EFFECTS OF GUIDED INQUIRY STRATEGY ON LEARNING OUTCOME OF LOW ACHIEVING SECONDARY SCHOOL PHYSICS STUDENTS IN KADUNA METROPOLIS, NIGERIA.

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THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA. IN PARTIAL FULFILMENT FOR THE REQUIREMENT FOR THE DEGREE OF MASTERS IN SCIENCE EDUCATION

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DECLARATION

I declared that the work in the thesis titled "**Effect of Guided Inquiry Strategy on Learning Outcome of Low Achieving Secondary School Physics Students in Kaduna Metropolis**" has been written by me in the Department of Science Education, 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 titled "**Effect of Guided Inquiry Strategy on Learning Outcome of Low Achieving Secondary School Physics Students in Kaduna Metropolis**" *by* Surajudeen SHITTU, meets the regulations governing the award of the degree of masters in Science Education (M.ED) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my Father, Mudathir Shittu and my Mother Nusirat Shittu. I thank you all for your efforts towards my success in life. May Allah (SWT) bless and grant you His mercy, Amin.

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OPERATIONAL DEFINITION OF TERMS AS USED IN THIS STUDY

Learning Outcome: as used in this study means the academic achievement and attitude of low achievers to Physics.

Guided Inquiry Strategy: Guided inquiry as used in this study is a student centred, activity-oriented teaching strategy in which the teacher directs students through problem-solving approach to discover answers to instructional topic at hand.

Achievement: This is the assessment of how much students have learned, the extent to which a student has acquired certain information or mastered skill usually because of planned information or training.

Low Achievers: These are students whose academic potential are judged below class average while their performance is described as poor. Low achievers are students who score 35 to 45 per cent of total marks consistently for three consecutive examinations.

Attitudes: Is the favourable or unfavourable response to things, places, people, events or ideas.

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ABBREVIATIONS USED

FME:	Federal Ministry of Education
NERDC:	National Educational Research and Development Council
EG:	Experimental Group
CG:	Control Group
NRC:	National Research Council
STAN:	Science Teachers Association of Nigeria
PAT:	Physics Achievement Test
PSAQ:	Physics Students Attitude Questionnaire
NCCE:	National Commission for Colleges of Education
SSCE:	Senior Secondary Certificate Examination
WAEC:	West Africa Examination Council
SSS:	Senior Secondary School

ABSTRACT

This study investigated the effect of guided inquiry strategy on the learning outcome of low achieving secondary school Physics students in Kaduna metropolis. The study is a pretest, posttest quasi experimental in nature. The population consists of 1,714 SS2 science students consisting of 1,018 males and 696 females. Two schools were randomly selected through table of random digits and were randomly assigned control and experimental groups using balloting. Ninety-one (91) students identified as low achievers were purposively selected from the two sampled schools based on the schools' records i.e (students who consistently scored below average in 3 consecutive examinations in Physics). 48 students were in control group; lecture method was used to teach them, while 43 students were in experimental group and taught using guided inquiry strategy. The two groups were taught light concept for six weeks. Two instruments, namely Physics Achievement Test (PAT) and Physics Students Attitude Questionnaire (PSAQ) were used for data collection. Four research questions were raised with corresponding hypotheses stated. These hypotheses were tested using t-test and Wilcoxon statistics at $P \leq 0.05$. The findings of the study showed that low achievers of senior secondary school exposed to guided inquiry strategy in the teaching and learning of light concepts performed significantly better than those exposed to lecture method of instruction. The attitude of the experimental group improved significantly. While on gender related effect, guided inquiry strategy favours both male and female low achievers of senior secondary school. Recommendations based on the findings were made which include the provision of in-service training and retraining for teachers on the use of guided inquiry strategy for teaching Physics concepts.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Science as a concept is a process that is geared towards problem solving in order to enhance the living standard of man. Nwagbo (2005) defines science as intellectual activity carried out by human and designed to discover information about the natural world in which he lives as well as to discover the ways in which the information can be organized to benefit human race. Similarly, the Microsoft Encarta Reference Library (2005) defines science to consist of the following:

i. The systematic observation of natural events and conditions in order to discover

facts about them and to formulate laws and principles based on these facts.

ii. The organized body of knowledge that is derived from such observations and that can be verified or tested by further investigation.

From the definitions, science can be seen as not just mere acquisition of facts but rather the active involvement of students through activity – based methods such as, discussion method, project method, fieldtrip, discovery, co- operative learning and guided inquiry strategies. These teaching methods make the teaching and learning of science more meaningful in such a way that students would be able to unfold concepts by themselves as a means of achieving one of the objectives of the National Policy on Education, (FME, 2004). Students' interest in science should therefore be aroused at the secondary school level in order to prepare them for further studies in science courses at

the tertiary level to realize these goals. Physics as a science subject at the secondary school level is an important subject that is required for the scientific and technological development of any nation. Okoronka (2004) asserts that Physics is a vehicle for achieving the long-term goals of science because it is instrumental to technological and socio-economic growth across the globe. The role of Physics in the education of scientists, engineers, chemists and practitioners of other physical and biological sciences are enormous (Oludipe, 2003).

According to Grant (1998), physics occupies unique position among other science subjects because of the numerous applications to which its concepts are being used to improve man's environments. The teaching of Physics should therefore, reflect the processes and methods of modern science, which could enhance technological development. According to Hermann (2005), the effectiveness of teaching any subject could be measured in terms of the knowledge of what to teach, how to teach it and when to teach it. The "how" of teaching constitutes what is called teaching, (Hermann, 2005). No wonder National Commission for Colleges of Education, NCCE, (2002) stated that teachers should use several methods of teaching when effective teaching and learning is desired.

The overall poor academic performance in physics among secondary school students raise doubt on the efficacy of the teaching methods utilized by teachers in schools, (Eta, 2000). The achievement momentum of students in the classroom teaching and learning of physics varies according to certain factors such as; students' background, teaching method and developmental level in terms of chronological and cognitive maturity. Such variations lead to "labeling" students as under-achievers (limited learners), slow learners,

dropout, all being descriptions of weak and low ability group, and the "talented" generalized as high-ability group (Oxenhorne, 1992; Ali, 1998; Nkwo, 2003).

This trendy movement towards the direction of low achievement in physics learning could likely suggest that tomorrow's physics education practitioners may be bereft of techno-scientific competencies, required for future development and the applications of physics in achieving the goals of science (physics) education,(FME, 2002, 2004). Low achievement according to Oxenhorne (1992), is due to inability of classroom instructional experience to provoke the innate potentials of learners. Low achiever according to Shanmukappa,(1978) is a student who scores 35 to 45 per cent of total marks consistently for two years in an annual examination. Panchalingappa (1994) described low achievers as those with a marked discrepancy between potential (as shown by ability tests) and performance (as shown by grades or achievement test) scores. Bharatidevi (1982) states that, low achievers are those students who scored an average less than 50per cent marks consecutively over two years in their previous examinations. While according to Reddy and Ramar (2003), low achievers are those whose ability is not quite so limited but nevertheless who have more difficulty in learning than average students. The students' attainment is not in tune with their capability but below the expected level of achievement. Low achievers in this study are regarded as students who score below average in three consecutive examinations.

Recent studies Ogunleye (2001) and Bunkure (2008) and statistics from the West Africa Examination Council (WAEC 2004,2006,2007 &2008) chief examiner's report on senior secondary school students' achievement in physics revealed that, the subject had both the lowest enrolment relative to other science subjects and recorded poor

achievement in the Senior School Certificate Examination (SSCE). The reasons identified for these anomalies by several researchers (Onwioduokit and Efut, 2000, Akanbi 2002, Owolabi 2006, Daniel & Lasisi 2009) include such factors as lack of infrastructure and suitable environment, inadequate laboratory facilities, shortage of qualified teachers, the perception of physics by learners as very difficult subject, lack of opportunity for the learners to have direct experience with learning materials and most fundamentally, the instructional strategies used in teaching physics. Of these factors, the most related one to this study is the factor on instructional strategy.

Iroham (1991) observed that the present method of teaching physics whereby teachers use lecture method does not in any way provide for sequence of learning experiences. Lecture method is a method of teaching in which the teacher delivers pre – planned lesson to students with little or no instructional aides. In using this method, the teacher talks about science/physics while the student reads about it, (Gbamanja, 1991). Lecture method, traditionally referred to as didactic approach is defined as a technique in which one person, usually the teacher, presents a spoken discourse on a particular subject (Atadoga & Onaolapo, 2008). Lecture is used for elaborating; simplifying, clarifying and discussing new materials to learners the materials may include facts or views on issues and problems related to the learners, which provide an aesthetically stimulating experience. Effectiveness of lecture method depends on the type of student, circumstances of the class, the subject, educational purposes and teacher's own characteristics and skills. According to Adesoji (2009), many academics have accepted lecture method as a proper way of imparting knowledge since our educational system puts so much premium on external examinations. This is however a detriment to student

learning, since one of the objectives of science education is to develop student's interest in science and technology as today's society depends largely on development in science and technology. The teaching and learning of physics concepts should therefore be done using teaching methods that are activity-oriented such as discussion method, demonstration method, project method, fieldtrip as well as guided Inquiry teaching method(Okebukola, 1994,1997 and 2004). Lecture method is been used in this study to teach the control group.

The guided inquiry strategy is described by Sola and Ojo (2007) as a student – centered, activity – oriented teaching strategy in which the teacher directs students through problem – solving approach to discover answers to instructional topic at hand. In fact Adedoyin (1990) and Callahan , Clark and Kelloough (1995) in their opinion described guided inquiry as a style or method of teaching where the learner with minimum guidance from the teacher seeks to discover and create answer to a recognized problem through procedure of making a diligent search. Research findings of science educators like Jegede and Taylor (1998), Okebukola(2002),Tsui and Treagust(2002) revealed that teaching methods that are activity –oriented which involve the learner taking active role in the teaching/learning process result in meaningful learning of science concepts. However, teachers in schools resort to the use of lecture method which several studies such as James (2000), Usman (2000) and Bichi (2002) pointed out that it only encourages rote learning and as such does not enhance academic performance and positive attitude towards science among both male and female students. Therefore, in this study an investigation is made on the effect of guided inquiry strategy on the academic achievement and attitude of low achievers in Physics at senior secondary level

to see whether the academic achievement of low achievers in physics could be enhanced .

Kobolla (1995) defined attitude as the favorable or unfavorable response to things, places, people, events or ideas while Erdemir and Bakirci, (2009) described attitude as tendency for individuals to organize thought, emotions and behaviors towards psychological object. Human beings are not born with attitudes they learn afterwards. Some attitudes are based on peoples own experience, knowledge and skills and some are gained from other sources. Gibson and Chase (2002) reported that inquiry activities not only led to more interest in science but that this interest persisted long after inquiry intervention was over. The inappropriate use of teaching method as opined by Akinmade, (1992) leads to the decline in students' attitude to science.

Another important variable of concern in science education is the issue of gender-related differences in performance. The findings of science educators have revealed under-representation of girls in science, mathematics and technical subjects at the secondary school level (Yoloye, 1994 & Fakorede, 1999). In addition to under representation is also the under achievement of girls in science and science related courses, Lieberrnan (1998), James (2000) while Nwosu (2001) stated no gender difference in their performances in science. This study intends to find out, the effect of guided inquiry on the low achieving male and female students' performance and attitude towards physics at the Secondary School level.

1.1.1 Theoretical Framework of the Study

The theoretical basis for this research work is the constructivist theory proposed by Bruner (1960), which is premised on the active nature of learning. Bruner's theory of learning prefers to promote the acquisition of knowledge through inquiry.

Inquiry is used according to this theory as all forms of obtaining knowledge for oneself by use of mental processes. Bruner (1962) states that the greater the students involvement in the learning process, the greater the learning. Bruner (1962) and Njoku (2007) said that the learning environment should be learner- centered rather than teacher- centered, especially at the secondary education level because the learner masters what he gets involved in doing and not what the teacher gets involved in doing.

Learning according to Erinosho (2008) is an active process. Facets of the process include selection and transformation of information, decision making, generating hypotheses, and making meaning from information and experiences. Hartman & Glasgow (2002) opine that for effective learning to occur, "part of the naïve ideas in students must be revised, part can be built upon and part must be discarded. As far as instruction is concerned, the instructor should try and encourage students to discover principles by themselves. The instructor and student should engage in an active dialogue (i.e., Socratic learning). To the constructivist, knowledge resides in the individual learner, and as such, learning is a process through which an individual tries to make sense of what is taught by trying to fit it into her/his existing knowledge structure and prior experience(s) (Erinosho,2008). Therefore the use of active instructional strategies such as discussion, role play, guided inquiry, concept mapping are invaluable support for students to strengthen connections between new concepts and prior ones, and build up their knowledge of science hence perform better (Erinosho, 2008). Based on these facts, it is assumed that guided inquiry strategy which is an activity based strategy will assist learners to form their own concepts and consequently enhance performance and attitude to Physics.

1.2 Statement of the problem

The consistent and steady increase in failure rate in physics within the last two decades attests to the fact that physics teaching and learning among secondary school students has not been properly addressed (Stephen, 2008). Review of past achievement in Physics had been low (Olotu 1992, Ivowi1993, Owolabi 1999, Atadoga 2001 and Otuka2006) at Senior Secondary School Certificate Examination (SSCE).The situation appears to still remain the same till date. This view was further stressed by the chief examiner's reports of 2005, 2006 and 2007. The observed failure rate according to Onwioduokit and Efut (2000) is mostly attributed to improper exposure to laboratory activities, poor science background at junior secondary school and lack of problem solving ability while Kalijah (2000) stated part of the problems leading to this failure rate in physics to include poor method of instruction. This is supported by the assertion of Agommuoh and Nzewi (2003) where they attributed the deterioration in students' achievement in Physics to ineffective method of teaching Physics. Based on this deplorable trend of poor performance, Physics educators have designed some instructional strategies over the years to curb the problem of underachievement in the subject as well as achieve the aims and objectives of teaching physics (Nwagbo, 2001). For instance, Iroegbu (1998) designed Problem-Based learning for better achievement, problem solving and line graphing skills in Physics. Orji (1998) recommended the use of problem solving and concept mapping strategies and cognitive style to improve achievement and attitude towards physics. While Osisioma (2005) recommend student centered method such as guided inquiry used in this study.

Attitude has been proven to play a major role in learning among students (

Ajewole, 1991 & Okebukola, 2002). Gibson and Chase (2002) reported that inquiry strategy not only led to better interest in science but that this interest persisted long after inquiry intervention was over. Reports in most literatures showed that the studies carried out were on students of mixed ability levels without considering low ability level students (low achievers). In the light of this, the researcher deems it necessary to employ the use of guided inquiry strategy to teach the low achievers in physics among senior secondary two students in Kaduna metropolis. Their negative attitude toward the subject is also of interest. Specifically the study investigated the effect of guided inquiry strategy on learning outcome of low achieving secondary school physics students in Kaduna metropolis.

