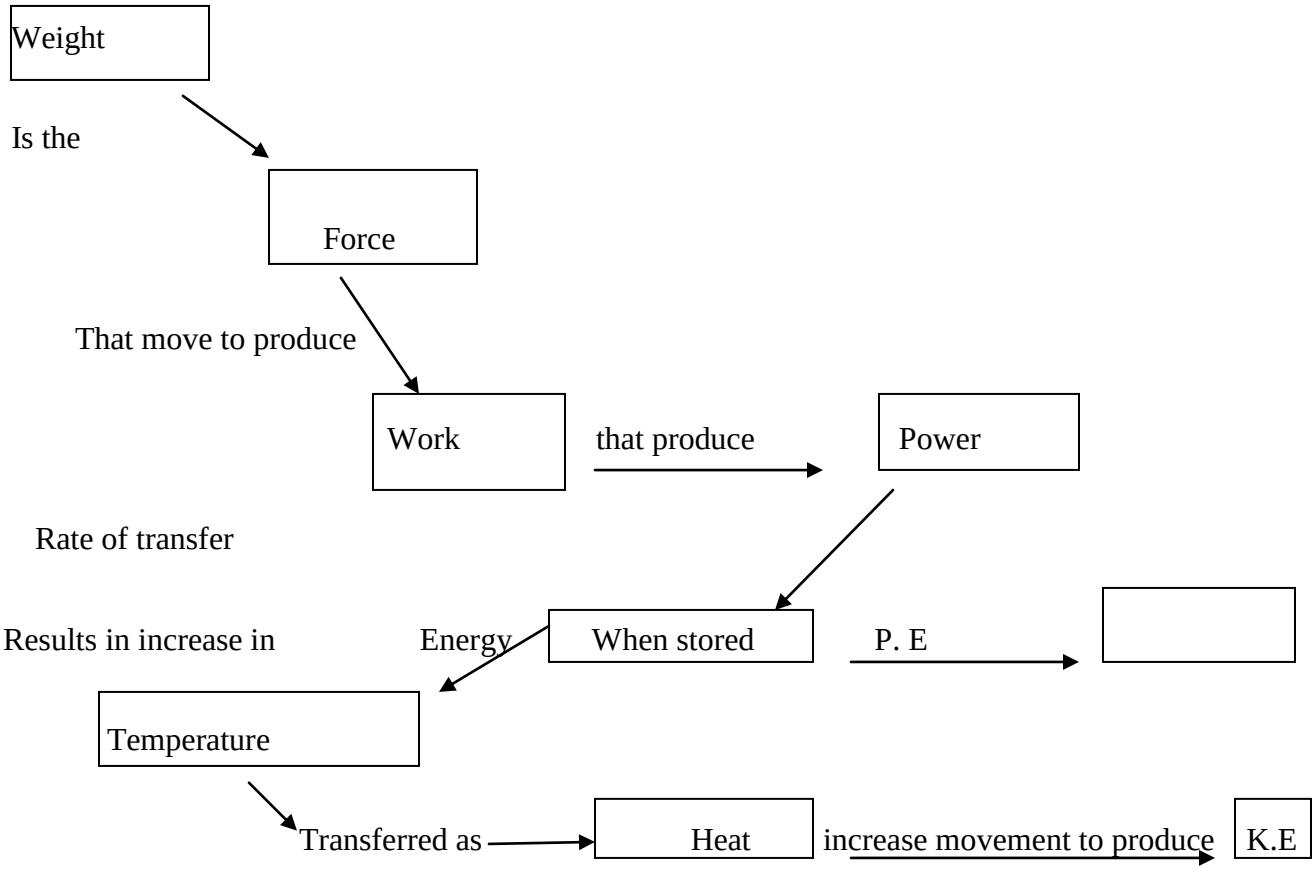
Training Session II Concept Map using Physics Concepts

Concepts	Propositions
Physics	Explains
Energy	Results
Motion	Can be
Newton's Law	Follows
Unbalance	Study of
Acceleration	Change in
Force	Describes
Position	Causes
Speed	To produce



Training Session III (Using Energy concepts)

Concepts	**Proposition**
Energy	Is the
Power	That move to produce
Work	Rate of transfer
Heat	Decrease
Kinetic energy	Transferred as
Potential energy	Result in increase in
Temperature	When stored
Heat	In a given time



Appendix vi

Lesson Plan of Concept Mapping Strategy (Experimental Group 1)

Lesson 1

School: C.O.E Jalingo

Level: NCE I

Course; PHY 121 (Thermal Physics I). Credit Unit 2

Topic: Heat and Temperature

Duration: 2 Hours

Behavioral Objections: By the end of the lesson, the students should be able to

(i). Distinguish between heat and temperature;

(ii). Define power

(iii). Identify temperature measuring instruments and state units of measurements

(iv). Draw a Concept Map linking the concepts.

Teaching Aids/Materials: Cardboards carrying key concepts in PHY 121 (Introduction to Thermal Physics I) and propositions.

Prior knowledge The students have an idea on warm and cold bodies.

Introduction: Students were asked to touch their bodies and express how they feel when they are in contact with hot and cold objects.

Presentation:

Step I

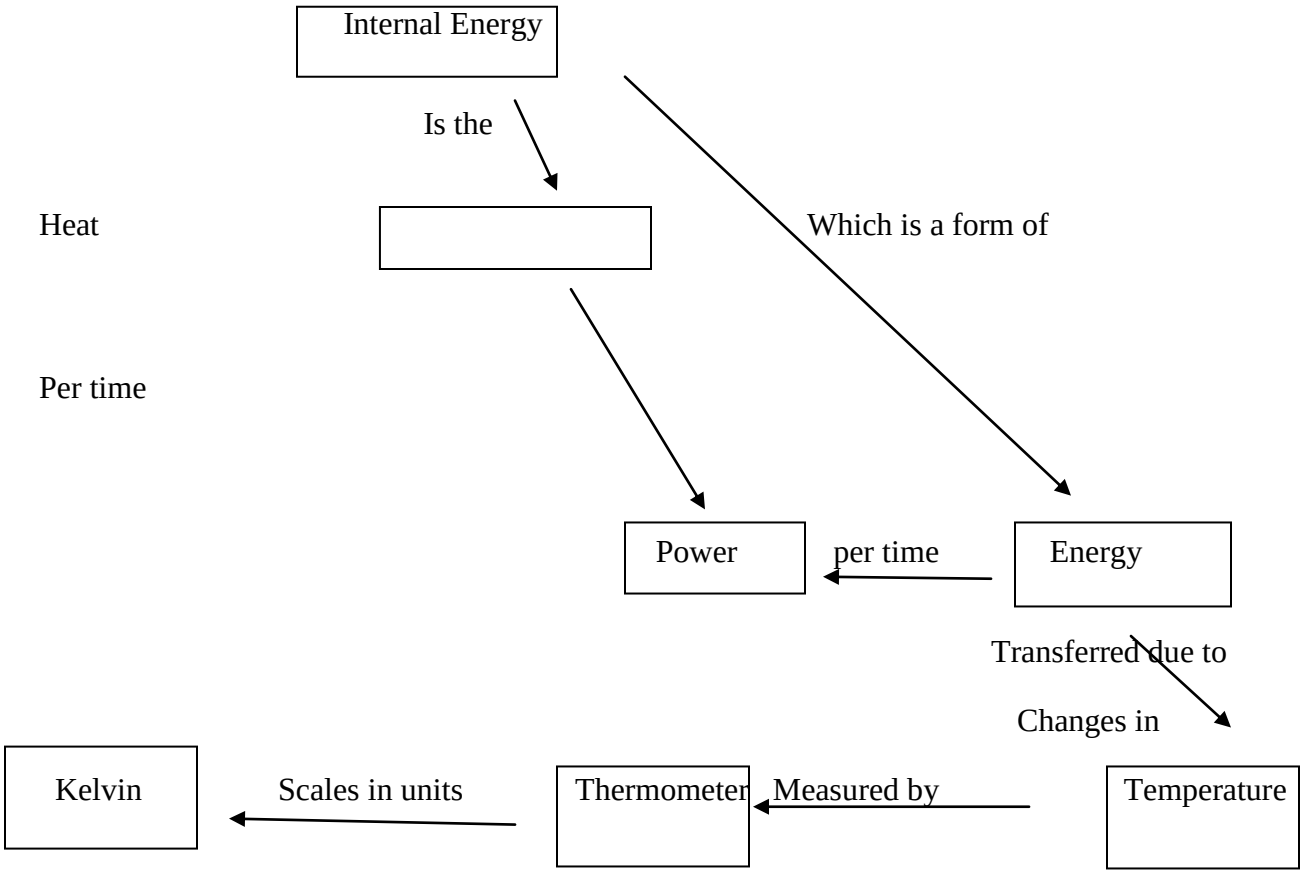
The teacher defines the concepts of internal energy, heat, energy, thermometer, temperature, Kelvin and power.