1.3 Objectives of the Study

The study has the following objectives to:

- investigate the effect of guided inquiry strategy on the academic achievement of low achievers in physics at senior secondary school level.
- examine gender related effect of guided inquiry strategy on the academic achievement of low achievers in physics at senior secondary school level.
- find out the effect, guided inquiry strategy has on the attitude of low achievers in physics at senior secondary school level.
- determine the gender related effect of guided inquiry strategy on the attitude of low achievers in physics at senior secondary school level.

1.4 Research Questions

This study attempts to answer the following research questions;

- What is the effect of guided inquiry strategy on the academic achievement of

low achievers in physics?

- To what extent does guided inquiry strategy has gender related effect on the academic achievement of low achievers in physics?
- Is there any difference in the attitude of low achievers in physics after exposure to the guided inquiry strategy?
- Will there be any gender related difference in the attitude of low achievers in physics when taught using guided inquiry strategy?

1.5 Hypotheses

The following null hypotheses were formulated for testing at $P \leq 0.05$ level of significance;

Ho_1: There is no significant difference in the mean achievement scores of low achievers in physics exposed to guided inquiry strategy and those exposed to lecture method.

Ho_2: There is no significant difference in the mean achievement scores of male and female low achievers in physics exposed to guided inquiry strategy.

Ho_3: There is no significant difference in the attitudinal change of low achievers in physics after exposure to guided inquiry strategy.

Ho_4: There is no significant difference in the attitudinal change of male and female low achievers in physics after exposure to guided inquiry strategy .

1.6 Significance of the Study

It is hoped that the findings of this study would be useful in the teaching and learning of physics in the following ways:

1. Motivate curriculum planners of senior secondary school physics to emphasize the use of guided inquiry teaching method in teaching various concepts in physics. This will help to enhance the performances of low achievers in physics thus reducing the rate of drop out in the subject.
2. Afford low achievers in physics the opportunity to learn by themselves with little guidance from their teachers hence affect positively their attitude to physics subject.
3. Textbooks authors should emphasize guided inquiry strategy as an instructional procedure that should be adopted for effective teaching and learning of various concepts in physics. As this method is activity oriented and would help low achievers in physics to learn meaningfully.
4. Students will also benefit when introduced to suitable method of instructions that will promote their performance in physics.
5. Provide a teaching method for teaching physics in order to inculcate in students the skills of diligent search and enhance positive attitude toward physics.
6. It would help fellow researchers, curriculum developers and educationists to be able to research further, based on the findings of this research work by using low achievers in other science subjects .

1.7 Scope of the Study

The study was limited to one thousand three hundred and seventy seven (1,377) SSII physics students of the public secondary schools in Rigachikun Education Inspectorate Division of Kaduna State as at the time of this study. The SSII students were

considered because they were rooted and more knowledgeable in physics concepts than SSI students who have not yet gained much academic experience and the SS3 students who are busy preparing for SSCE examination. From the population two schools were randomly selected for the study because two groups were involved in the study that is, the control (48 students) and experimental groups (43 students). Light as a concept in physics consisting of reflection on plane and curved mirrors, refraction through rectangular and triangular prism and lenses, which also features in SSII syllabus and could be taught using guided inquiry strategy was selected for the study.

1.8 Basic Assumptions:

The study has the following basic assumptions:

1. Experienced and qualified teachers are teaching the students under study as recommended in the National Policy on Education (FME, 2004).
2. The schools under study run the same academic calendar and use the same syllabi.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature reviewed is discussed under the following sub headings.

- Physics at Secondary School Level
- Concept of Academic Achievement in Science and Categorization of Academic Achievers
- Concept of Guided Inquiry Teaching Method
- Science Teaching Methods
- Gender and Academic Performance in Science
- Attitude as a Factor in the Learning of Science
- Overview of Similar Studies on Guided Inquiry in Science Teaching
- Implications of Reviewed Literature on the Present Study

2.2 Physics at Secondary School Level

Teaching is a dynamic, well-planned and systematic presentation of facts, ideas, skills and techniques to students and its focus is to acquire maximum learning experiences. Selection of the most suitable teaching strategies is the basic condition for successful teaching/learning process. Teaching of science requires more specific teaching/learning techniques /strategies because learning scientific concepts and methods involve understanding and conceptual linkage of various scientific representations (Ainsworth, 2006). These teaching/learning strategies must have

necessary provision for students' active engagement with explanatory ideas and evidence to enable them make connection of scientific theories and concepts to real purposes and practices in the world they live (Tytler, 2003). The most recommended strategies for teaching science (Physics) are problem solving, inquiry-based teaching, laboratory-based activities and project-based teaching/ learning (Mazur, 2008).

Physics, one of the basic sciences, was introduced in Nigeria by "Africa colonies" in 1920 and it has since been studied in our secondary schools starting from Senior Secondary School one (Ali, 1998). The teaching of physics involves developing basic skills, which include observation, manipulation, classification, inference, hypothesizing, interpreting data and formulating model (FME, 2005). Physics as a science subject at the secondary school level is an important subject that is required for the scientific and technological development of any nation. Okoronka (2004) asserts that Physics is a vehicle for achieving the long-term goals of science because it is instrumental to technological and socio-economic growth across the globe. The role of Physics in the education of scientists, engineers, chemists and practitioners of other physical and biological sciences are enormous (Oludipe, 2003). The subject is the foundation of scientific knowledge as it has contributed immensely to the existence and activities of man towards improved standard of living and growth in wealth. Despite the importance of Physics, there are a number of observable problems plaguing the teaching and learning of the subject, especially at the secondary school level. These problems include poor method of instruction (Kalijah, 2002) supported by the assertion of Agommuoh and Nzewi (2003) who attributed the deterioration in students' achievement in Physics to ineffective method of teaching physics while,

Onwioduokit (2000) attributed it to, improper exposure to laboratory activities, poor science background at junior secondary school and lack of problem solving ability. These perhaps may be the reasons for students' poor academic performance in the subject both at the secondary and tertiary school levels.

Based on this deplorable trend of poor performance, Physics educators have designed some instructional strategies over the years to curb the problem of underachievement in the subject. For instance, Iroegbu (1998) designed Problem-Based learning for better achievement, problem solving and line graphing skills in Physics. Orji (1998) recommended the use of problem solving and concept mapping strategies and cognitive style to improve achievement and attitude to Physics. In spite of the scope, depth and supposed efficacy of these varieties of strategies, Physics students at the secondary school level continue to exhibit poor performance in the subject. Statistics obtained from the Research Library of the West African Examinations Council Headquarters Office, Ikeja, Lagos show that between 1999 and 2009 in Nigeria, students' performance in Physics at the Senior School Certificate level is poor as the percentage pass at credit level and above consistently falls below 50% except in the years 2004 and 2006 when it was 51.02% and 58.05% respectively. In one of the years with these fairly high percentage passes i.e. 2006, the highest proportion of candidates who sat for the examination had their results either cancelled or withheld. This incidence might be due to students' involvement in one form of examination malpractice or the other out of desperation to pass. This puts to question the reality of the high level of achievement and by extension the quality and effectiveness of the teaching-learning process in schools. This trend of poor

achievement is not good enough for a technologically aspiring country as Nigeria where there is the incidence of poor enrolment of students and consequently few numbers of persons aspiring to study in the fields of science, technology and related disciplines. A pass in Physics at the distinction or credit level is a pre-requisite for university admission into these fields of study. Poor student performance in Physics perhaps may be linked to the use of instructional strategies which have not totally incorporated learners' previous knowledge and how they reasoned (Ezeliora, 2004; Okoronka, 2004; Okoli, 2006; Longjohn, (2009).

This is more so as instructional strategies adopted by teachers have not solved the problem probably because those strategies have not actually focused on learners as constructors of their own theories and knowledge. Learners need to be made to construct their own knowledge and ideas in learning because they are the architects of their own learning and constructors of their own ideas and knowledge (Glasserfield, 1995 and Okoronka, 2004). Otherwise, continued use of teacher-centered or teacher-dominated strategies would yield nothing but learning by rote thereby making it difficult for students to recall pieces of information from memories. It is against this background that the present researcher undertakes a study on the effect of guided inquiry strategy on the academic achievement of low achievers in physics among senior secondary school two students in Kaduna metropolis, in order to determine whether the guided inquiry strategy would improve performance of low achievers in physics or not.

2.3 Concept of Academic Achievement in Science

Sciences educators have given various definitions of academic achievement.

Amuset (1994) defined academic achievement as the knowledge attained or skill developed in school subject, usually designed by means assigned by teacher. Usman (2000) described academic achievement as the assessment of how much students have learned, the extent to which a student has acquired certain information or mastered skill usually because of planned information or training. Academic achievement according to Chibio (2002) is what students are able to gain in the Senior Secondary School Certificate Examination (SSCE) after completion of senior secondary instruction. Ogunboyede (2003) has defined academic achievement as when teachers spend larger amount of time in direct teaching of reading Mathematics, Science and Social Studies rather than in music art or social awareness.

Furthermore, according to Achino (2000) achievement to be the level of an individual's educational growth in a test when compared with the scores of others of the same level. Generally, academic achievement means accomplishment or proficiency of performance in a given skill or body of knowledge. The major objectives of teaching are to promote the understanding of the concept being taught with a view to applying such knowledge to real life situations and promote academic achievement of student in science. According to Eta (2000), the consistent poor performance and negative attitude towards science attest to the fact that science teaching procedure has not been properly done. Hence, the concepts being taught are not properly understood and leads to poor performance in science subjects. Therefore, science teaching needs appropriate method of instruction that will best achieve the aim of science teaching, thus improving the performance and enhancing the positive attitude towards science subjects such as physics. Scientific achievement simply mean

the use of scientific knowledge acquired by an individual to solve a problem confronting him in the society, Maikano (2006) expressed the view that most important aspects of scientific achievement are those concerned with the development of knowledge and skills needed to make decision and solve societal scientific and technological problems. According to Musa (2000), academic achievement is the quality of result produced by students as reflected in their examination scores. In this study therefore, academic achievement of low achievers in physics is considered. That is, the study determines the effectiveness of guided inquiry strategy on the academic achievement and attitude of low achievers in physics among senior secondary two students compared to lecture method.

2.3.1 Categorization of Academic Achievers

Academic achievers are of different types. Collia (2002) identified three types of academic achievers as follows;

i. **The higher achievers:** James (1991) describes high achievers as those learners who perform well in test, assignments and examinations. While according to Collia (2002) high achievers as those who did not ascribe their fate to luck or to vagaries of chance but rather to their own personal decision and efforts.. Ofonime (2007) further describes the high achievers as learners whose academic potentials are above class average and their performance described as good.

ii. **Middle (average) achievers :** these are the group of learners who according to Eleda (2002) and Awe (2003) can only record an average achievement, not because they are not capable of doing better, but partly because they cannot put in extra effort to attain better achievement. They are therefore contented to remain

average.

iii. **The underachievers (low achievers):** They are described by Ofonime (2007) also described the low achievers as learners whose academic potential are judged below class average while their performance is described as poor. Low achievers are learners who score 35 to 45 per cent of total marks consistently for three consecutive examinations (Shanmukappa, 1978). Panchalingappa (1994) described under achievers as those with a marked discrepancy between potential (as shown by ability tests) and performance (as shown by grades or achievement test) scores. Bharatidevi (1982) states that, low achievers are those learners who scored on an average less than 50 per cent marks consecutively in two previous examinations. According to Reddy and Ramar (2003), low achievers are learners whose ability is not quite so limited but nevertheless who have more difficulty in learning than average learners. Absences from school, unfortunate personal circumstances or inadequate environmental conditions have often further limited their progress. The learners attainment is not in tune with their capability but below the expected level of achievement.

Ayeremo (2001), contended that the underachiever/ low achievers need constant study, evaluation and help so as to reverse their condition. Chadua (2002), identified the problem of the underachievers/low achievers to be one of the tragic dilemmas in education. Low achievers are regarded in this study as learners whose academic achievement or scores in an examination or test are less than the class average score. It is in this regard that the researcher undertakes this study to find out the effect of guided inquiry strategy on the academic

achievement and attitude of low achievers in physics among senior secondary school learners.

2.4 Concept of Guided Inquiry Strategy

Guided inquiry strategy is one of the instructional methods that is activity based. Brunner (1961), postulated this method in science teaching. Research findings of science educators like, Jegede and Taylor (1998), Okebukola (2002), Tsui and Treagust (2002), reveal that those teaching methods that are activity-based such as problem solving, field trip, project method and guided inquiry strategy among others which involved the learner taking active role in the teaching/ learning process, results in better learning and understanding of science concepts on the part of the learner. Guided inquiry is a teaching method that involves mental skills for learning by students such as observing, measuring, classifying, formulating hypothesis, experimenting, data collection, data analysis, making conclusion (James, 2000 & Usman, 2000).

According to Abdullahi (1982), guided inquiry strategy involves an unstructured exploration in the laboratory in which student, through their mental processes such as observing, measuring, classifying ,etc., can draw general conclusion from the data, which they have gathered. Furthermore, Hassard (2005), describe guided inquiry strategy as one of the two types of inquiry namely

1. Guided inquiry.
2. Open inquiry.

Open inquiry strategy is described as a student- centered approach. Students, in this approach, form their own problems and hypotheses, make plans for a scientific research, carry out these researches in order to test their hypothesis and discuss their findings with

other friends (Colburn,2000). Studies on research method conclude that this approach has a positive influence on students' academic success (Ertepinar & Geban,1996; Blonder, Naaman & Hofstein, 2008), their development of scientific process skills (Basaga, Geban & Tekkaya, 1994) and their attitude toward science lessons(Shepardson and Pizzini,1993). However, open inquiry strategy requires a higher order thinking (Orlich,Harder, Callahan & Gibson, 1998). According to Furtak (2006), scientific teaching stands somewhere between the boundaries of the conventional lecture method, in which certain answers known by the teachers are transferred to the students and the open inquiry method, in which students construct their own problems and problem solutions. This version is called guided inquiry strategy. Guided inquiry is to integrate the scientific and constructivist rationales together with the facts, principles and rules accepted as scientific and stressed by contemporary science educator reforms (Magnusson & Palinscar,1995). Guided inquiry strategy is defined as interacting with concrete materials to gain knowledge about some scientific concepts by making use of the guidance made to a certain degree apart from the teacher in order to be able to solve a problem (Lewicki, 1993).

In guided inquiry strategy, teachers and learners play a crucial role in asking questions, developing answers and structuring of materials and cases. The application of guided inquiry strategy is very important in transition from lecturing method to other teaching methods, which are less and more clearly structured for alternative solutions. Guided inquiry activities help students to develop their individual responsibility, cognitive methods, report making, problem solving and understanding skills. According to National Research Council (NRC,2000), guided inquiry approach can best facilitate focusing on learning the development of certain scientific concepts, but while the students in the teachers'

guidance focus their attention on to the content, they have less suitable means for discovering scientific thinking processes and gaining experience (Kai and Krajcik, 2006). The process of guided inquiry strategy involves certain steps. Olagunju (2002) highlighted seven steps as follows;

1. Formulating problem for investigation
2. Formulating hypotheses to guide investigation
3. Designing experiments to collect data
4. Analyzing data
5. Reporting findings
6. Drawing conclusions through generalization or finding solution to problem
7. Possessing certain scientific attitudes such as objectivity, curiosity and open mindedness.