Step II Exposure to concepts and prepositions as shown in the Table

Concepts	Propositions
Internal Energy	Is the
Heat	Which is a form
Energy	Due to changes
Temperature	Per time
Thermometer	Study of
Kelvin	Measured by
Power	Scales in units

Step III

Students required making linkages between concepts and relevant prepositions.



Evaluation of Lesson

(1) Distinguish between heat and temperature

(2) Define power

(3) Identify temperature measuring instruments and the scale used in measuring it.

(4) Draw and read the concept map

Summary: The Teacher explains each of the concepts as follows:

(a) Temperature is the degree of hotness or coldness of a place.

(b) Heat is the transfer of energy due to temperature difference.

(c) Thermometer is used to measure the temperature of a body.

(d) Thermometric scales involve the Celsius scale, kelvin scale and the Fahrenheit scale.

Scale	lower fixed point	upper fixed point
Celcius	0^oC	100^oC
Fahrenheit	32^oF	212^oF
Kelvin	273.15K	373.15K

ASSIGNMENT:

(1) Draw concept map to relate the concepts in the table

Lesson II

Topic: Transfer of Heat.

Duration: 2 Hours

Behavioral Objectives: By the end of the lesson, the students should be able to

(i) distinguish heat capacity and specific heat capacity.

(ii) determine the heat capacity and specific heat capacity of substances using calorimetry.

(iii) calculate known quantities using the relation $H = mc\Delta T$ when no heat is involved.

(iv) Draw Concept Map with the relevant concepts

Teaching Aids: Cardboards carrying concepts on heat and specific heat capacity and Propositions

Prior Knowledge: The students have an idea on heat and temperature.

Introduction: Teacher introduced the lesson by exposing the prior knowledge of the students to defineheat and temperature.

Presentation:

Step I: The teacher defines the concepts heat capacity, heat, specific heat capacity, Kelvin, J/K, J/KgK

Heat lost by one object equals heat gained by another object, ($H = mc\Delta T$), where H is the quantity of heat loss by metal, m is the mass of bob, c is the specific heat capacity and ΔT is the change.

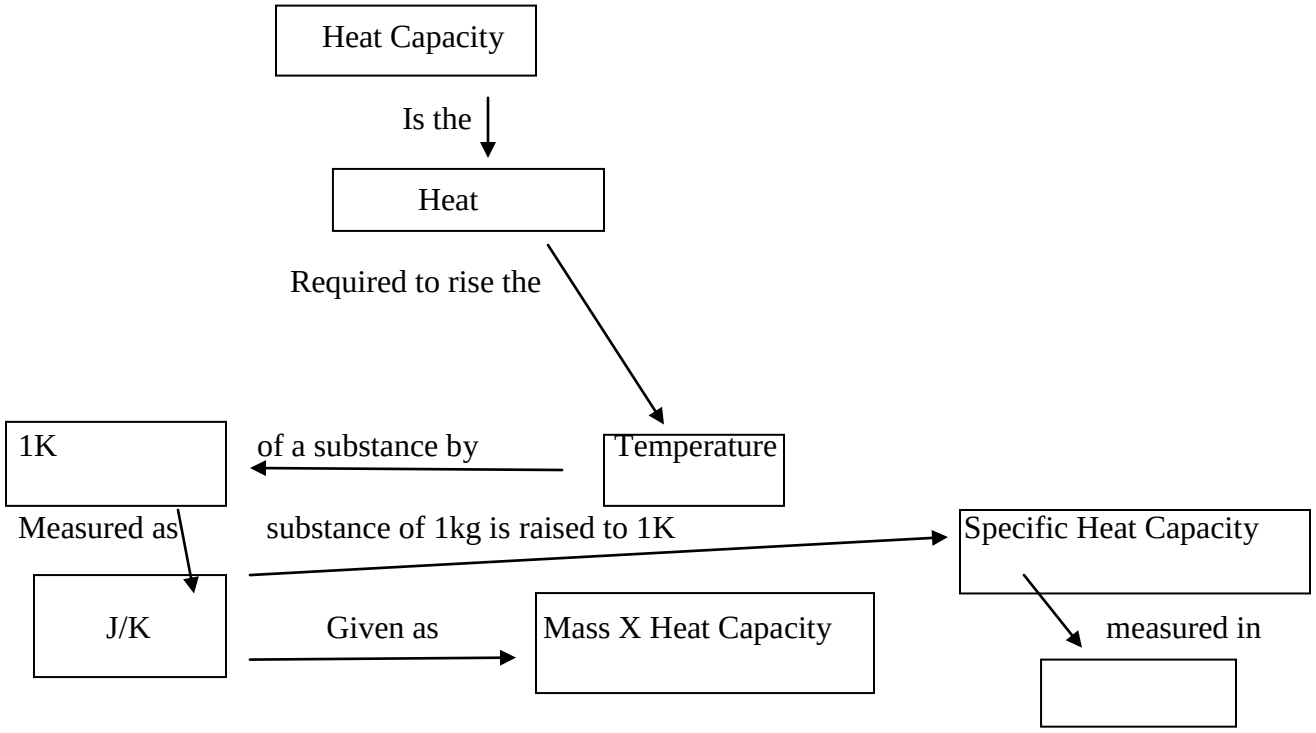
Specific heat capacity of a substance is the heat required to raise the temperature of a unit mass

That substance by one degree (1^oC or 1K, while heat capacity is the quantity of heat required to raise the temperature of that substance by 1^oC or 1K. The various concepts are tabulated below.

Step II: The Teacher outlined the concepts and prepositions the students and explains.