Guided inquiry strategy being one of the activity – based strategies of science teaching was investigated whether it is effective or not in teaching and learning of physics in relation to low achievers' academic achievement and attitude at the senior secondary level. This is in line with Ojo and Obembe (2006) that each strategy of teaching physics should be critically analyzed to see its effectiveness in teaching physics.

Many studies have been completed regarding the effectiveness of guided inquiry strategy in secondary school. Most of the results seem to come to similar conclusions. A study by Rust (2011) on high school physics students showed that the students' problem solving abilities increased and students demonstrated increase in conceptual understanding and thereby performed high in physics. Other studies designed to investigate the effectiveness of guided inquiry strategy include Haury (1993), as cited by Anderson

(2002), which indicated that increase in conceptual understanding as well as an improved attitude towards science (physics). Another study carried out was that of Tural, Akdenic and Alev (2010) who investigated the effects of using the 5E (Engage, Explore, Explain, Elaborate and Evaluation) model of guided inquiry on student teachers' understanding of weightlessness and found that students learning improved and performed high. Another study carried out by Lin, Peng and Wu (2009) investigated the effects of the 5E model of guided inquiry on fourth graders' knowledge, understanding levels and the students' perception about science learning. The result showed that the fourth graders improved in both knowledge and understanding of science. In addition, the students reported that they enjoyed learning through the guided inquiry strategy.

2.5 Science Teaching Methods

The experiences a learner gets depends not only on what the learner is being taught but also on how the learner is taught, (Okebukola, 1997).The nature of science teaching in our schools today has been revealed to be dominated by teacher centered approach(Okebukola,1997). This approach as opined by Nwagbo (1997) has been ineffective at engaging students' interest or making them develop conceptual understanding of the subject matter. Eniayeju (2001) argued that the natural curiosity and eagerness in students to understand their surrounding are often diminished by such instructional procedures as they discourage inquiry and discovery. These and several other reasons have made science educators to advocate for instructional procedures such as guided inquiry, problem solving, field trip, demonstration, project and discussion methods among others, Okebukola, (1994), Okebukola, (1997), Okebukola, (2002), Okafor and Okeke, (2006).The purpose of all teaching is to make the students learn what they are taught. That is, teachers teach to impact

knowledge and skill to students. Physics as a science subject needs to be therefore taught using an activity based method of teaching such as guided inquiry which is investigated in this study in relation to students' performance and attitude

The Lecture Method

This is a method of teaching that emphasizes "talk - chalk" in the teaching of science subjects. More than 80% of scientific information, ideas, concepts, generalization and facts are verbally presented to students by the teacher (Abdullahi, 1982).The teacher does much of the activity in form of talking while the students are either passive or slightly involved. However, Abdullahi (1982) stated that, two teaching skills that make lecture method effective are:

i. Clear and good command of language and

ii. Ability to write clearly and boldly on the chalkboard. In its true nature the lecture approach is not effective for science teaching because it does not promote meaningful learning (Abdullahi 1982, James 2000 and Usman 2000).

Olarewaju (1994) sees lecture method as pure teacher centered approach where students are not given opportunity to ask questions or give feedback to the teacher. Here, the teacher talks and writes notes on the board while the students listen and copy down notes. The lecture method does not promotes academic performance in science as observed by Abdullahi (1982),Awodi (1984) and James (2000). But the aspect of relating the method of instruction to students' performance and attitude in physics is an area of study particularly at the secondary school level. This study determines lecture method effectiveness in teaching/learning of physics in relation to performance and attitude of students at Senior Secondary School Level.

Demonstration Method

This method is a process of presenting, establishing principles or simply display of some things (Abdullahi, 1982). A science demonstration is simply used not only as an exhibition to display parts of equipment but also to describe the correct use of equipment. Abdullahi (1982) and Oguniyi (1986) have independently observed that there are shortcomings of this method, which they have outlined as follows:

In the first instance, students' psychological demand for carrying out activities on their own is not satisfied since students are not usually given the opportunity to develop manipulative skills. Secondly visibility problems encountered by students are not taken care of as students might have difficulties of seeing laboratory equipments used for demonstration. Most students often than not, are unable to follow the demonstrations as these demonstrations are often carried out by the science teachers. Based on these shortcomings Itamah (2007) has advocated that students should have "mind on" experiences in addition to "hands on" activities. Itamah further noted that students subjected to inappropriate class-size cannot achieve high levels of performance without access to skilled professional teachers, adequate classrooms and laboratory, time, accommodating work spaces and an array of learning materials among others. To ensure that students attain meaningful learning in science, Osobuonye (2002) recommended a new instructional technique in the form of guided inquiry.

Concept Mapping Strategy

The idea of concept maps as learning tool was developed by Novak in 1976 as an attempt to explore the changes in children's knowledge of Science (Novak & Musonda, 1991; Novak & Canas, 2008). The ideal derives from Ausubel's (1963) cognitive theory,

which places central emphasis on the connection of students' existing knowledge as the anchor for subsequent meaningful learning. Concept maps are useful tools for helping students learn about the structure of knowledge and tie new knowledge to current experience. They are valuable tools for stimulating students' thinking process and representing knowledge in meaningful learning patterns (Novak, 1991; Jonassen, 1992; Mintzes, Wanderson &Novak, 2000; Novak &Canas, 2008). They are also useful for cooperative learning, to make students support each other and strengthen their understanding of a subject matter, and as members of a group, to bring their thought processes to bear on the interpretation of concepts and relationships. In addition, concept mapping enhances students' achievement and improve their attitude (Jegede, Alaiyemola & Okebukola, 1990; Horton *et al*, 1993; Danmole & Femi-Adote, 2004). Novak (1998) claims that concept maps help to reduce rote learning, and helps a teacher to negotiate meaning with students.

2.6 Gender and Academic Achievement in Science

In Nigeria, reports from some studies requesting female and male adolescents to indicate their choices of subjects revealed that the adolescents selected different courses that followed gender stereotype. Males prefer mathematics and sciences while the females opted for reading and if science, life sciences (Biology) (Ogunsola-Bandele,2000; Akanbi, 2004). Many research works carried on gender effects on academic achievement have shown proportionately low achievement of females in science education programmes and careers (Ogunsola-Bandele, 2000a). Oakley (1993) in Bichi (2002) defines gender as the amount of masculity and feminity found in a person and obviously while there are mixtures of both in most human beings, the normal male has a preponderance of masculinity and the normal female has a preponderance of feminity. Striving after academic achievement in science

conflicts with the traditional female role in many societies. Right from childhood, a boy traditionally receives more training and encouragement for achievement than girls, (Sears et al. 1957 in Bichi 2002). A drop in academic performance of many girls during adolescent is the side effect of their new concentration on personal appearance (Oakley, 1993).

According to Bichi (2002) ,there is sex difference in subject choice and in academic performance within the subjects and that School subjects are sex – stereotyped such that mathematics, physical sciences, computing and engineering for example are regarded as masculine subjects while humanities, languages, domestic subjects are regarded as feminine. Research findings such as Usman (2000) and James (2000) pointed out that male students are academically superior to their female counterparts in science. And researchers such as Aigbomian (2002), Njoku (2007) reported that boys perform better than girls in science, Technical and Mathematical subjects. Uhumuavbi, Oriahi and Olusi (2003) still raised the concern and worry that female achievement in Science, Technology and Mathematics is not encouraging. Nwaiwu and Audu (2005) in the same vein agreed, that, the number of women enrollment in tertiary education has increased at a slower rate than male enrollment. Nwaiwu et al (2005) viewed gender gap in education to be very wide with male enrollment at least three times higher than females. This development perhaps has resulted from the fact that girls still have the difficulty of understanding the physical sciences notably Physics as observed by (Aigbomian, 2002). Nwagbo (2002) reported female science student's appreciation of the role of science as much as their male counterparts but lagging behind in knowledge, application and communication in science. Nwosu (2001) in her study revealed that exposure to science process skills based learning involving activities for both boys and girls yield more effective learning irrespective of gender and ability level. Ogunboyede

(2003) in line with Nwosu (2001) reported that boys are not better than girls in terms of educational achievement in his study of sex difference and students' achievement at the primary school level.

Nwosu (2001) suggest that gender – stereotyping has to be discouraged in homes, schools and societies to enable girls participate freely in the learning of science. One of the aims of this study is an attempt to shed more light as regards the above controversy of the superiority of male over female or otherwise with respect to achievement in science , especially when using guided inquiry strategy of instruction and lecture method in relation to academic achievement on gender difference in physics among low achievers of Senior Secondary II students.

2.7 Attitude as a Factor in Physics/ Science Learning

Attitude is acquired through learning and can be changed through persuasion using variety of techniques. Attitudes, once established, help to shape the experiences the individual has with object, subject or person. Although attitude changes gradually, people constantly form new attitudes and modify old ones when they are exposed to new experiences (Adesina and Akinbobola, 2005). Gagne (1979) defined attitudes as an internal state that influences the personal actions of an individual. He recognized attitudes as a major factor in subject choice. He considers attitudes as a mental and neutral state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's responses to all objects and situations with which it is related. Teachers have the opportunity of structuring lessons cooperatively, competitively or individualistically and the decisions teachers make in structuring lessons can influence students' interactions with others, knowledge and attitudes (Carson 1990).

Teaching strategies can also influence the attitude of students positively or negatively, Olorukooba (2001) reported that students taught using cooperative learning strategy in science has positive attitude to the educational benefits derived from group work. Samba (1998) reported that conceptual change instructional strategy significantly improved students' attitude towards science (Biology) Ajewole (1990) found out that guided inquiry help students develop a significantly more favorable attitude to science subjects than the lecture method and hence enhanced students' cognitive achievement in science at senior school level.Also, Schunk and Hanson (1985) in Akinbobola (2009) suggest that the attitude of students is likely to play a significant part in any satisfactory explanation of variable level of performance shown by students in their school science subject. While Ogunleye (1993) also in Akinbobola (2009) reports that many students develop negative attitudes to science learning, probably due to the fact that teachers are unable to satisfy their aspiration or goals. Alao (1990) showed that there is positive correlation between attitudes and performance in the science subjects.

Other studies such as Ivowi (1997) attributed students' poor performance in physics to poor teaching methods, unqualified and inexperienced teachers, poor student attitude toward physics, poor learning environment and gender effect. To combat the negative attitude towards physics and the enduring problem of high dropout rates with physics course new initiatives must be implemented into the classroom. Tinto (2003) highlighted five conditions to help promote persistence within a course; expectations, support, feedback, involvement and learning. This study highlights how inclusion of guided inquiry teaching method can offer the opportunity to integrate these five conditions into a physics classroom thus enhancing the performances of low achievers

and improve their attitudes towards physics.

2.8 Overview of Similar Studies on Guided Inquiry in Science Teaching

For a long time now, science teaching has been dominated by emphasis on factual knowledge despite the effort by researchers to suggest better method of science teaching. The poor academic performance and unhealthy attitude towards science have been reported in scientific literature (Adeniyi,1995). This as earlier stated, is as a result of ineffective teaching (Stephen 2008). Other factors identified include; learning by rote, (Abdullahi 1998;Eniayeju 2001), improper exposure to laboratory activities (Ekpo 1986) and lack of problem solving ability(Onwioduokit *et al* 2000). Literature also indicates that the conventional method of teaching , which is used by most teachers is only efficient in promoting rote learning (Nwagbo 2001). But Science involves active participation of the learner in the learning process, that is, Science is activity-oriented and any teaching that neglects the activity/process aspect of science rather promotes rote learning. Some of the research work on teaching strategies and their effects on students' performance in and attitude to science including Physics are as follows:

Okeke (1986) worked on the comparative effectiveness of two instructional approaches upon science students' achievement and attitude. His sample composed of 570 form four students from six secondary schools in Aguata Local Government Area of Anambra State of Nigeria. The data collected were analyzed using analysis of variance (ANOVA), analysis of covariance (ANCOVA) and post hoc comparison test. The result indicated that:

i. Inquiry based or open classroom and refined conventional approach were viable alternatives to science teaching and are both superior to the traditional

approach.

ii. Outdoor laboratory approach is better for teaching low ability students.

iii. Outdoor laboratory approach promotes positive attitude to science by

students. The findings of this study imply that the outdoor laboratory teaching which activity-oriented is a better strategy for promoting the understanding of science as well as positive attitude to science.

Ajewole (1987) studied the effect of discovery and expository instructional methods on the achievement of students in 'O'level Biology. The learning outcome investigated included cognitive achievement, attitude to science, scientific process and practical skills achievement. Two hundred and forty (240) form four students were selected from six schools in Ilesa, Oyo State. The test scores were analyzed using analysis of covariance and the t-test. The result indicates that:

i. There is a significant difference between students exposed to the discovery and expository methods in favour of the discovery method.

ii. All the various ability groups in the discovery class out-perform their counterparts in the expository class in the process and practical skills.

Ajewole (1991) also investigated 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 favourable 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.

Bilgin (2009) investigated the effects of guided inquiry instruction incorporating with cooperative learning environment on University students' achievement of acid bases concepts and attitude toward guided inquiry instruction. He selected 55 first year university students from two intact classes of a chemistry course instructed by the same teacher. One of the classes was randomly assigned as the experimental group and the other was assigned as the control group. The experimental group cooperatively studied worksheets which were related to acid- base concepts in the group while the control group individually studied the worksheets in the class. Acid and Bases Achievement Test (ABAT) was administered to the experimental and control groups as pre and post-tests to measure the students' understanding of the concept of acid and bases. An Attitude Toward Guided Inquiry Instruction Scale (ATGIIS) was also used as pre and post-test for both groups. The data collected were analyzed using Multi Variance Analysis (MANOVA). The result showed that, students in the experimental group had better understanding of acid and base concepts and a more positive attitude toward guided inquiry instruction.

Akinbobola (2009) conducted a study to find out the attitude of students toward the use of cooperative, competitive and individualistic learning strategies in Nigerian Senior Secondary School Physics. He used a quasi-experimental design. A total of 140students consisting of 66 males and 77 females were selected by a random sampling technique from a population of 680 senior secondary two (SSII) Physics students drawn from all the 13 co-educational secondary school in Ife south Local Government area of Osun State, Nigeria. The data collected were analyzed using Analysis of Variance (ANOVA) and the

result of the findings showed that cooperative learning strategy was the most effective in facilitating students' attitude toward Physics. This was followed by competitive strategies with the individualistic learning strategies being the least facilitative. The result also showed an insignificant gender difference in the attitude of students toward Physics when taught with cooperative, competitive and individualistic strategies. Many educational studies have explored the effectiveness of scientific inquiry

teaching on learner performance (Furtak, 2006).