Concepts	Preposition
Heat Capacity	Given as
Heat	Measured as
Specific Heat Capacity	Substance of 1kg is raised to 1K
J/K	Is the
K	Of a Substance
Temperature	Required to raised
$J/Kg^{-1}K^{-1}$	Measured in

Step III. Teacher and Students make linkages with concepts and relevant prepositions.



Evaluation: The teacher evaluates the lesson by asking the following questions

(1) Define heat capacity
(2) Specific heat capacity
(3) Read the Concept Map drawn.

Summary: The teacher summarized the lesson by defining Heat capacity, specific heat capacity, and the units of measuring each.

ASSIGNMENT;

1. What is meant by the statement "the specific heat capacity of water is 4200Jkgk-^{1}"?
2. Calculate the temperature change when 1000J of heat is supplied to 0.1kg of water.

Lesson III

Topic: Change of state

Duration: 2 Hours

Behavioral Objectives: By the end of the lesson, the students should be able to

(i) Mention the three states of matter.

(ii) Define heat of fusion, fission, Transformation, latent heat and heat of vaporization.

(iii) Draw Concept Maps relating to change of state.

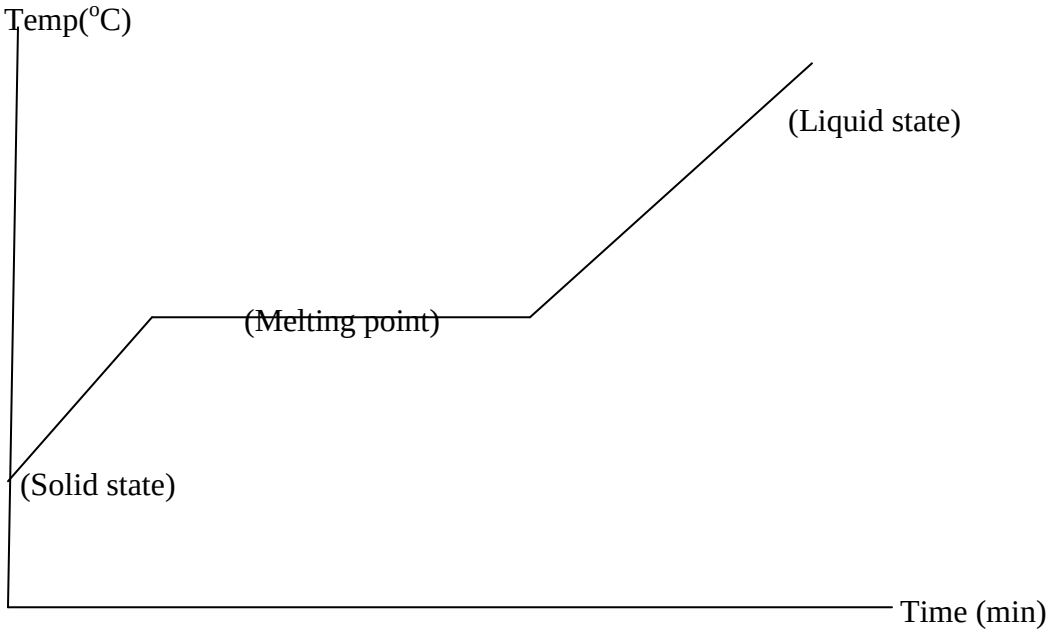
Teaching Aid: Cardboard carrying key concepts and prepositions, samples of ice block and a source of heat

Prior Knowledge: The students are aware of how heat is involved in raising the temperature of a material

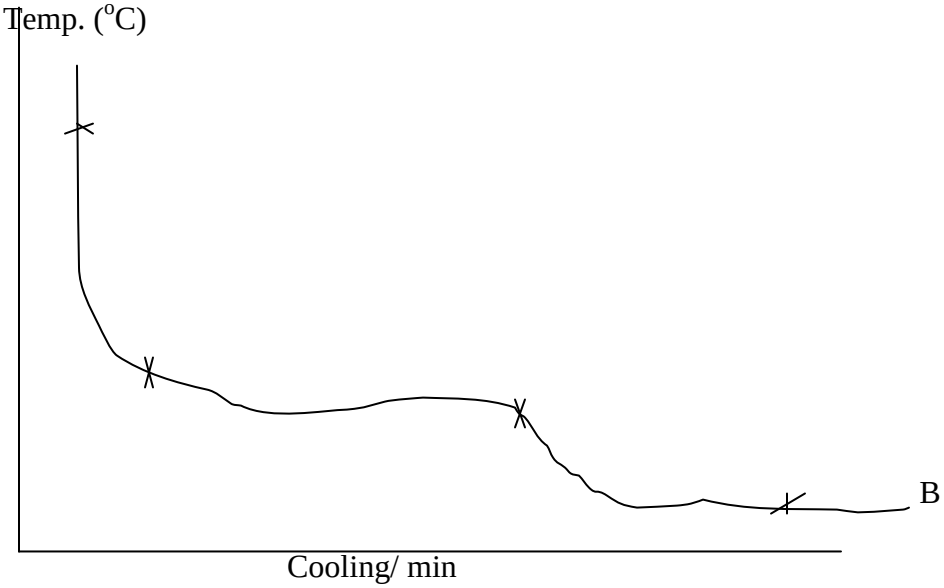
Introduction: The teacher introduces the lesson asking the students how the temperature of a material is raised.

Step I: The teacher begins the lesson by explaining the concepts of matter, heat of fusion, heat of vaporization, heat of transformation, solid, liquid and gas.

(Graphical representation of Change of state)



Above is the change of naphthalene from solid to liquid. (Figure 3.)



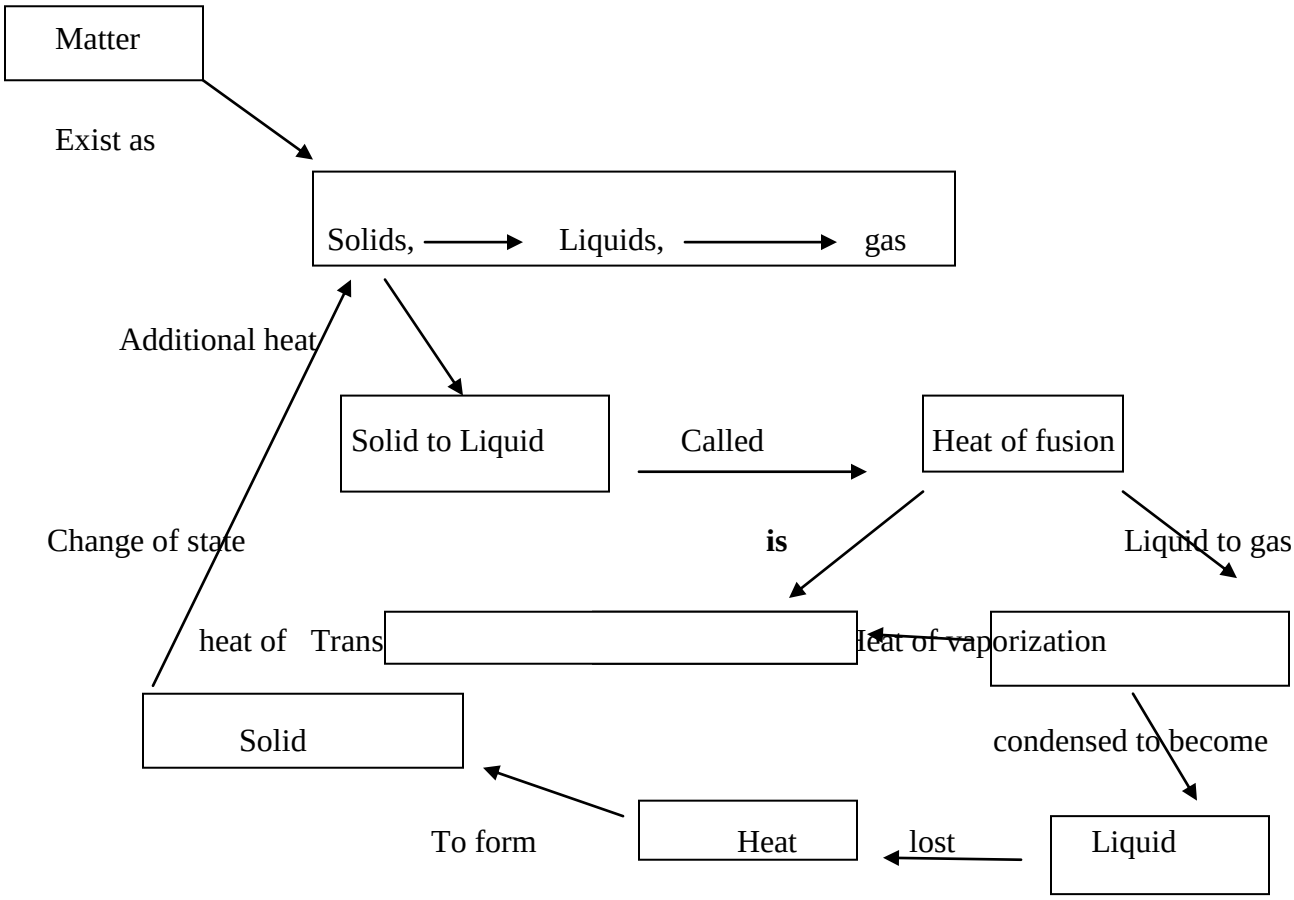
Above is the cooling of naphthalene (Figure 4)

Figures 3 and 4 showed the change of phase in solid naphthalene.

Step II: Exposure to the concepts and prepositions and present them in a table.

Concepts	**Proposition**
Matter	Exists
Solid, Liquid, Gas	That move to produce
Solid to gas	Rate of transfer
Heat of fusion	Decrease
Heat of vaporization	Transferred as
Heat of transformation	Result in increase in
Solid	When stored
Heat	In a given time

Step III: Teacher and students make linkages



Evaluation: The teacher evaluates the lesson by asking the following questions

(1) Define matter

(2) Outline the states of matter

(3) Define heat of fusion, heat of transformation and heat of vaporization

Summary: The teacher summarizes the lesson as follows

Heat of transformation: is defined as the amount of heat per unit mass that must be transferred when

Sample completely undergoes a phase change.

Heat of vaporization: this is when a substance changes phase from liquid to gas (absorbs heat) or

from gas to liquid (releases heat).

Heat of fusion: this is when a substance changes phase from solid to liquid (absorbs heat) or from

Liquid to solid (releases heat).

Assignment: what quantity of heat will be necessary to change 2kg of ice at $0^{o}C$ to water at $10^{o}C$. Specific latent heat of ice = $3.36 \text{ X } 10^{5}Jkg^{-1}$ and the specific heat capacity of water = $4200JkgK^{-1.}$

Lesson IV

Topic: Conduction, Convection and Radiation.

Duration: 2hours

Behavioral Objective: By the end of the lesson, the students should be able to;

(i) Enumerate ways in which heat is transferred.

(ii) Define thermal conductivity

(iii) Electromagnetic radiation

(iv) Draw a concept map.

Teaching Aids: Cardboards containing concepts and prepositions written on them, a solid iron bar, a cup of water and a source of heat.

Prior knowledge: The students are familiar to the concepts of heat and temperature.

Introduction: The teacher introduces the lesson by asking the students to define heat and temperature.

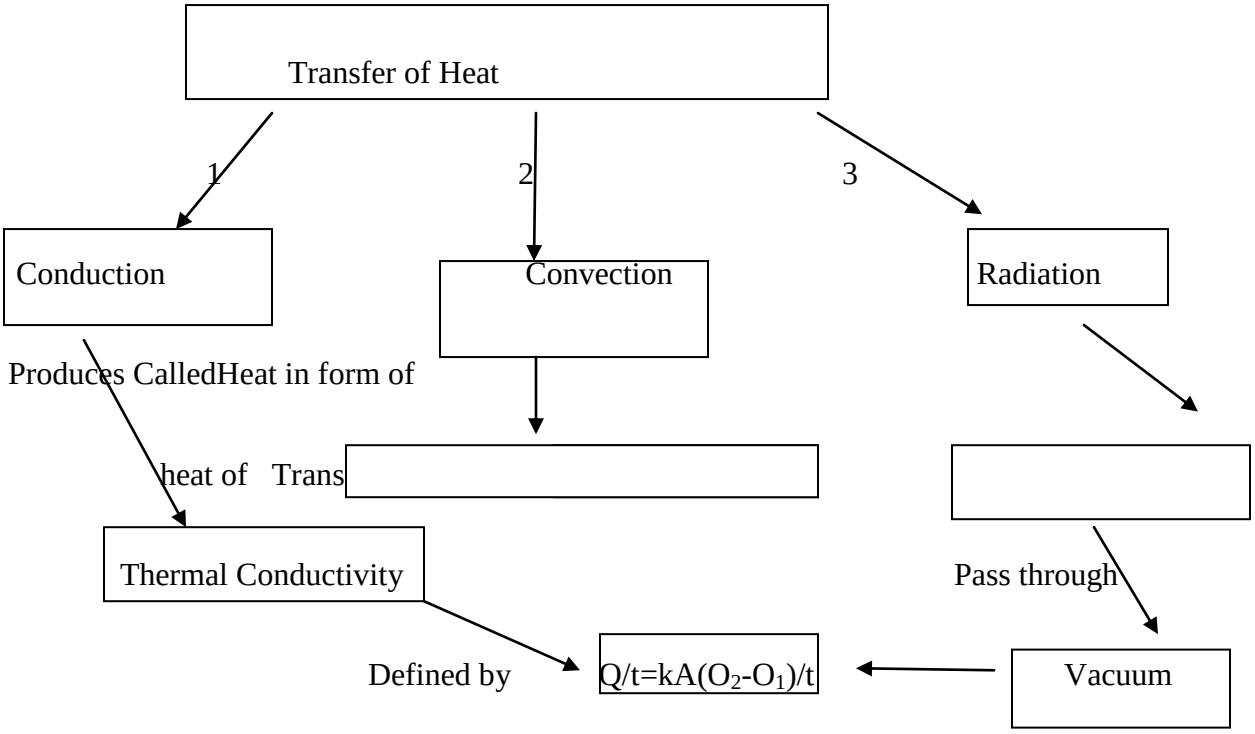
PRESENTATION:

Step I: The teacher defines the concepts heat transfer, conduction, convection, and radiation, thermal Conductivity and electromagnetic radiation.