Jacinta (2011) conducted a study on inquiry method and students academic achievement in biology. She used quasi experimental design comprising of 120 senior secondary I students of Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria. The sample was selected from four schools drawn from the fifteen secondary schools in Ogba/Egbema/Ndoni Local Government Areas using stratified random sampling technique. Students were randomly assigned to two groups (treatment and control groups). The study shows that inquiry method has a significant effect on students' achievements in biology and that the use of inquiry method favours the male more than the female in biology achievement.

Ashiq, Mohammad and Azra (2011) compared scientific inquiry method and traditional lecture method of teaching. They adopted a pretest post test control experimental design. 175 male physics students from 10^{th} grade students of public institutions in Faisalabad District, Lahore, Pakistan were used. Three experimental groups were taught by scientific inquiry; one of the groups was taught by guided inquiry; second group was taught by unguided inquiry, third group was taught by combination of scientific inquiry and fourth group was taught by traditional method. Groups were

randomly chosen for treatment. 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 physics in real life situation.

Schwarz and Gwekwerere (2006) stated that inquiry practices are very important in terms of forming scientific knowledge. The authors also found that pre-service teachers who experienced guided inquiry and modelling as part of the instructional framework improved their prior ideas of science teaching and felt that the course had increased their knowledge on how to teach science. Similarly, Nugent, Kunz, Levy, Harwood and Calson (2008) found that field-based inquiry-focused models significantly improved pre-service teachers' use of cooperative learning strategies, deep learning, and confidence in teaching science. Also, Akerson, Hanson, and Cullen (2007) stated that guided inquiry was effective in improving most secondary teachers' views of nature of science. In various research studies about guided inquiry teaching practices, the participants specifically noted that working as a group has very crucial role in addition to gaining effective results and understanding (Deckert, Nestor & DiLullo, 1998; Farrell, Moog &Spencer, 1999). In the study conducted by Farrell, Moog and Spencer (1999), half of the students stated that one of the strengths of this guided inquiry is the use of groups in developing learning and understanding, and for teaching. Thus, these contributions of guided inquiry practices are very critical for teachers that teach science to elementary students more often and effectively than others (Plourde, 2002).There are, therefore, several studies that provide evidence as to the varied benefits of using a guided inquiry approach in science instruction. Those benefits may either be offset or augmented

by the effect that guided inquiry instruction has on low achievers in physics. This study therefore aims to determine the effect of guided inquiry strategy on learning outcome of low achievers in physics among senior secondary two students in Kaduna metropolis.

2.9 Implication of Literature Reviewed on the Present Study.

The literature reviewed clearly explained the concept of guided inquiry teaching methods of instruction. The scope of description of academic achievement as it relates to teaching/ learning of science is shown. In the same vein, related studies covering gender and performance mainly in science subjects such as Biology, Chemistry and Physics were reviewed, Okeke (1986), Ajewole (1987), Ajewole (1991), Bilgin (2009), and Akinbobola(2009). Also attitude as a factor in the teaching/learning of science was highlighted. The related literatures reviewed for the purpose of this study showed that the use of guided inquiry strategy in science instruction enhanced students' performance as well as improved students' attitude to science. However, the use of the lecture method of teaching has been shown to be of little help for learners in enhancing learners' performance. And reports in the literature showed that the studies were carried out on students of mixed ability level without considering low ability level students (low achievers). In the light of these reports, the researcher deem it necessary to employ the use of guided inquiry strategy to teach the low achievers in physics among senior secondary two students in Kaduna metropolis.

In addition the guided inquiry strategy has been found by science educators like Okeke (1986), Ajewole (1991) and Bilgin (2009), to have effects on such variables as attitude and gender. These variables have been shown to have effects on learning. Most of the studies were carried out in Chemistry and Biology. The present study is carried out

in Physics. The present study is unique in that, it is aimed at homogenous subjects. That is, low achievers rather than heterogeneous subjects (students of mixed ability level) as evident in all the cited researches. Specifically, the study seeks the effects of guided inquiry strategy on learning outcome of low achievers in physics from Senior Secondary School in Kaduna metropolis.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in conducting the study. Specifically, the chapter is presented in the following sub headings:

- Research Design
- Population of the Study
- Samples and Sampling Techniques
- Instrumentation
- Pilot Study
- Administration of Treatment
- Data Collection Procedure
- Data Analysis

3.2 Research Design.

The design for this study is Quasi-experimental control groups consisting of pretest and posttests. Pretest and posttest were administered to the experimental and control group as recommended by Kerlinger (1973) , Fraenkle and Wallen (2000). A pretest (PAT) was administered in order to determine the equivalence of the two groups in their ability level. Physics Students Attitude Questionnaire (PSAQ) was also administered to the xperimental group as pretest. At the end of the treatment, posttest (PAT) was administered to the two groups to determine the significant difference if any in their mean academic performance in Physics. PSAQ was also administered as posttest after the treatment in order to determine the effect of the treatment i.e. guided inquiry

strategy on the experimental group. The illustration of the research design is presented in figure 3.1

EG $O_1{}^P{}_A \longrightarrow x_1 \longrightarrow 0_{2A}{}^P$

CG $O_1{}^P \longrightarrow x_o \longrightarrow O_2{}^P$

Fig 3.1: Research Design illustration

EG: Experimental group

CG: Control group

O_1: Pre test

O_2: Posttest

A: Attitude

P: Performance

X_1:Treatment (Guided inquiry strategy).

X_o: Lecture method.

This design is recommended by Kerlinger (1973), Fraenkle and Wallen, (2000) for experimental study of this nature.

3.3 The Population of the study.

The population of this study consists of all the SSII science students of public senior secondary schools located in Kaduna metropolis of Rigachikun Education Inspectorate Division of Kaduna State. These schools were used for the study because they represent the types of schools found in Kaduna state being public schools, day and co-educational. There are 17 senior secondary schools within the division with a population of 1,377 SSII science students consisting of 757 males and 620 females. This category of students were targeted for the study because of their experience in Physics

and stability in secondary education more than SS1 students who have not yet gained much academic experience and the SS3 students who are busy preparing for SSCE examinations. The detail of the population is given in Table 3.1

Table 3.1: Population of the Study

S/No	Name of school	No.of students	M (%)	F(%)	Total
1	GSS Rigachikun	80	45(56.3)	35(43.7)	80
2	DGSS,Kawo	80		80(100)	80
3	GSS Zangon Aya	94	54(57.4)	40(42.6)	94
4	GSS Dandaura	80	55(68.8)	25(31.2)	80
5	GSS Jaji	70	40(57.1)	30(42.9)	70
6	GSS,Turunku	80	45(56.3)	35(43.7)	80
7	GSS,Zangon aya	65	40(61.5)	25(38.5)	65
8	GSS,Gama gira	93	60(64.5)	33(35.5)	93
9	GSSBirni yero	80	45(56.3)	35(43.7)	80
10	GSS,Fara kwai	85	45(53.9)	40(47.1)	85
11	GSS,Gadar gayan	90	50(55.6)	40(44.4)	90
12	GSS,Buruku	95	50(52.6)	45(47.4)	95
13	GSS,Afaka sabuwa	98	60(61.2)	38(38.8)	98
14	GSS,Igabi.	87	50(57.5)	37(42.5)	87
15	GSS,Katabu.	100	60(60)	40(40)	100
16	Dr Ahmad Makarfi GSS Hayin banki	70	40(57.1)	30(42.9)	70
17	GSSl, Rafin guza.	30	18(60)	12(40)	30
TOTAL		**1,377**	**757**	**620**	

Source: Ministry of Education, Kaduna (2011).

3.4 Sample and Sampling Technique

For the purpose of this study, a simple random sampling technique was used to select the sample. Two schools were sampled out using table of random digit. Low achievers from these schools were identified based on their teachers' record of three consecutive exams in Physics. Among 150 SSII science students in both schools, 91 students who consistently scored below average in three consecutive exams were purposively selected from their physics teachers' record. This is because they can be called low achievers according to Shanmukappa (1978) and Ofonime (2007). There were 43 students in experimental group and 48 students in control the group.

These two schools were randomly selected and assigned control and experimental group using balloting . Since all the schools in the population are at different locations, it is assumed that interaction did not occur between the groups during the period of treatment, which could affect the result of the study. Details of the samples are as shown in Table 3.2

Table 3.2 Sample Selected for the Study

S/No	Group	Number of Students Present	Number of Students Selected		Total
			Male	Female	
1.	Experimental	70	28	15	43
2.	Control	80	27	21	48
	Total	150	55	36	91

3.5 Instrumentation

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

1. Physics Achievement Test (PAT), which was used as pre and Posttests to determine both the ability level and academic achievement of the subjects respectively to see the effects of the treatment.
2. Physics Students Attitude Questionnaire (PSAQ) which was used to determine any attitudinal change in the subjects of the experimental group.

3.5.1 Physics Achievement Test (PAT)

PAT test items were drawn from the West African Examination Council (WAEC) past objective questions of years 2000 to 2009. The items in the test covered the concept that was taught by the researcher. The PAT test items are made up of forty multiple-choice questions.

3.5.1.1 Validation of Physics Achievement Test (PAT)

The test items with the marking scheme were revalidated by three experts. They included one science educator, a PhD holder and senior lecturer with Physics background and two Physics teachers, M.sc holders and principal education officers from Command Secondary School, Kaduna and Government Secondary School, Rafin guza. The detail of item specification for PAT based on the topic selected is shown in Table 3.3

Table 3.3 Item Specification for PAT based on Topics selected

Topics selected	Items	Total
Reflection on plane mirror	1,4,9,15,18,20,33and 35	08
Reflection on curved mirror	7,10,19,25,27and 32	07
Refraction through prism	2,5,8,11,14,21,22,26,29,30, 34,36,37,38,39 and 40	16
Refraction through lenses	3,6,12,16,17,23,24,28 and 31	09
Total		40

The experts were requested to examine and assess the entire test items with reference to the following:

i. Whether PAT instrument is valid, that is whether it conforms to the objective of the content and specifications it was to test.

ii. Are the items clear, precise and free from ambiguity?

Among the 50 questions that were corrected and approved 40 were selected.

3.5.1.2 Reliability of the Instrument (PAT)

For the purpose of determining the reliability of PAT, the instrument was pilot tested. A reliability co-efficient of 0.60 was found using the Kr-21 formula. The facility index (F) and the discrimination index (D) of the test items were also determined. See appendix V. The item specification based on Bloom taxonomy of cognitive level is shown in appendix VIII

3.5.1.3 Item Analysis of PAT

Item analysis was carried out on the data generated from the pilot study in order to determine the facility and discrimination indices. The facility index (FI) of each item of PAT was calculated using the formula: FI = R/T

Where R = number of correct responses

F = total number of students

Wiseman (2002) recommended values within the ranges of 0.30 to 0.70 for good test item values in assessing achievement. The ranges of 0.30 to 0.65 were chosen for the study. Items whose FI were within these range were selected. See appendix V

The discrimination index of each item of PAT was calculated using scores of the top twenty seven percent (27%) and bottom twenty seven percent (27%) of the total respondents. This was calculated using the formula given by Furst in Olorukooba (2001). See details of result in appendix V

3.5.2 Physics Students Attitude Questionnaire (PSAQ)

The Physics Students Attitude Questionnaire (PSAQ) `was adapted from Katcha (2005) which was used on Biology students to test for change in attitude after teaching Biology. It was adapted to suit the present study. Statements such as" I enjoy reading Biology"," I do not like discussing Biology" were reframed to feature Physics rather than Biology. The attitude questionnaire consists of 30 questions. The purpose of this instrument is to determine whether students have favorable or unfavorable attitude towards Physics after exposure to guided inquiry strategy. The questionnaire was constructed based on the Likert five-point scale of Strongly Agree (SA), Agree (A),

Undecided (UD), Strongly Disagree (SD) and Disagree (D) respectively. The attitude questionnaires were administered to the experimental group before and after treatment in order to determine a change if any in the attitude of the students towards physics.

3.5.2.1 Validation of Physics Students Attitude Questionnaire (PSAQ)

The questionnaire was validated by two science educators, two senior psychologists and a senior language expert all with PhD and senior lecturers. Their suggestions led to the reframing and replacing of not so appropriate attitudinal statements.

3.5.2.2 Reliability of Physics Student Attitude Questionnaire (PSAQ)

The reliability coefficient of PSAQ was found to be 0.61 using Guttman Split- Half method with statistical tool of Cronbach Alpha. The instrument is hence reliable and was used for data collection on attitudinal change in this study.

3.6 Pilot Testing

The Instruments Physics Achievement Test (PAT) and Physics Students' Attitude Questionnaire (PSAQ) were pilot- tested on the SSII Physics students of Government Secondary School, unguwar sarki. 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 18 boys and 12 girls participated in the pilot testing. The subjects were administered the achievement test (PAT) which covered the topics, laws of reflection, images formed in plane mirror, laws of refraction and refractive index of glass block and glass prism. After PAT and PSAQ were administered, the data generated were analyzed to determine the characteristics of the test items of PAT and the reliability

coefficient of PAT and PSAQ. The results of the item analysis are shown in Appendix V. The results of the pilot test were then used to:

i. asses the clarity of the items of PAT

ii. calculate the reliability coefficient of PAT.

The facility index and difficulty index were also determined using the scores of the students. The following adjustments were hence made based on the findings of the pilot study:

i. The length of time required to answer the PAT was increased from 45 minutes to one hour because the students needed time to carry out some calculations.

ii. The diagrams in some questions such as questions 6, 8, and 20 were redrawn and well labeled.

3.7 Administration of Treatment

The treatment that was administered to the subjects involved teaching the concept of Light by the researcher using:

(a) The guided inquiry strategy adapted from Bybee, Taylor, Gardner, Van, Powell, Westbrook and Landes (2006) for the experimental group and

(b) Lecture method for the control group.

Lesson notes were prepared to teach the selected physics concepts (appendix VI).

Guided inquiry strategy based on the constructivist theory of learning where learners construct new ideas or concepts based on their current/past knowledge as used in this study is described as follows;

Guided Inquiry Strategy Package

In this study, the guided inquiry strategy used was adapted from Bybee *et al* (2006) i.e the instruction was designed based on one of many instructional strategies that support inquiry-based science - the 5E learning cycle model, which includes five specific components: engage, explore, explain, elaborate, and evaluate (Bybee & Landes, 1990). 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 laboratory 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 (Bybee & Landes, 1990). The lesson plans of guided inquiry strategy as used in the study can be illustrated on a flow chart as follows:

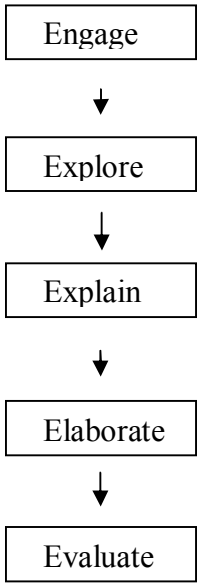


Fig.3.2 flow chart of Bybee *et al* (2006) model

Engage – learners encounter the material, define their questions, lay the groundwork for their tasks, and make connections from new to known.