Step II: Exposure to concepts and prepositions

Concepts	**Proposition**
Conduction	1,2,3
Heat Transfer	Called
Covection	Rate of transfer
Radiation	Heat in form of
Thermal Conductivity	Transferred as
Electromagnectic Radiation	In 3 ways 1,2,3
Convection Current	When stored
Vacuum	Pass through
$Q/t = kA(0_2\text{-}01)/t$	Defined by

Step III: Teacher and student make linkages from concepts and prepositions..



Evaluation: The teacher evaluates the lessons by asking the following questions;

(1) Mention ways of transferring heat

(2) Define thermal conductivity

(3) Define electromagnetic radiation

(4) Students to read the map.

Summary: The teacher summarizes the lesson by defining the concepts and reading the map for the students

(i) Conduction. This is defined as the transfer of heat through solids.

(ii) Thermal conductivity refers to heat flow per unit time, mathematically written as

$\frac{Q}{t} = KA\frac{\theta 2-\theta 1}{l}$, where Q is the quantity of heat, t is the time, A is the cross-sectional area of the metal rod, l is the length of rod K is the thermal conductivity of the material and $\theta 1\ and\ \theta 2$ are the initial and final temperatures of the for.

(iii) Convection refers to the transfer of heat through fluids.

(iv) Radiation refers to the transfer of heat through a vacuum. Radiant heat consist of electromagnetic radiation which passes through vacuum

Lesson V

Topic: Kinetic Theory of gases

Behavioral Objective. By the end of the lesson, the students should be able to:

(i) Define kinetic theories of gases.

(ii) Boyle's and Charle's laws of gases

(iii) State the general gas laws.

(iv) Outline the postulates of the kinetic theory

(v) Draw a Concept Map

Teaching Aids: Cardboard carrying concepts and propositions.

Prior Knowledge: The students have an idea on conduction, convection and radiation.

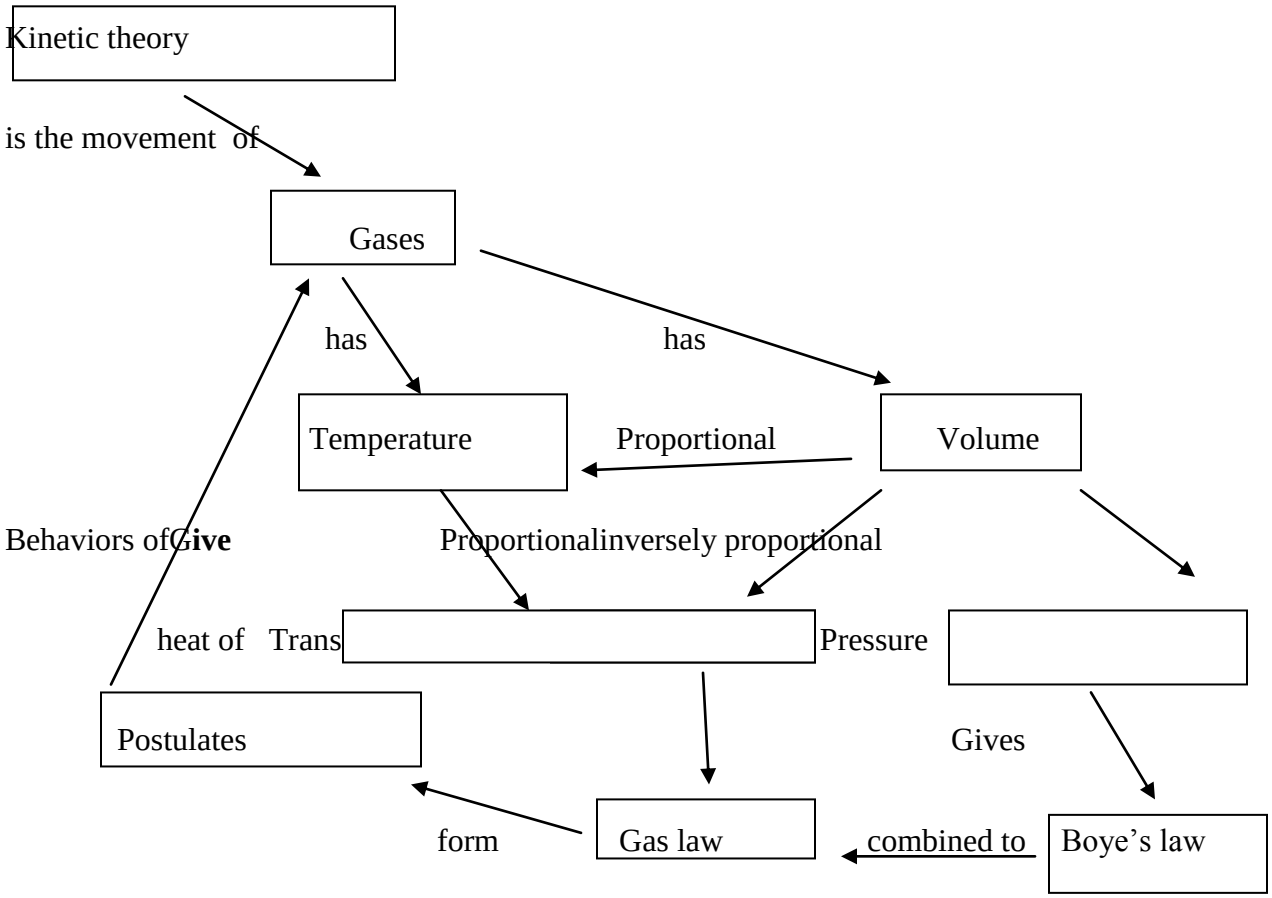
Introduction: The teacher ask the students to define conduction, convection and radiation.

Presentation:

Step I: Defining the concepts of Kinetic theory, Boyle's and Charle's laws, gas laws, and postulates of the kinetic theory.

Step II: Exposure to concepts and prepositions

Concepts	**Proposition**
Kinetic theory	Is the movement of
Gases	has
Volume	Inversely proportional
Charle's Law	Proportional
Postulates	Behaviors
Boyle's Law	Gives
Gas Law	form
Temperature	Combined to



Evaluation: The teacher evaluates the lesson by asking the following questions.

(1) Define the kinetic theory

(2) State Boyle's and Charle's laws

(3) State the general gas law

(4) Outline the basic postulates of the kinetic theory

(5) Draw a Concept Map.

Summary: The teacher summarizes the lesson by stating the concepts as follows

Basic postulates of the kinetic theory.

(i**).** There are a large number of gas molecules, N, each of mass m moving in random With a variety of speed v. this assumption is in accordance with the observation that gas fills its container.

(ii). The molecules are on the average far apart from each other, and their average separation is much greater than the diameter of each molecule.

(iii). Collisions with one another or walls of the containing vessels are assumed to be Perfectly elastic.

(iv). The molecules are assumed to obey the laws of classical mechanics, and are assumed to Interact with one another only when they collide**.**

General gas laws.

(i). Boyle's law. "the volume of a fixed mass of gas at constant temperature is inversely proportional to the pressure". Mathematically $V \alpha \frac{1}{p}$ where V is the volume and P is the pressure of the gas.

(ii). Charles's law. "the volume of a fixed mass of gas is directly proportional to the absolute temperature when the pressure remains constant".

Mathematically, V α T. where V is the volume and T is the absolute temperature.

General gas law is mathematically represented as $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T}$.

ASSIGNMENT: A mass of gas at 7^oC and pressure 70cmHg has a volume 1000cm3. Determine its volume at 27^oC and pressure 85cmHg.

Lesson VI

Topic: Thermodynamics.

Duration: 2hours

Behavioral Objectives: By the end of the lesson, the students should be able to

(i) Define and state the laws of thermodynamics

(ii) Draw Concept Map linking the laws of thermodynamics.

Teaching Aids: Cardboards carrying key concepts in thermodynamics.

Prior Knowledge: The students have an idea on internal energy, heat and temperature.

Introduction: The teacher introduces the lesson by asking the students to define internal energy, heat and temperature.

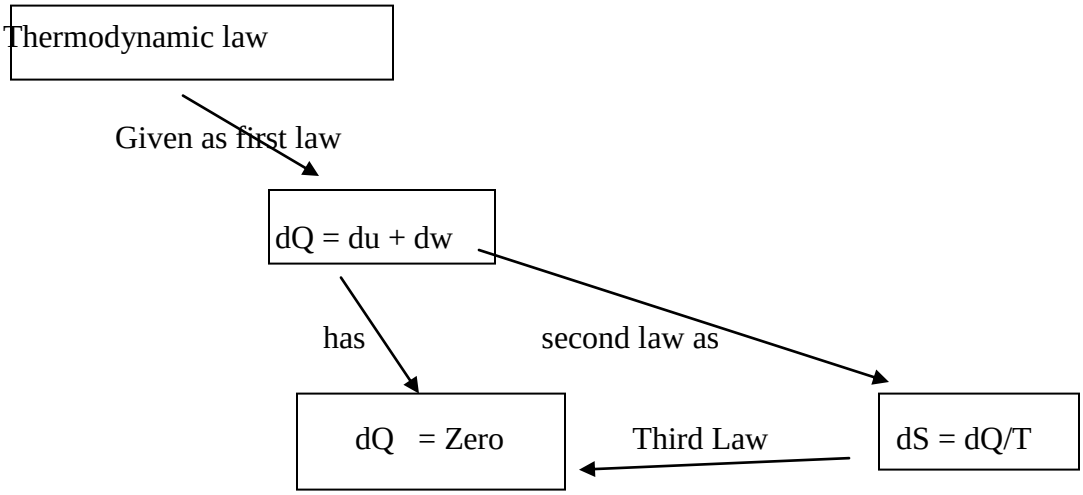
Presentation:

Step I: The teacher defines the concepts of thermodynamics, stating the laws of thermodynamics.

Step II: Exposure to concepts and prepositions

Concepts	**Proposition**
Thermodynamic Laws	First Law
dQ = du + dw	Second law
dS = dQ/T	Third law
dQ =Zero	Has

Step III



Evaluation: The teacher evaluates the lesson by asking the following questions:

(1) State the three laws of thermodynamics
(2) Draw a concept map linking the laws of thermodynamics

Summary: The teacher summarizes the lesson the stating the laws of thermodynamics as follow:

Laws of thermodynamics:

First law: If work is done on a given mass of gas, the heat change is given as

dQ = dw + du. Where dQ is the heat change, dw is the work done and du is the internal energy.

Second law: state that as the entropy of any closed system is always on the increase, mathematically

Given as $ds = \frac{dQ}{T}$, where ds is the entropy , dQ is the heat energy and t is the temperature.

Third law: The entropy of a perfectly reversible system is zero at absolute temperature, or at thermal equilibrium, the heat capacities, coefficient of expansion and other thermal properties including entropy cease to exist.

APPENDIX VII

Lesson I

Lesson Plan of Inquiry Strategy (Experimental Group 2)

Inquiry Strategy.

School: C.O.E Waka Biu

Level: Nce I

Course; Phy 121 (Thermal Physics I). Credit Unit 2

Topic: Heat and Temperature

Duration: 2 Hours

Statement of the problem: Transfer of heat

Behavioral Objections: By the end of the lesson, the students should be able to

(i). Distinguish between heat and temperature;

(ii). Define power

(iii). Identify temperature measuring instruments and state units of measurements

Teaching Materials: hot and cold water, thermometer

Previous Knowledge: The students have an idea on warm and cold bodies.

Engage

Pre-Lab Discussion:

(i) What happens if a finger is dipped into a bowel of hot water and then immediately transferred into another bowel of hot water?

(ii) What happens if a thermometer comes into contact with a hot or cold object?

(iii) Identifying what is contained in each of the thermometers.

Explore

Pupils Activity:

(i). Students are divided into a group of five.

(ii). Collect materials for the experiment

(iii). Perform the investigation set up.

(iv). Make and record all observations.

Explain nd Elaborate:

Post-Lab discussions and observations.

(i) Heat is the transfer of energy due to temperature difference, while temperature is the degree of hotness or coldness of a place.

(ii) Thermometers are used to measure the temperature of a body, it has lower and upper fixed points.

(iii) Types of thermometers include: Gas thermometers, mercury in-glass thermometers, alcohol thermometers, thermocouples/thermo-electrical thermometers and resistance thermometers.

(iv) The temperature measuring scales include:

Scale	lower fixed point	upper fixed point
Celcius	0^oC	100^oC
Fahrenheit	32^oF	212^oF

Kelvin	273.15K	373.15K

Evaluation: The teacher evaluates the lesson asking the students the following questions:

(1) Define heat and temperature

(2) Define power

(3) Identify temperature measuring instruments

Assignments. Convert (i) 40^{o}C to ^{o}F (ii). 27^{o}C to Kelvin scale

Lesson II

Topic: Transfer of heat

Statement of the Problem: Rise in Temperature is proportional to the heat supplied to a body.

Behavioral Objectives: By the end of the lesson, the students should be able to

(i) distinguish heat capacity and specific heat capacity.

(ii) determine the heat capacity and specific heat capacity of substances using calorimetry.

(iii) calculate known quantities using the relation $H = mc\Delta T$ when no heat is involved.

Materials: hot metal bob, water, calorimeter, mercury in-glass thermometer, and beam balance.

Previous Knowledge: The students have an idea on heat and temperature.

Engage:

Pre-Lab discussion:

(i) What happens if a hot body comes into contact with a cold body?

(ii) If the hot metal bob is transferred into the calorimeter containing cold water, what is the observation that will be made?

(iii) Is there any change in the temperature of either the bob or calorimeter and its contents?

Explore

Pupils Activity:

(i) Divide the class into a group of five.

(ii) Collect all the materials for the investigations.

(iii) Measure and record the masses of water, calorimeter and bob. Record also the initial and final temperatures of the materials collected.

Explain and Elaborate:

Post-Lab discussion:

Heat lost by one object equals heat gained by another object, ($H = mc\Delta T$), where H is the Quantity of heat loss by metal, m is the mass of bob, c is the specific heat capacity and ΔT is the change.

Evaluation.