Explore – learners directly involved with material, inquiry drives the process, teamwork is used to share and build knowledge base

Explain - learners explains the discoveries and concepts that have been learned through written report

Elaborate - learners expand on their knowledge, connect it to similar concept, apply it to other situation- can lead to new inquiry.

Evaluate – on - going process by both instructor and learner to check for understanding. The model is further illustrated thus:

Engage	Learners have need to know, therefore, define questions, issues or problems that relates to topic at hand.
Exploration	Objects and phenomena are explored. Hands – on activities with guidance
Explanation	Learners explain/report their understanding of concepts and processes
Elaboration	Activities allow students to apply concepts in context and build on or extend understanding/skill
Evaluation	Learners assess their knowledge, skills and abilities

Bybee *et al* (2006) model

Before the commencement of the treatment, the subjects in both groups (experimental and control) were given achievement test (PAT) in order to determine group equivalence. While the physics students' attitude questionnaire (PSAQ) was

administered to the subjects in the experimental group and their responses collected. Subjects in the experimental group were taught the concept light by the researcher in order to ensure effective utilization of the adapted guided inquiry strategy model and to ensure that the teaching procedure was in conformity with the direction of the model. This comprised laboratory work, problem solving and discussions. The subjects were allowed to explore the concepts in question through practical activities and problem solving and small group discussions. In the exploration session, they were asked focusing questions meant to lead them to observe and discuss their experiences. This is with a view to stimulate the subjects to articulate the inconsistencies and discrepancies between the phenomenon under consideration and their own previously held ideas. The teaching lasted for six weeks consisting of 6-double periods of 80 minutes each.

The subjects were taught laws of reflection, images formed in plane mirror, laws of refraction, Refractive index of water and refractive index of rectangular glass block and triangle glass prism. The control group was also taught same concept by the researcher for six weeks using lecture method.

3.8 Data Collection Procedure

At the end of the treatment, study subjects were post-tested and data were collected through the following:

i. Physics Achievement Test (PAT): A posttest (PAT) was given and marked using the marking scheme (appendix IV). Data were collected after marking the students' scripts with maximum score of 40. The scores were collated into experimental and control groups. Also the scores were further collated based on gender. ie male and female. After sorting out the scores, the data were subjected

to analysis. This is to determine significant difference if any in their academic achievement and any gender difference.

ii. Physics Students Attitude Questionnaire (PSAQ): PSAQ was also administered as Pretest and posttest on the experimental group. Data collected were subjected to statistical analysis to determine attitudinal change if any in the experimental group.

3.9 Data Analysis

The students' scores from the posttests of both Physics Achievement Test (PAT) and Physics Student Attitude Questionnaire were collated for analysis. The hypotheses were re-stated with corresponding statistical tools for analysis at $P \leq 0.05$ as follows:

Ho_1 : There is no significant difference in the mean achievement scores of low achievers in physics exposed to guided inquiry strategy and those exposed to lecture method.

t-test statistical tool was used for analysis.

$H\theta_2$: There is no significant difference in the mean achievement scores of male and female low achievers in physics exposed to guided inquiry strategy.

t-test statistical tool was used for analysis.

Ho_3: There is no significant difference in the attitudinal change of low achievers in physics after exposure to guided inquiry strategy.

Mann-Whitney test statistical tool was used for analysis.

Ho_4: There is no significant difference in the attitude of male and female low achievers in physics after exposure to guided inquiry strategy .

Mann-Whitney test statistical tool was used for analysis.

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CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This chapter contains analysis, result and discussions. The results are presented according to the sequence of the research questions and hypotheses, which guided the study. The level of significance adopted for retaining or rejecting each of the null hypotheses is $P \leq 0.05$. The procedure for analysis and results are presented.

4.2 Analysis and Results Presentation

Research Question One: What is the effect of guided inquiry strategy on the academic achievement of low achievers in physics?

To answer question one, a descriptive statistics of mean and standard deviation was used. The detail of the result is presented in table 4.1a

Table 4.1a: Descriptive statistics (mean & standard deviation) results of difference in academic achievements between experimental and control groups.

Variable	N	Mean	SD	Mean Difference	Remark
Experimental group	43	32.48	2.43	11.44	*There is difference
Control group	48	21.04	2.36		

* There is difference in the mean score of experimental and control groups

The results in table 4.1a show that the experimental group with mean of 32.48 performed higher than the control group with mean of 21.04. To test whether the difference is significant or not, null hypothesis one was formulated and tested using t-test statistic

H_{o1}: There is no significant difference in the mean academic scores of low achievers in physics exposed to guided inquiry strategy and those exposed to lecture method.

Table 4.1b: t-test Comparison of the Mean Academic Achievement scores of Experimental and Control Groups.

Variables	N	Mean	SD	df	t-cal	P	Remark
Experimental group	43	32.48	2.43				
				89	22.75	0.00	*significant
Control group	48	21.04	2.36				

*Significant at P≤ 0.05

The result presented in Table 4:1b showed that the p-value is 0.00 which is less than the level of significance of α=0.05 with df = 89**.** This means that there is significant difference between the posttest scores of the experiment and the control groups in favour of the experimental group. Thus the hypothesis is rejected. This implies that the experimental group taught light concepts using guided inquiry strategy achieved significantly higher than the control group taught the same light concepts using lecture method.

Research Question Two: To what extent does guided inquiry strategy has gender related effect on the academic achievement of low achievers in physics?

To answer question two, a descriptive statistics of mean and standard deviation was used. The detail of the result is presented in table 4.2a

Table 4.2a: Descriptive statistics (mean & standard deviation) results of the difference in academic achievement between female and male of experimental group .

Variable	N	Mean	SD	Mean difference	Remark

Female group	**Experimental**	15	30.06	2.84	1.22	*There is difference
Male	**Experimental group**	28	31.28	2.33		

* There is difference in the mean score of male and female (experimental group)

From table 4.2a, the achievement of females in the experimental group with mean score of 30.06 and standard deviation of 2.84 is lower than the achievement of their male counterparts with mean score of 31.28 and standard deviation of 2.33.

To find out if the difference of the effects of guided inquiry strategy on the academic achievement of female low achievers as shown in table 4.2a is significant or not, null hypothesis two was formulated and tested using t-test statistic.

H_{o2}: There is no significant difference in the mean achievement scores of male and female low achievers in physics exposed to guided inquiry strategy.

Table 4.2b: t-test Comparison of the Posttest Mean Scores of Male and Female Low Achievers exposed to Guided Inquiry Strategy.

Variables	N	Mean	SD	Df	t-cal	P	Remark
Female	15	30.06	2.84	41	1.51	0.65	*Not significant
Male	28	31.28	2.33				

*Not significant at P≤ 0.05

The result presented in Table 4.4b showed that the p-value is 0.650 which is greater than the level of significance at α= 0.05 with df = 41. This means that there is no significant difference between the posttest scores of male and female low achievers exposed to

guided inquiry strategy. This implies that the achievement level of male low achievers exposed to guided inquiry strategy is the same with their female counter parts. Therefore, the null hypothesis two is retained.

Research Question Three: Is there any difference in attitude of low achievers in physics after exposure to guided inquiry strategy?

To answer question three, a descriptive statistics of mean rank was used. The detail of the result is presented in table 4.3a

Table 4.3a Descriptive statistics (mean rank) results of attitudinal change of the experimental group exposed to treatment .

Variable	N	Mean Rank	Remark
Attitude before treatment	43	22.00	*There is difference.
Attitude after treatment	43	65.00	

*There is difference in the mean rank scores of the experimental group exposed to treatment.

From table 4.3a, there is attitudinal change in the experimental group exposed to treatment. This is as shown in the table 4.5a where the mean rank score of attitude before treatment is 22.00 and the mean rank score after treatment is 65.00.

To find out if the attitudinal change in the experimental group exposed to treatment is significant or not, null hypothesis five was formulated and tested using Mann-Whitney test statistic.

H_{03}: There is no significant difference in the attitudinal change of low achievers in Physics

after exposure to guided inquiry strategy.

The pretest and posttest data collected through the Physics Students Attitude Questionnaire (PSAQ) were subjected to Mann-Whitney test to determine if there is any significant difference between the attitude of low achievers after exposure to guided inquiry strategy. Summary of the analysis is presented in Table 4.3b

Table 4.3b: Man-Whitney test Analysis of Mean Scores of Attitudinal Change of the Experimental Group exposed to Treatment.

Variable	N	Mean Rank	Sum of Rank	Mann-Whitney U	Z-value	P-value
Attitude before treatment	43	22.00	946.00	946.000	-7.997	0.000
Attitude after treatment	43	65.00	2794.00			
Total	86					

* Significant at P≤ 0.05

The results presented in Table 4.3b revealed that, at 0.05 level of significance p-value of 0.000 was obtained. The p-value obtained is less than the level of significance hence, the null hypothesis of no significant difference in the attitude of low achievers in Physics after exposure to guided inquiry strategy is rejected. Meaning that there is significant difference in the attitude of low achievers in Physics after exposure to guided inquiry strategy. The low achievers' attitudes improved positively towards the subject after treatment.

Research Question four: Will there be any gender related difference in the attitude of low achievers in physics after exposure to guided inquiry strategy?

To answer question four, a descriptive statistics of mean rank was used. The detail of the result is presented in table 4.4a

Table 4.4a: Descriptive statistics (mean rank) results of the difference in attitude of male low achievers and female low achievers of experimental group exposed to treatment.

Variable	N	Mean Rank	Remark
Female after treatment	15	9.27	*There is difference
Male after treatment	28	28.82	

*There is difference in the attitude of male and female low achievers after treatment

From table 4.4a, the mean rank scores of the female low achievers and male low achievers exposed to treatment are 9.27 and 28.82 respectively. This shows that there is difference in the attitude of the female and male low achievers exposed to treatment.

To find out if the difference in attitude between the female and male low achievers exposed to treatment is significant or not, null hypothesis four was formulated and tested using Mann-Whitney test statistic.

$\mathbf{H_{04}}$: There is no significant difference in the attitude of male and female low achievers in Physics after exposure to guided inquiry strategy.

The posttest data collected through the use of PSAQ were subjected to Mann-Whitney test statistics to determine if there is any significant difference in the attitude of male and female low achievers in Physics after exposure to guided inquiry strategy. The summary of the analysis is shown in Table 4.4b

Table 4.4b Man-Whitney test Analysis of Posttest Mean Scores of Attitude of Male and Female Low Achievers after treatment.

Variable	N	Mean Rank	Sum of Rank	Mann-Whitney U	Z-value	P-value
Female after treatment	15	9.27	139.00	139.000	-4.900	0.000
Male after treatment	28	28.82	807.00			
Total	43					

* Significant at P≤ 0.05

From the result presented in the Table 4.4b, comparing the significance value of 0.000 with the level of significance at α= 0.05 with df = 41. It is observed that the significance value is less than the level of significance so the null hypothesis is rejected. This implies that there is significant difference in the attitude of female low achievers compared to the male low achievers after exposed to guided inquiry strategy. The male low achievers taught with guided inquiry strategy as observed from their mean score had better attitude change compared to the female. Meaning that the male low achievers' attitude improved more positively towards the subject Physics than their female counterparts taught the same concept of light using the same instructional method i.e guided inquiry strategy.

4.3 Summary of Findings

In this study, the following findings were made:

(i) There is significant difference in the posttest mean scores of the experimental group taught light concept using guided inquiry strategy compared to the control group taught same concept using lecture method.

(ii) There is no significant difference in the posttest mean scores of the male experimental group taught light concept using guided inquiry strategy and

the posttest mean scores of their female counterparts taught same concept using guided inquiry strategy.

(iii) There is significant difference in the attitude of the experimental group after

treatment i.e taught light concept using guided inquiry strategy.

(iv) There is significant difference in the attitude of the male experimental group compared to their female counterparts when taught light concept using guided inquiry strategy. in favour of male low achievers.

4.4 Discussion of the Results

This study investigated the effects of guided inquiry strategy on the learning outcome of low achievers in Physics among senior secondary school students in Kaduna metropolis. The data collected from the posttest administered were analyzed employing t-test statistic and Mann-Whitney test statistic at $P \leq 0.05$ levels of significance.

In Table 4.1b the result of testing hypothesis one shows that there is a significant difference in the mean academic achievement scores of low achievers exposed to guided inquiry strategy and those taught with lecture method. The significant difference found between the two groups is likely to be due to use of guided inquiry strategy (an activity-oriented method) on the experimental group. If the treatment administered has no effect, the two groups are expected to perform equally the same. Since the experimental group performed significantly better, it implies that using guided inquiry strategy in teaching low achievers improves their performance. The result confirms earlier findings of Awodi (1984), James (1991) and Bilgin (2009) who recommended that students should be provided with appropriate method of instruction in science such as guided inquiry

strategy in order to make abstract concepts better understood.

On the issue of gender in relation to academic achievement when exposed to guided inquiry strategy and lecture method, the results in table 4.2b shows that guided inquiry strategy enhances the academic performance of both male and female low achievers in Physics at senior secondary school level. This finding is in agreement with those of Daramola (1983), Inomiesia (1985), Adewole (1990) and Usman (2000) who individually found out that there is no gender difference in the academic achievement of students when exposed to activity-based methods of instruction such as guided inquiry, problem solving and process approach e.t.c. In addition, the finding is in agreement with those of Abimbola (1993) and Bichi (2000) who observed that the type of instructional strategy used does not discriminate between male and female. The finding is however in disagreement with that of Musa (2000) who reported a significant difference in the performance of male and female of the experimental group-favouring male of the experimental. Also in studies of Mari (1994), Shaibu and Mari (1997) a significant difference was observed between male and female subjects in academic achievement in problem- solving requiring understanding of the process skills the result shows that the female subjects performed significantly better in the mastery of process skill than their male counterparts at senior secondary school level. However, similar conclusion was drawn by Ibe and Nwosu (2003) who show that gender dose not combine with teaching method to affect students' performances. Also in line with these studies is the finding of this study that there is no gender difference in the academic performance of low achievers in Physics at senior secondary school level when exposed to guided inquiry strategy. Since the method allows students to carry out investigation on their own and to arrive at a

particular concept, it makes what they learn meaningful and promote their understanding of the concept despite gender difference among the students.