(i) Define heat capacity

(ii) Specific heat capacity and the units of measurements

ASSIGNMENT;

1 What is meant by the statement "the specific heat capacity of water is 4200Jkgk-^{1}"?

2Calculate the temperature change when 1000J of heat is supplied to 0.1kg of water.

Lesson III

Topic: Change of State.

Statement of the Problem: Phase Change between Solid, Liquid and Gas.

Behavioral Objectives. By the end of the lesson, the students should be able to

(i) Mention the three states of matter.
(ii) Define heat of fusion, fission, Transformation, latent heat and heat of vaporization.
(iii) Solve numerical problems on change of state.

Materials. Solid Naphthalene, Thermometer, beaker, water and bunsen burner.

Previews Knowledge. The students have an idea on heat exchange between different object.

Engage

Pre-Lab Discussion: What happens if a substance is heated or steam is collected and then allowed to cool, or water is stored in a refrigerator?

Explore

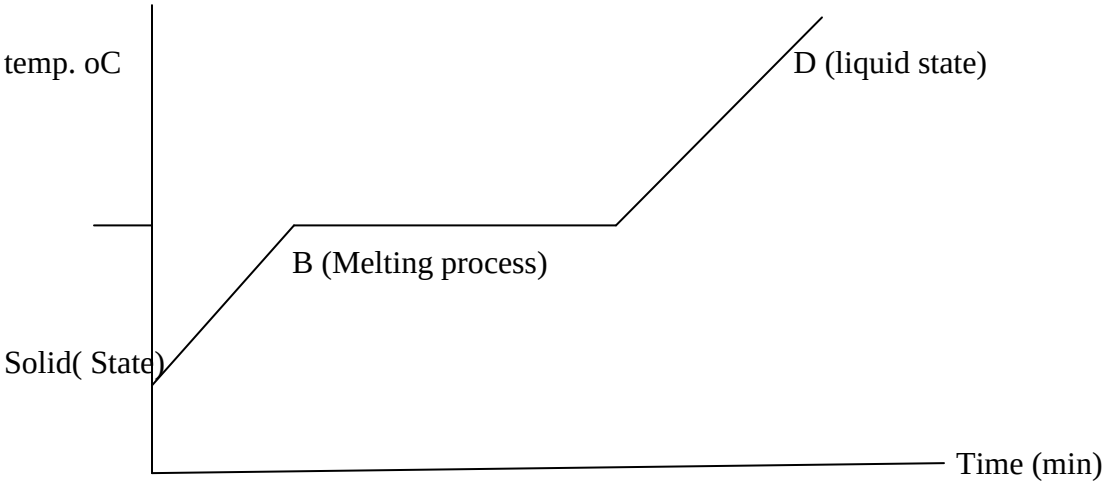
Pupils Activity:

(i) Divide the students into a group of five.
(ii) Collecting the materials- solid naphthalene, thermometer, test tube, beaker, water and Bunsen burner.
(iii) Perform the investigation- put solid naphthalene into a test tube and insert all into a beaker containing hot water.
(iv) Read and record the temperature of melting naphthalene at one minute interval as the water moreand more.

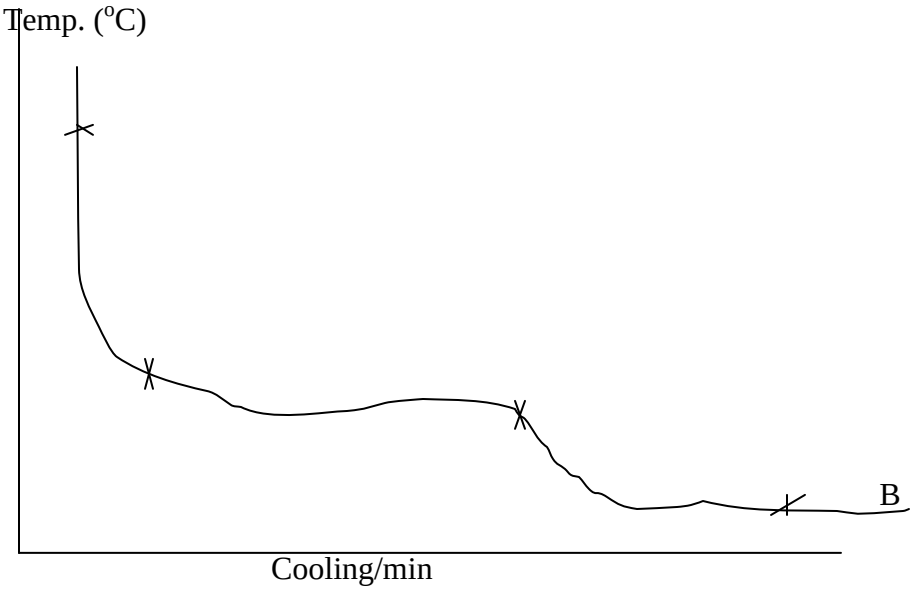
(v) When all naphthalene have melted, remove beaker of hot water and allow to cool slowly and undisturbed. Record the time interval after one minute.

Explain and Elaborate:

Post-Lab Discussion: The discussion is done with the aid of graphs.



Above is a graph of the heating of naphthalene



Above is the cooling of naphthalene

Figure 2 and 3 showed the change of phase in solid naphthalene.

Evaluation: The teacher evaluate the lesson by asking the following questions

(1) Define Heat of vaporization

(2) Heat of transformation

(3) Heat of fusion

Summary: The teacher summarizes the lesson based on the following:

Heat of transformation: is defined as the amount of heat per unit mass that must be transferred when Sample completely undergoes a phase change.

Heat of vaporization: this is when a substance changes phase from liquid to gas (absorbs heat) or from gas to liquid (releases heat).

Heat of fusion: this is when a substance changes phase from solid to liquid (absorbs heat) or from Liquid to solid (releases heat).

Assignment: what quantity of heat will be necessary to change 2kg of ice at $0^{o}C$ to water at $10^{o}C$. Specific latent heat of ice = $3.36 \text{ X } 10^{5}Jkg^{-1}$ and the specific heat capacity of water = $4200JkgK^{-1.}$

Lesson IV

Topic: Conduction, Convection and Radiation.

Statement of the Problem: Ways in which heat is transferred.

Behavioral Objective: By the end of the lesson, the students should be able to;

(i) Enumerate ways in which heat is transferred.

(ii) Define thermal conductivity

(iii) Electromagnetic radiation

Materials: long metallic rod, thermometer, two calorimeters containing hot and cold water and a lagging material.

Previous Knowledge: the students have an idea on heat and temperature.

Engage

Pre-Lab Discussion: What happens if a long metallic rod comes into contact with a hot object, or water is boiled and the cap lifted?

Explore

Pupils Activities:

(i). Dividing the class into group of five.

(ii). Collect the materials according to the groups.

(iii). Perform the investigation. Example;- insert one end of the metallic rod into a flame and allow it to remain for some time touch the other end with a finger and make the observation. Measure the initial and final temperatures of the calorimeters containing hot and cold water respectively and pour the hot water into the calorimeter containing the cold water, stir and then measure the temperature of the mixture and then make the observation.

Explain and Elaborate

Post-Lab Discussion:

Heat is transferred form a hot region to a cold region in three different ways;- conduction, convection and radiation. When the metallic rod or the calorimeter containing the hot water is lagged with the lagging material, heat loss from the environment is controlled, and this ensures a uniform heat flow or a steady heat flow.

Evaluation: The teacher evaluates the lesson by asking the following questions:

(1) State ways in which is transferred

(2) Define each of the ways in which heat is transferred

(3) Define thermal conductivity

Summary: The teacher summarizes the concepts as follows:

(i) Conduction. This is defined as the transfer of heat through solids.

(ii) Thermal conductivity refers to heat flow per unit time, mathematically written as $\frac{Q}{t} = KA\frac{\theta 2-\theta 1}{l}$, where Q is the quantity of heat, t is the time, A is the cross-sectional area of the metal rod, l is the length of rod K is the thermal conductivity of the material and $\theta 1\ and\ \theta 2$ are the initial and final temperatures of the for.

(iii) Convection refers to the transfer of heat through fluids.

(iv) Radiation refers to the transfer of heat through a vacuum. Radiant heat consist of electromagnetic radiation which passes through vacuum

Lesson V

TOPIC: Kinetic Theory of Gases.

Statement Of The Problem: The General behavior of gases.

Behavioral Objective. By the end of the lesson, the students should be able to:

(i) Define kinetic theories of gases.

(ii) Boyle's and Charle's laws of gases

(iii) State the general gas laws.

(iv) Outline the postulates of the kinetic theory

Materials: A sealed empty can, Bunsen burner

Previous Knowledge: The students have an idea on conduction, convection and radiation.

Engage

Pre-Lab Discussion: If the empty can is heated with its opening closed, what happens to the air inside?

Explore

Pupils Activity:

(i) Divide students into a group of five.

(ii) Close the can with a stopper and heat with the opening closed.

(iii) Record all observations made.

Explain and Explore

Post- Lab discussion. The gallon on hearting increases in size which indicates an increase volume when the temperature rises.

Evaluation: The teacher evaluates the lesson by asking the following questions.

(1) Define the kinetic theory

(2) State Boyle's and Charle's laws

(3) State the general gas law

(4) Outline the basic postulates of the kinetic theory

Summary: The teacher summarizes the lesson by revising the following concepts:

Basic postulates of the kinetic theory.

(i**).** There are a large number of gas molecules, N, each of mass m moving in random With a variety of speed v. this assumption is in accordance with the observation that gas fills its container.

(ii). The molecules are on the average far apart from each other, and their average separation is much greater than the diameter of each molecule.

(iii). Collisions with one another or walls of the containing vessels are assumed to be Perfectly elastic.

(iv). The molecules are assumed to obey the laws of classical mechanics, and are assumed to

Interact with one another only when they collide**.**

General gas laws.

(i). Boyle's law. "the volume of a fixed mass of gas at constant temperature is inversely proportional to the pressure".Mathematically $V \alpha \frac{1}{p}$where V is the volume and P is the pressure of thegas.

(ii). Charles's law. "the volume of a fixed mass of gas is directly proportional to the absolute temperature when the pressure remains constant".

Mathematically, V α T. where V is the volume and T is the absolute temperature.

General gas law is mathematically represented as $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T}$.

ASSIGNMENT: A mass of gas at 7^oC and pressure 70cmHg has a volume 1000cm3. Determine its volume at 27^oC and pressure 85cmHg.

Lesson VI

Topic: Thermodynamics.

Statement of the Problem: Establishing the laws of thermodynamics.

temperature, volume and pressure.

Behavioral Objectives: By the end of the lesson, the students should be able to

(i) Define and state the laws of thermodynamics

Previous Knowledge: The students have an idea on the kinetic theory of gases.

Materials: A sealed empty can, Bunsen burner.

Engage

Pre-Lab discussion: suppose a gas in a container is subjected to a pressure P and this causes

The volume of the gas to expand by an amount dV, what will be the work done on the gas.

Explore

Pupils Activity.

(i) Divide students into a group of five.

(ii) Close the can with a stopper and heat with the opening closed.

(iii) Record all observations made.

Explain and Elaborate

Post-Lab discussion: the work done on a mass of gas is the product of the pressure

experienced by the gas and the change in volume.

Note: if the work done is at constant volume, the process is known as isobaric process, if it is at Constant temperature, it is called isothermal process and if it is at constant pressure the Process is known as isochoric process.

Evaluation: The teacher ask the students to define and state the laws of thermodynamics

Summary: The teacher summarizes the lesson by reviewing the following:

LAWS OF THERMODYNAMICS:

First law: If work is done on a given mass of gas, the heat change is given as dQ = dw + du. Where dQ is the heat change, dw is the work done and du is the internal energy.

Second law: state that as the entropy of any closed system is always on the increase, mathematically Given as $ds = \frac{dQ}{T}$, where ds is the entropy , dQ is the heat energy and t is the temperature.

Third law: The entropy of a perfectly reversible system is zero at absolute temperature, or at thermal equilibrium, the heat capacities, coefficient of expansion and other thermal properties including entropy cease to exist.

Appendix viii

Table of Specification

S/No.	Topics	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Total
1	Heat and Temperature	1,2,8	20,28	19,26	-	-	-	07
2	Transfer of Heat	4,10,13	30,22	11,14	5,9,24	-	-	10
3	Thermal Energy Development	3	-	21	15,27	-	-	04
5	Kinetic theory	6,7,8	12,16	-	17,23		25,29	09
Total		10	06	05	07	-	02	30

Appendix ix

NCE 1 SECOND SEMESTER

PHY 121 THERMAL PHYSICS 1 2 Credits Compulsory

CONCEPTS OF HEAT AND TEMPERATURE

Nature (properties) of Heat and Temperature

Various measurements involving them with emphasis on constant pressure and Resistant thermometers. Other thermometric properties.

THERMAL ENERGY DEVELOPMENT

Quantity of heat and calorimetry including cooling corrections

Change of state, molecular interpretations

Gaseous process and laws;

Definitions and measurements of latent heats

Calculations involving quantity of heat and latent heat.

HEAT TRANSFER

Conduction, convection, radiation

Black-body radiation

Stefan's, Planck's and Wien's laws

Prevost's theory of heat exchange

Problems involving these.

KINETIC THEORY

Assumptions of the kinetic theory model of gases e.g. Brownian motion

Ideal gas laws and equations

Quantitative treatment of molecular speed and root mean square speed

Differences between real and ideal gas

Van der Waal's equation for real gases

Zeroth and First laws of thermodynamics

Appendix x

One Way Analysis of Variance Tuesday, March 20, 2012, 14:35:35

Data source: Data 1 in Notebook

Normality Test: Failed (P = <0.001)

Equal Variance Test: Passed (P = 0.424)

Group	N	Missing
AZ	40	0
KSHM	40	0
JYL	40	0
BIU	40	0

Group	Mean	Std Dev	SEM
AZ	18.200	7.640	1.208
KSHM	17.175	8.995	1.422
JYL	15.950	6.645	1.051
BIU	15.125	6.684	1.057

Power of performed test with alpha = 0.050: 0.101

The power of the performed test (0.101) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Source of Variation	DF	SS	MS	F	P
Between Treatments	3	219.525	73.175	1.283	0.282
Residual	156	8896.450	57.029		
Total	159	9115.975			

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.282).