On the issue of instructional methods and students' attitude to science (Physics), the results in Table 4.3b and 4.4b show that guided inquiry strategy enhanced positively the attitudes of low achievers to Physics. This finding agrees with the findings of Chang and Tsai (2005), Taraban, Box, Pollard and Bowen (2007), Zacharia (2003), Siegel and Ranney (2003), Simpson and Oliver (1990) and Oliver and Simpson (1998) that the nature of science teaching affects students' attitude strongly. The greater success and positive attitude toward guided inquiry strategy of students in experimental group can be explained as follows; students' participation and teaching materials which is prepared based on guided inquiry strategy helped them to recognize their ideas, share their ideas and facilitate their understanding as well as encouraged their conceptual restructuring and attitude toward guided inquiry strategy.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the entire study and presented in following subheadings:

- Summary
- Implications of the Study and Contribution to Physics Education
- Conclusion
- Recommendations
- Limitations
- Suggestion for Further Studies

5.2 Summary

This study investigated the effect of guided inquiry strategy on the learning outcome of low achievers in Physics among senior secondary school students in Kaduna metropolis. It also investigated the effects of gender related differences on students' academic achievement in the teaching of concepts of light in Physics using guided inquiry strategy. Available literatures relevant to the study were reviewed. Most of these literatures concluded that academic performance can be enhanced using effective instructional strategies which recognized active participation of students.

The design of the study was quasi experimental in nature. It was pretest, posttest control and experimental group design. The population of the study consist of all the 1,377 SSII science students (757 males and 620 females) of the 17 public senior secondary schools located in Kaduna metropolis of Rigachikun Education Inspectorate

Division of Kaduna State. These schools were used because they represent the type of schools found in Kaduna state being public schools and co-educational. Two schools were sampled out using table of random digits and randomly assigned experimental and control group using balloting. Low achievers from these schools were identified and purposively selected based on their teachers' record of three consecutive exams in Physics. 91 students consisting of 55 males and 36 females who scored below average and can be called low achievers according to Shamukappa (1978), Ofonime (2007) and Ashania (2001) were then used for the study. There were 43 students in the experimental group and 48 students in the control group. Six research questions and six hypotheses guided the study.

Two instruments, Physics Achievement Test (PAT) and Physics Students Attitude Questionnaire (PSAQ) were used for data collection. The Physics Achievement Test (PAT) consists of 40 items multiple choice questions on light concepts drawn from West African Examination Council (WAEC) past objective questions of years 2000 to 2009 with reliability coefficient of 0.6. While the Physics Students Attitude Questionnaire (PSAQ) was adapted from Katcha, (2005) which was used on Biology students to test for change in attitude after teaching Biology. The questionnaire consists of 30 questions constructed based on likert five- point scale of Strongly Agree (SA), Agree (A), Undecided (UD), Strongly Disagree (SD) and Disagree (D) respectively. The reliability coefficient of PSAQ was found to be 0.61 using Guttman Split-Half method with statistical tool of Cronbach'Alpha.

The treatment lasted for six weeks consisting of 12 periods of 80 minutes each. The subjects were taught the concept of light comprising of laws of reflection, image formed

in plane mirror, laws of refraction, refractive index of water and refractive index of rectangular and triangular glass prism using 5E method of guided inquiry strategy adapted from Bybee *et al* (2006). And the control group were taught same concept using lecture method. At the end of the treatment, study subjects were post-tested. The data collected through the use of PAT and PSAQ were subjected to t-test statistical analysis and Mann-Whitney test to determine any significant difference in their academic performance and measure attitudinal change if any in the experimental group respectively. The results indicated that the performance of low achievers taught Light concept using guided inquiry strategy was significantly better. Students gender had no significant effect in their performance in Physics when guided inquiry strategy is used. From the results, hypotheses one, three and four of the study were rejected. While hypothesis two was retained.

Based on the findings the study therefore recommends among others that, in service training for science teachers in form of seminars, workshops and conferences should focus more on how to use guided inquiry strategy for the teaching of physics concepts . In addition, the use of lecture method by science teachers should be minimized and done with caution to avoid under achievement and negative attitude among science students to Physics.

5.3 Implications of the Study and Contribution to Physics Education

The single best-supported finding in the research literature reviewed is that the use of guided inquiry strategy (constructivism) as a supplement to traditional, teacher centered instruction procedures achievement effects is superior to those obtained with the traditional lecture method. Most research reports in science education at secondary school

level have considered students of mixed ability level (mixture of both high achievers and low achievers) without considering the low achievers separately. This study considered low achievers in physics to see whether their plight of achieving low could be addressed using guided inquiry strategy to teach them.

Based on the findings of the study, low achievers in physics taught the concept of light using guided inquiry strategy are found to achieve higher than those taught same concept using lecture method. In addition, the attitude to physics of low achievers exposed to guided inquiry strategy improved significantly. It can be deduce that the guided inquiry strategy used in teaching enhanced low achievers' achievements and positive attitude. Hence, it is hoped that when science teachers, physics teachers in particular use guided inquiry strategy in teaching, low achievers would be carried along and their achievement is better.

5.4 Conclusion

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

1. Teaching strategies that teachers use in science teaching have significant effects on the low achievers' achievement at senior secondary school level.
2. Guided inquiry strategy facilitates meaningful learning of light concepts among low achievers at senior secondary school level.
3. Neither the male nor the female low achievers performed significantly better than the other when taught light concepts using guided inquiry strategy at senior secondary school level.
4. Guided inquiry strategy enhances attitudes of low achievers toward Physics at senior secondary school level.

5.5 Recommendations

On the basis of findings emanating from this study , the following recommendations are made:

1. The teaching of Physics should be conducted in such a way that students learn meaningfully and develop positive attitude towards the subject. The use of guided inquiry strategy seems to be appropriate in that respect. It should therefore be incorporated into the main stream of pedagogy in the teaching of Physics at senior secondary school level.
2. The use of lecture method of teaching has been found to be less effective in this study with respect to academic achievement and attitude of low achievers towards Physics. Science teachers should therefore exercise their expertise and caution in the use of lecture method to avoid a situation, where under achievement and negative attitude is promoted among low achievers at senior secondary school level.
3. In service training for science teachers in form of seminars, workshops and conferences should focus more on how to use guided inquiry strategy for the teaching of Physics concepts. The government or relevant professional bodies like Science Teachers' Association of Nigeria (STAN) could do this.
4. There should be proper provisions of facilities/equipments, which are necessary for effective inquiry strategies.
5. This study showed that gender does not play a significant role in the learning of light concepts using guided inquiry. Hence, the method is recommended, as it is gender friendly and aided learning between male and female.

5.6 Limitations of the Study

This study has some limitations, which include the following;

1. The study is restricted to only two secondary schools in Rigachikun Inspectorate Division of Kaduna State as such generalization of the study is narrow.
2. A sample size of only 91 SS2 low achievers in Physics is used in this study. It may be

   possible that when larger sample size is used the result will not be the same.

5.7 Suggestions for Further Studies

1. A similar study on low achievers should be carried out focusing on the teaching of other science subjects using guided inquiry strategy with a view to finding out if similar or different results as in this study may be obtained.
2. This study can be extended to the tertiary level of education to investigate if level has an effect on the variables that this study dealt with.
3. There is need to conduct similar studies to investigate the effects of other activity oriented teaching methods such as problem solving method, project method, discussion method e.t.c on teaching low achievers light concept.

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APPENDIX I

PHYSICS ACHIVEMENT TEST (PAT)

SECTION A:
Name of School:
Class:
Sex: Male ☐ Female ☐
Age:
SECTION B:
ACHIEVEMENT TEST
INSTRUCTIONS:

i. Answer all the questions.

ii. Each question is followed by four options letters A to E. find out the correct option for each question and shade in pencil on your answer sheet, the answer space which bears the same letter as the option you have chosen. Give only one answer to each question.

1. Which of the following statements is/are not correct about the image formed by a plane mirror? I) The magnification produced is 1. ii) The image distance is the same as the object distance. iii) The image is real.

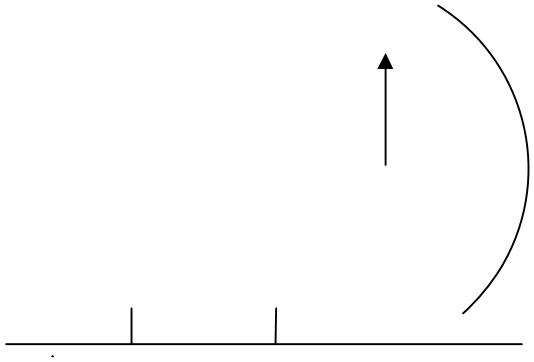
   A) i& ii only

   B) I , ii & iii

   C) ii only

   D) ii & iii only

E) iii only



2. What will be the characteristics of the image of the object OB shown above after reflection from the mirror?

   A. Diminished, real and erect

   B. Magnified, real and inverted.

   C. Diminished virtual and erect

   D. Magnified, virtual and erect

   E. Magnified, virtual and inverted.

3. A transparent rectangular block 5.0cm thick is placed on a black dot. The dot when viewed from above is seen 3.0cm from the top of the block. Calculate the refractive index of the material of the block.

   A.2/5

   B. 3/5

   C. 3/2

   D. 5/3

   E. 5/2.

4. An object is placed 36cm from a converging lens of focal length 24cm. if a real image which is 4cm high is formed, calculate the height of the object.

   A. 2.0cm

   B. 4.0cm

   C. 6.0cm

   D. 8.0cm

   E. 10.0cm

5. A ray of light is incident on a plane mirror at an angle of 35^0. What is the angle made by the reflected ray with the surface of the mirror?

   A. 125^0

   B. 70^0

   C. 65^0

   D. 55^0

   E. 35^0

6. The refractive index for a given transparent medium is 1.4. Which of the following is the minimum angle for total internal reflection to take place in the medium?

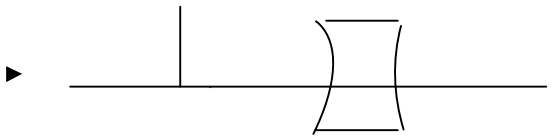
   A. 30^0

   B. 36^0

   C. 44^0

   D. 46^0

E. 54^0.



7. What will be the characteristics of the object OB shown above after refraction through the lens?

   A. Magnified, virtual and inverted

   B. Real, inverted and magnified

   C. Diminished, virtual and inverted

   D. Erect, real and diminished

   E. Diminished, virtual and erect.

8. A concave mirror of radius of curvature 20cm has a pin placed at 15cm from its pole. What will be the magnification of the image formed?

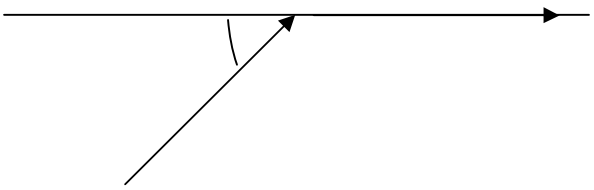
   A. 4.00

   B. 2.00

   C. 1.33

   D. 1.50

   E. 0.25



9. The diagram above shows an incident ray AO inclined at an angle 50^0 to the interface CB.

10. The refracted ray OB is found to lie along the surface. What is the refractive index of the medium X with respect to air?

    A. sin 50/sin 40.

    B. sin 40/sin50.

    C. sin 90/sin 50.

    D. sin 40/sin90.

    E. sin 90/sin40.

11. A ray of light strikes a plane mirror at an angle of incidence i. Determine in terms of i the angle of deviation of the ray after reflection from the mirror.

    A. i

    B. 2i

    C. 90-i

    D. 90+ i

    E. 180- 2i.

12. Images formed by a convex mirror are always.

    A. Inverted, real and diminished.

    B. Inverted, virtual and diminished.

    C. Erect, virtual and diminished

D. Erect, real and magnified.

E. Erect, virtual and magnified.

12. Which of the following statements is not correct for a light ray passing through a rectangular glass block which is surrounded by air?

A. Suffers a displacement at the point of emergence.

B. emerges parallel to the incident ray.

C. is partly reflected at the point of incidence.

D. is deviated at the point of emergence

E. is reflected in the block.

13. A real image of a pin formed by a converging lens of focal length 15cm is three times the size of the object. What is the distance of the object from the lens?

A. 30cm

B. 25cm

C. 20cm

D. 15cm

E. 10cm.

14. The change of the direction of a wave front as a result of a change in the velocity of the wave in another medium is called

A. refraction

B. Reflection

C. diffraction

D. polarization.

E. interference

15. An image which cannot be formed on a screen is said to be

A. inverted.

B. real

C. virtual

D. erect

E. blurred.

16. The image formed by a diverging lens are always

A. diminished, virtual and inverted.

B. diminished, inverted and real.

C. diminished, virtual and erect.

D. magnified, virtual and erect.

E. magnified, real and inverted.

17. A lens of focal length 15.0cm forms an upright image four times the size of an object. Calculate the distance of the image from the lens.

A.11.3cm.

B.18.8cm.

C. 37.5cm.

D. 45.0cm.

E,75.0cm.

18. An object is placed between two mirrors which are inclined at an angle of 120 and facing each other. Determine the number of images observed in the two mirrors.

A. 1

B. 2

C. 3

D. 4

E. 5

19. The image of an object placed at the centre of curvature of a concave mirror is …….

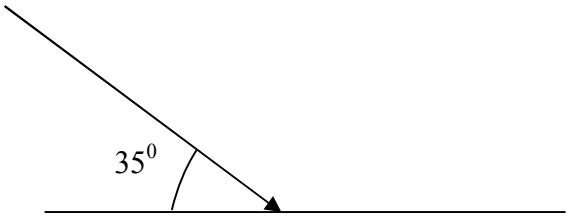
A. inverted and magnified.

B. at the principal focus.

C. real and diminished.

D. erect and virtual

E. at the centre of curvature.



20. The diagram above shows a ray of light IK incident on plane mirror at K. Calculate the angle of deviation of the ray after reflection.

A. 35

B. 55

C. 70

D. 105

E. 145

21. If the critical angle of glass-air boundary is c and the refractive index of the glass is n, which of the following relationships is correct?

A. n = 90/sin c.

B. n = sin c /90.

C. sin 90 sin c = n.

D. sin c = 1/n.

E. n = sinc/sin 45

22. The refractive index of a medium relative to air is 1.8. Calculate the critical angle for the medium to the nearest degree.

A. 18^0.

B. 34^0.

C. 45^0.

D. 68^0.

E. 90^0.

23. A converging lens of focal length 5cm forms a virtual image which is 10cm from the lens. How far from the lens is the object?

A. 2.0cm

B. 3.3cm.

C. 5.0cm.

D. 10.0cm.

E. 15.0cm.

24. A converging lens of a focal length 15cm is used to obtain a real image magnified $1\frac{1}{2}$ times. Calculate the distance of the image from the lens

A. 37.5cm

B. 22.5cm

C. 15.0cm

D. 7.5cm

E. 3.3cm

25. A concave mirror can be used to produce a parallel beam of light if a lighted bulb is placed

A. between its focus and the pole.

B. at its focus.

C. at its centre of curvature

D. between the focus and centre of curvature.

E. all of the above.

26. Which of the following conditions is necessary for the occurrence of total internal reflection of light?

A. light must travel from an optically less dense to a denser medium.

B. the angle of incidence must be equal to the critical angle.

C. the angle of incidence must be greater than the critical angle.

D. the angle of refraction must be 90.

E. none of the above.

27. An object is place on the principal axis and at the centre of curvature of a concave mirror, the image of the object formed by the mirror is

A. real and magnified.

B. real and inverted

C. erect and magnified.

D. erect and virtual.

E. all of the above

28. A converging lens produces an image four times as large as an object placed 25cm from the lens. Calculate its focal length.
    A. 100cm.
    B. 33cm.
    C. 29cm.
    D. 20cm.
    E. 23cm
29. The horizontal floor of a water reservoir appears to be 1.0m deep when viewed vertically from above. If the refractive index of water is 1.35, calculate the real depth of the reservoir
    A. 2.35m
    B. 1.35m
    C. 1.00m
    D. 0.35m.
    E. 0.41m

30. A wave travelling from water to glass suffers a change in its speed at the common boundary. Which of the following properties explains this observation?
    A.dispersion
    B. refraction
    C. interference
    D. diffraction
    E. reflection
31. An object is placed 5cm in front of a converging lens of focal length 10cm.Calculate the linear magnification.
    A. 0.7
    B. 1.5
    C. 2.0
    D. 3.3
    E. 2.1

32. An object is placed in front of concave mirror of focal length 15.0cm.If it forms a virtual image 10.0cm from the pole, determine the position of the object.

A. 6.0cm

B. 10.5cm

C. 20.5cm

D. 25.0cm

E.21.5cm

33. An image which can be formed on a screen is said to be

A. virtual

B. blurred

C. inverted

D. real

E. upright

34. Which of the following statements explain(s) why a ray of light travelling from air into water bends towards the normal?

i. Air is denser than water. ii. Light has the same speed in the two media. iii. Light travels faster in air than in water.

A. i only

B. iii only

C. i and ii only

D. i and iii only

E. iii and ii only

35. A ray of light is incident on a plane mirror at an angle of 35^0.What is the angle made by the reflected ray?

A. 1250

B. 70^0

C. 65^0

D. 55^0

E. 66^0

36. The refractive index for a transparent medium is 1.4 .Which of the following is the minimum angle for total internal reflection to take place in the medium?

A. 30^0

B. 36^0

C. 44^0

D. 46^0

E.45^0

37. Calculate the critical angle of a medium of refractive index 1.60.

A. 58^0

B. 51.3^0

C. 38.7^0

D. 32^0

38 . When a ray of light enters a triangular glass, it is dispersed. The dispersal is possible because……..?

A. The different colours have different critical angles as they pass through the prism.

B. The prism is made of a bifocal lenses.

C. The different colours have different refractive indices.

D. The prism acts as a number of lenses put together

E. The prism has accommodating power

39. The change in the direction of motion of light on moving from one medium to another is known as

A. Diffraction

B. reflection

C. refraction

D. interference

E. polarization

40. The following are all luminous bodies except

A. the sun B. a candle

C. the moon D. the fluorescent body

E) fire fly

APPENDIX II

PHYSICS ACHIEVEMENT TEST (PAT) ANSWER SHEET.

INSTRUCTION

DO NOT WRITE ANYTHING ON THE QUESTION PAPER AND RETURN THE QUESTION PAPER ALONG WITH THE COMPLETED ANSWER SHEET.

You are to read each question carefully and the five possible answers given after each question. Select one from the five options as your answer to the question and enter it on the answer sheet by shading the letter A, B, C, D OR E that corresponds to your choice.

Ex ample:

If you choose letter D for question 20, then you should cross letter D as shown: 20. =A= =B= =C= = D = =E=

School .....

Class .....

Sex: Male ☐ Female ☐

Age:

PHYSICS ACHIEVEMENT TEST (OAT) ANSWER SHEET

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

33. =A= =B= =C= = D = =E= 40. =A= =B= =C= = D = =E= 47.=A= =B= =C= = D = =E=
34. =A= =B= =C= = D = =E= 41. =A= =B= =C= = D = =E= 48.=A= =B= =C= = D = =E=
35. =A= =B= =C= = D = =E= 42. =A= =B= =C= = D = =E= 49.=A= =B= =C= = D = =E=
36. =A= =B= =C= = D = =E= 43. =A= =B= =C= = D = =E= 50.=A= =B= =C= = D = =E=
37. =A= =B= =C= = D = =E= 44. =A= =B= =C= = D = =E=

APPENDIX III

Physics Students Attitude Questionnaire

(PSAQ)

Dear Student,

You are expected to answer this questionnaire as correctly and honestly as you possibly can. You are to fill Section A.

SECTION A: Biodata.

Name of School: _____

Sex: **Male** ☐ **Female** ☐ **Age** _____

SECTION B

Instruction: The following are statements made about Physics as a subject. Read carefully and tick the most appropriate to you from the responses.

Strongly Agree (SA) Agree (A) Undecided (U) Disagree (D) Strongly disagree (SD)

Item	SA	A	U	D	SD
1. Physics is as fascinating as other subject is.					
2. Physicists are as fit as other people are.					
3. Physicists are a nuisance.					
4. I hate spending my free time doing physics work.					
5. Physics laboratory practical are interesting and lovely.					
6. Physics is more fascinating and thrilling than other subjects.					
7. A job as a physicist would be interesting.					

Item	SA	A	U	D	SD
8. Listening to a talk on Physics is boring.					
9. I would like to be a Physicist when I leave school.					
10. I look forward to more Physics lessons.					
11. I would like to work with people who make discoveries in physics.					
12. Physicists have no social concerns or interests.					
13. A job as a physicist will be boring.					
14. I do not like watching Physics film.					
15. I would dislike a job in Physics laboratory.					
16. Physicists are less friendly than other people are.					
17.It is interesting attending public lectures on physics.					
18. Physicists are very useful in the society.					
19.I would not like to be a Physicist after leaving school.					
20. Excursions would not help me in understanding Physics concepts.					
21. I enjoy reading Physics.					
22. I do not like discussing physics.					
23. Participating in physics practical is thrilling.					
24. I would like a job in a physics laboratory.					
25. Working as a physicist would be too hard for me.					
26. Physicists are always interested in making life better for man.					
27. Physics is the simplest science subject and that is the reason for offering it.					
28. I study physics only as a fulfillment of WAEC requirement.					
29. Physics is for gifted students.					
30. It is interesting watching Physics films					

APPENDIX IV
PHYSICS ACHIEVEMENT TEST (PAT). MARKING SCHEME.

1. A
2. D
3. D
4. A
5. D
6. D
7. E
8. B
9. E
10. E
11. C
12. E
13. C
14. A
15. C
16. C
17. E
18. B
19. E
20. C
21. D
22. B
23. D
24. C
25. B
26. C
27. B
28. D
29. B
30. B
31. C
32. A
33. D
34. B
35. D
36. D
37. C
38. C
39. C
40. B

39. APPENDIX V

40. Item Analysis of PAT items.

S/N	$F = \frac{R}{T}$	$D = \frac{R_U - R_L}{\frac{1}{2}N}$
1.	0.63	0.46
2.	**0.60**	**0.40**
3.	**0.43**	**0.33**
4.	**0.40**	**0.26**
5.	**0.37**	**0.33**
6.	**0.33**	**0.26**
7.	**0.60**	**0.66**
8.	**0.66**	**0.60**
9.	**0.63**	**0.33**
10.	**0.66**	**0.80**
11.	**0.50**	**0.33**
12.	**0.57**	**0.33**
13.	**0.33**	**0.26**
14.	**0.66**	**0.40**
15.	**0.83**	**0.46**
16.	**0.53**	**0.53**
17.	**0.33**	**0.40**
18.	**0.47**	**0.40**
19.	**0.57**	**0.33**
20.	**0.37**	**0.33**
21.	**0.47**	**0.26**
22.	**0.47**	**0.40**
23.	**0.33**	**0.40**
24.	**0.33**	**0.40**
25.	**0.43**	**0.33**
26.	**0.33**	**0.26**
27.	**0.43**	**0.46**
28.	**0.57**	**0.33**
29.	**0.40**	**0.26**
30.	**0.37**	**0.33**
31.	**0.60**	**0.40**
32.	**0.63**	**0.46**
33.	**0.66**	**0.53**
34.	**0.40**	**0.26**
35.	**0.33**	**0.53**

41.

36.	**0.37**	**0.46**
37.	**0.33**	**0.40**
38.	**0.50**	**0.33**
39.	**0.43**	**0.33**
40.	**0.66**	**0.26**

APPENDIX VI

LESSON PLANS FOR EXPERIMENTAL GROUP USING GUIDED INQUIRY STRATEGY

Lesson I

Class : SS2

Duration : 80 minutes

Subject : Physics

Topic : Reflection on Plane Mirror.

Sub-Topic: Laws of reflection

Specific objectives: By the end of the lesson, students should be able to;

i. Define reflection
ii. Sketch the reflection of light on plane mirror
iii. Indicate angles of reflection and incidence
iv. State the laws of reflection

Instructional resources: Plane mirror, drawing board, drawing paper, 4-drawing pins,4 optical pins and plasticine.

Previous knowledge: Students have been taught properties of waves.

Introduction: The teacher introduces the lesson by asking the following questions:

i. What is reflection?
ii. State laws of reflection

Lesson Presentation:

Step I:

i. Pin the paper to the board.
ii. Draw a straight line MM^1 as shown below;

Step II:

iii. Place the mirror by means of plasticine on the line MM^1 with the reflecting surface facing you.
iv. Fix pins at k1 and k2 in a straight line to represent the incident ray.

Step III:

v. What did you see in the mirror?
Insert pins k3 such that it appears in line with the images of k1and k2. Do the same with k4 such that k3,k4 and k1,k2 are all seen in same straight line.
What do you think the line k3k4 represent?
vi. Remove the mirror, join k3k4 and k1k2.
vii. Produce both to meet at O.

viii. Draw a normal to MM1 at O. Measure the angle of incidence i and angle of reflection r.
What do you notice about the angles i and r ?

Step IV:

ix. Repeat the experiment for three other values of i
x. State two precautions taken.
xi. Results/readings.

i^0	r^0

Evaluations: (i) What do you notice in your table of results?
(ii) define reflection
(iii) calculate r in the following diagram.

Conclusion: salient points are emphasised to conclude the lesson.

Lesson II
Class : SS2
Duration : 80 minutes
Subject : Physics
Topic : Reflection on Plane Mirror.
Sub – topic : Images formed on a plane mirror.
Specific objectives : By the end of the lesson, the students should be able to :

(i) define angle of deviation and its relationship with angle of incidence and angle of reflection
(ii) sketch ray diagram to show the relationship above.
(iii) State the characteristics of images formed on a plane mirror.
(iv) Distinguish between real image and virtual image.

Instructional Resources : Plane mirror, optical pins, protractor, drawing pins, drawing board, drawing paper and plasticine.
Previous knowledge : students have been taught properties of waves
Introduction : the teacher introduces the lesson by writing the topic on the board.
Presentation : the lesson is presented as follows:

Step I: the experiment to verify these characteristics is done in groups.

Step II: Measure and record the length of the plane mirror.

(i) Draw a line MN on the paper, mark a point O at the mid-point of MN

(ii) Draw a normal PO and SM to MN at O and M respectively as shown below.

(iii) Draw a line OU making an angle i = 30 with PO, produce it to meet SM at Q.

(iv) Place the mirror on its outline

(v) Fix a pin at Q and one at U. Look through the mirror from position T,
What do see in the mirror? Fix a pin at V such that the three pins now appear to be in a straight line.

(vi) Produce VO to meet SM produce at R. What dose line VO represent and by how much angle has it deviated ?

Step III:

Measure and record θ and QR, find the values of θ/2 and tan θ/2

(vii) Repeat the experiment with i = 35, 40, 45, 50 and record θ, θ/2, QR, and tan θ/2 in each case.
What do you observe in θ as angle i increases?

Step IV

(viii) Plot a graph of QR against tan θ/2

(ix) Determine the slope of the graph. What do you think the slope represent?

(x) State two precautions taken

Results / Readings;

I	Θ	QR/cm	θ/2	tan θ/2
30.0				
35.0				
40.0				
45.0				
50.0				

Evaluations: the lesson is evaluated by the following questions:

(i) The image formed in the plane mirror is due to..... ?

(ii) A ray of light is incident on a plane mirror at an angle of 35. What is the angle made by the reflected ray with the surface of the mirror?

(iii) state 3 applications of reflection of light.

(iv) A ray of light strikes as a plane mirror at an angle of incidence

i. Determine in terms if i the angle of deviation of the ray after reflection from the mirror.

(v) An image which cannot be formed on a screen is said to be -------

Conclusion: the students' questions are answered and the salient points are highlighted.

Lesson III

Class : SS2

Duration : 80 minutes

Subject : physics

Topic : Refraction of light

Sub-topic : Refraction of light through glass block.

Specific objective: by the end of the lesson, students should be able to :

(i) Define refraction of light

(ii) Indicate and define angles of incidence and refraction

(iii) State the laws of refraction

(iv) Define refractive index of a medium with respect to another.

(v) Explain real and apparent depth.

(vi) Solve numerical problems on refraction of light in glass block.

Instructional resources: glass block, drawing pins, optical pins, and drawing sheet.

Previous knowledge: students have been taught reflection of light.

Introduction : the teacher introduces his lesson by citing some practical applications of refraction of light such as, the bottom of a clear river appear shallower than it really is.

Presentation : the lesson is presented as follows:

Step I : the experiment to demonstrate refraction through glass block is done in groups.

Step II:

(i) Trace the outline ABCD of the glass block.

(ii) Remove the block. Mark a position O very close to A.

(iii) Draw the normal MOF from the point F, measure and mark out points Y_1, Y_2, Y_3, Y_4 and Y_5 along line FC at distances 1,2,3,4 and 5cm respectively from F.

(iv) Replace the glass block on the outline ABCD. Fix a pin at O and another at Y_1.

(v) Fix a pin at P_1 such that the pins at P_1 and Y_1 are in line with the pin at O when viewed through the side DC of the glass block. What do you observe?

(vi) Remove the glass block. Join the line OY_1 and Y_1P_1, measure and record the angles α and β. Are angles α and β the same?. Evaluate sin α and cos β.

Tabulate the results / observations as follows:

Y(cm)	α^0	β^0	Sin α^0	Cos β^0

Step III:

(vii) Repeat the experiment with the pin at Y_1 now at Y_2, Y_3, Y_4 and Y_5 respectively while the pin at O remains unaltered. In each case, measure and record the vales of α, β, sin α and cos β.

Step IV:

(viii) Plot a graph of Sin X against Cos B starting both axes from the origin.

(ix) Calculate the slope S of the graph, evaluate C = 1/S.

(x) State two precautions taken to ensure accurate results.

Evaluation: the evaluation questions are as follows:

(1) The change of the direction of a wave front as a result of a change in the velocity of the wave in another medium is called.....?

(2) The horizontal floor of water reservoir appears to be 1.0m deep when viewed vertically from above. If the refractive index of water is 1.35, calculate the real depth of the reservoir.

(3) The refractive index for a transparent medium is 1.4. Which of the following is the minimum angle for total internal reflection to take place in the medium.

Conclusion: the salient points are highlighted.

Lesson IV

Class : SS2
Duration : 80 minutes
Subject : Physics
Topic : Refraction of light
Sub – topic : Lateral displacement of light ray passing through

glass block.

Specific objectives: By the end of the lesson, students should be able to:

i. Define critical angle
ii. Explain total internal reflection
iii. Differentiate between refraction and deviation
iv. State relationship between refractive index and critical angle.
v. Solve numerical problems on refractive index of media.

Instructional resources: glass block, four optical pins, four drawing pins and drawing board.

Introduction: the teacher introduces the lesson by citing some practical applications of total internal reflection such as the water like phenomenon seen from a distant on a tar road during the day.

Presentation: the lesson is presented as follows :

Step I: the experiment to demonstrate the lateral displacement of light ray passing through glass block is done in group.

Step II:

(i). Trace the paths of five rays through the glass block for angles $\alpha = 65^0, 55^0, 45^0, 35^0$ and 25^0 as shown below:

(ii). for each ray, measure and record the angle of incidence i and the Corresponding lateral displacement d. What do observe in angle d compared to i?

Results/readings

α^0	I^0	d/cm
65		
55		
25		

Step III:

(iii). plot a graph of d against i

(iv). draw a smooth curve through your points. Determine the value of d when $i = 90^0$.

(v). state two precautions taken to ensure accurate results.

Evaluations:

1. Distinguish between refraction and deviation
2. Calculate the critical angle of a medium of refractive index 1.60.
3. What are the conditions necessary for total internal reflection.

Conclusion: students questions are answered and emphasise is laid on salient points.

Lesson V

Class : SS2

Duration : 80 minutes

Subject : Physics

Topic : Refraction of light through converging lens.

Sub – topic : Image in a converging lens.

Specific objectives: by the end of the lesson, students should be able to:

(i) Define optical center and principal focus of lens

(ii) State characteristics of image formed by converging lens depending on the object distance through drawing.

(iii) State lens formular.

(iv) Solve numerical problems.

Instructional Resources: converging lens (F = 15cm), lens holder, screen, metre rule, Ray box.

Previous Knowledge: students have been taught refraction of light through glass block.

Introductions: the teachers introduces the lesson by writing the topic on the board.

Lesson Presentation: the teacher presents the lesson as follows;

Step I: the experiment to demonstrate the images in converging lens is done in group.

Step II:

(i) Measure and record the size of object b_o=

(ii) Place the object at a distance u = 20cm from the lens that is ray box is placed at zero end of the rule and the screen at the other end as shown below:

(iii) Adjust the screen to obtain a sharp image.

(iv) Measure and record V. What do you observe in both the size of the image and distance V?

(v) Measure and record the size of image b. Evaluate $R = b/b_o$

Step III:

(vi) Repeat the experiment for U = 25, 30, 35 and 40cm respectively. Determine the corresponding values of b, V, and R. What relationship do you observe in the values of b,V and R?

Tabulate your readings as follows

Results / readings

u/cm	v/cm	b/cm	R=b/bo
20.0			
35.0			
40.0			

Step IV

(vii) Plot a graph of R against V starting both axes from the origin.

(viii) Determine the slope, s and the value of v for which R = 0.

(ix) State precautions taken to ensure accurate results.

Evaluations: 1. Define principal focus and optical centre.

2. An object 4cm high is at right angle to the principal axis of a converging lens of focal length 20cm and at 30cm from it. Determine the position of the image.

3. What is the characteristics of image of an object placed at the principal focus of a converging lens?

Conclusion: students questions are answered and emphasise is laid on salient points.

Lesson VI

Class : SS2

Duration : 80 minutes

Subject : Physics

Topic : Refraction of light through lens.

Sub – topic : Images formed in a converging lens.

Specific objectives: By the end of the lesson, students should be able to:

(i) Describe nature of images formed in convex lens.

(ii) Draw and interpret common ray diagrams.

(iii) Solve numerical problems on lenses.

Instructional resources: converging lens (f = 15cm), lens holder, screen, metre rule, ray box(illuminated object).
Previous knowledge: students have been taught refraction in glass prism.
Introduction: the students are grouped and apparatus set.
Presentation: the lesson is presented in the following steps**:**

Step I:

Measure and record the size of the object b_0 = ?

(i) Place the object at a distance U = 20cm from the lens

(ii) Adjust the screen to obtain a sharp image.

(iii) Measure and record the distance V of the image from the lens.

(iv) Measure and record the size of the image b.

Evaluate $R = \frac{b}{bo}$

Step II:

(v) Repeat the experiment for U = 25, 30, 35 and 40cm respectively. Determine the corresponding vales of b, v, and R. Tabulate your results / observations as follows:

U (cm)	V (cm)	b (cm)	R = b/b0

Step III

(vi) Plot a graph of R against V, starting both axes from the origin.

(vii) Determine the slop S, of the graph and the value for which R = O.

(viii) State two precautions.

Evaluation: the evaluation questions are as follows :

(1) What are the characteristics of image formed by a diverging lens?

(2) A converging lens of focal length 5cm forms a virtual image which 10cm from the lens. How far from the lens is the object?

(3) An object is placed 5.0cm in front of a converging lens of focal length 10.0cm. Calculate the linear magnification.

Conclusion: Students questions are answered and emphasises are laid on the Salient points.

LESSON PLAN FOR CONTROL GROUP USING LECTURE METHOD

Lesson I

Class : SS2

Duration : 80 minutes

Subject : Physics

Topic : Reflection on Plane Mirror.

Sub-Topic: Laws of reflection

Specific objectives: By the end of the lesson, students should be able to;

v. Define reflection

vi. Sketch the reflection of light on plane mirror

vii. Indicate angles of reflection and incidence

viii. State the laws of reflection

Instructional resources: A chart showing the sketch of the reflection of light on plane mirror.

Previous knowledge: Students have been taught properties of waves.

Introduction: The teacher introduces the lesson by writing the topic on the board.

Lesson Presentation: The teacher presents the lesson in the following steps:

Step I: he defines reflection as the change in direction of a light wave when it encounters an obstacle without a change in its frequency, velocity and wavelength.

Step II: he indicates and explains letter i as the angle of incidence, i the angle between the incident ray and the normal.

Step III: he indicates and explains letter r as the angle of reflection, that is the angle between the reflected ray and the normal.

Step IV: he states the laws of reflection as:

(i) The angle of incidence i is equal to the angle of reflection r.

(ii) The incident ray, the reflected ray and the normal all at the point of incidence lie along the same plane

Evaluations: the teacher evaluate the lesson by asking students the following questions .

(i) State the laws of reflection**.**

(ii) Define reflection

(iii) Calculate r in the following diagram.

Conclusion: salient points are emphasised to conclude the lesson.

Lesson II

Class: SS2

Duration: 80 minutes

Subject: Physics

Topic: Reflection on Plane Mirror.

Sub – topic: Images formed on a plane mirror.

Specific objectives: By the end of the lesson, the students should be able to :

(v) define angle of deviation and its relationship with angle of incidence and angle of reflection

(vi) Sketch ray diagram to show the relationship above.

(vii) State the characteristics of images formed on a plane mirror.

(viii) Distinguish between real image and virtual image.

Instructional Resources: a chart showing image formed on a plane mirror.

Previous knowledge: students have been taught properties of waves

Introduction: the teacher introduces the lesson by writing the topic on the board.

Presentation: the teacher presents the lesson as follows:

Step I: he defines angle of deviation as the angle through Which the incident ray turns after reflection or refraction. It is given by $d = 180 – (i+r)$

Step II: he sketches ray diagram showing the relationship between d,i and r is as follows:

Step III: he uses the ray diagram on the chart to show the characteristics of image formed on a plane mirror.

Step IV: he states the characteristics of images formed on a plane mirror as:

(i) They are same size as object

(ii) They are virtual

(iii) They are Erect

(iv) They are at same distance behind the mirror as the object is in front of the mirror

(v) They are laterally inverted.

Evaluations: the teacher evaluates the lesson by asking students the following questions:

(1) A ray of light is incident on a plane mirror at an angle of 35. What is the angle made by the reflected ray with the surface of the mirror?

(2) A ray of light strikes as a plane mirror at an angle of incidence (i). Determine in terms if i the angle of deviation of the ray after reflection from the mirror.

(3) An image which cannot be formed on a screen is said to be -------

Conclusion: the students questions are answered and the salient points are highlighted.

Lesson III

Class : SS2

Duration : 80 minutes

Subject : physics

Topic : Refraction of light

Sub-topic : Refraction of light through glass block.

Specific objective: by the end of the lesson, students should be able to :

(i) Define refraction of light.

(ii) Indicate and define angles of incidence and refraction.

(iii) State the laws of refraction .

(iv) Define refractive index of a medium with respect to another.

(v) Explain real and apparent depth.

(vi) Solve numerical problems on refraction of light in glass block.

Instructional resources: a chart showing the refraction of light through glass block.

Previous knowledge: students have been taught reflection of light.

Introduction: the teacher introduces his lesson by displaying the chart on the board.

Presentation: the teacher presents the lesson as follows:

Step I: the teacher defines refraction as the bending of light ray as it travels from one medium into another medium of different density. It is caused by the change in speed of the light wave in the different media.

Step II: he indicates and explains that, letter i represent angle of incidence. It is

the angle between the incident ray and the normal. While letter r is the angle of refraction which, is the angle between the refracted ray and the normal.

Step III : he states the laws of refraction as:

(i) The incident ray, refracted ray, and the normal all at the point of incidence lie along the same plane.

(ii) The ratio of the sine of angle of incidence to the sine of angle of refraction is constant for a pair of media. This law is called the Snell's law.

Step IV : he explains the constant in Snell's law as refractive index i.e $n = \frac{Sin\ i}{Sin\ r}$.

Refractive index of air with respect to water is the ratio of the sine of angle of incidence in air to the sine of angle of refraction in water.

Step V : he explains that the refractive index n can also be expressed in terms of real (D) and apparent depth(d) i.e $n = \frac{d}{D}$.

Evaluation : the evaluation questions are as follows:

(1) The change of the direction of a wave front as a result of a change in the velocity of the wave in another medium is called.....?

(2) The horizontal floor of water reservoir appears to be 1.0m deep when viewed vertically from above. If the refractive index of water is 1.35, calculate the real depth of the reservoir.

(3) The refractive index for a transparent medium is 1.4. Which of the following is the minimum angle for total internal reflection to take place in the medium.

Conclusion: the salient points are highlighted.

Lesson IV

Class: SS2

Duration: 80 minutes

Subject: Physics

Topic: Refraction of light

Sub – topic: Lateral displacement of light ray passing through glass block.

Specific objectives: By the end of the lesson, students should be able to:

i. Define critical angle

ii. Explain total internal reflection

iii. Differentiate between refraction and deviation

iv. State relationship between refractive index and critical angle.

v. Solve numerical problems on refractive index of media.

Instructional resources: a chart showing lateral displacement of light through glass block leading to total internal reflection.

Introduction: the teacher introduces the lesson by citing some practical applications of total internal reflection such as the water like phenomenon seen from a distant on a tar road during the day.

Presentation: the lesson is presented as follows:

Step I : the teacher defines critical angle as the angle of incidence in the more dense medium which produces an angle of refraction of 90^0 in the less dense medium.

Step II: he explains that, total internal reflection occurs when light ray travelling from denser medium to a less dense medium incident at an angle greater than the critical angle.

Step III : he differentiates between refraction and deviation i.e refraction is the change in in direction of light ray as it travels across two different media while deviation is the change direction of a light ray due to reflection or refraction.

Step IV : he states the relationship between refractive index n and critical angle C as follows :

$$n = \frac{\sin i}{\sin r} = \frac{\sin c}{\sin 90}$$

but for glass to air $n = \frac{\sin 90}{\sin c} = \frac{1}{\sin c}$

Step v : he solves some numerical problems on critical angle such as:

Question 1: the refractive index of a transparent medium is 1.4. Which of the following is the minimum angle for total internal reflection to occur?

(a) 30^0 (b) 36^0 (c) 44^0 (d) 46^0 (e) 45^0

Solution :

$n = 1/\sin c$

$1.4 = 1/\sin c$

$C = \sin^{-1} 1/1.4$

$C = 46.$

Evaluations: the teacher evaluates the lesson by asking students the following Questions;

1. Distinguish between refraction and deviation
2. Calculate the critical angle of a medium of refractive index 1.60.
3. What are the conditions necessary for total internal reflection.

Conclusion: students questions are answered and emphasise is laid on salient points.

Lesson V

Class : SS2

Duration : 80 minutes

Subject : Physics

Topic : Refraction of light through converging lens.

Sub – topic : Image in a converging lens.

Specific objectives: by the end of the lesson, students should be able to:

(i) Define optical centre and principal focus of lens

(ii) State characteristics of image formed by converging lens depending on the object distance through drawing.

(iii) State lens formula.

(iv) Solve numerical problems.

Instructional Resources: a chart showing ray diagram of image formed by a converging lens.

Previous Knowledge: students have been taught refraction of light through glass block.

Introductions: the teachers introduces the lesson by writing the topic on the board.

Lesson Presentation: the teacher presents the lesson as follows;

Step I: he defines optical centre of a lens as a point on the principal axis through which light ray passes without deviation. It coincide with the geometrical centre of the lens. While principal focus is the point to which light close and parallel to the principal axis converge or from which it appears to diverge after refraction in the lens.

Step II: he states the characteristics of image formed by a converging lens when object is placed between optical centre and principal focus.

i. Magnified

ii. Erect.

iii. Virtual.

iv. Formed on same side as object

Step III: he states the lens formula as $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

Where f = focal lens, v = image distance, u = object distance. And linear magnification m $= \frac{v}{u}$.

Step IV: he solves some numerical problems on lens using the lens formula e.g an object is placed 10cm from a thin converging lens. If the focal length of the lens is 15cm, what is the image distance from the lens?

Solution

u = 10cm, f = 15cm, v = ? Using $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\frac{1}{15} = \frac{1}{v} + \frac{1}{10}$$

$$\frac{1}{v} = \frac{-1}{30}$$

$\therefore$ v = -30cm

Evaluations: the teacher evaluates the lesson by asking students the following Questions;

1. Define principal focus and optical centre.
2. An object 4cm high is at right angle to the principal axis of a converging lens of focal length 20cm and at 30cm from it. Determine the position of the image.
3. What is the characteristics of image of an object placed at the principal focus of a converging lens?

Conclusion: students questions are answered and emphasise is laid on salient points.

Lesson VI

Class : SS2
Duration : 80 minutes
Subject : Physics
Topic : Refraction of light through lens.
Sub – topic : Images formed in a converging lens.
Specific objectives : By the end of the lesson, students should be able to:

i. Describe nature of images formed in convex lens.
ii. Draw and interpret common ray diagrams.
iii. Solve numerical problems on lenses.

Instructional resources : a chart showing ray diagram of image formed in converging lens .
Previous knowledge: students have been taught refraction in glass prism.
Introduction : the students are grouped and apparatus set.
Presentation: the teacher presents the lesson in the following steps**:**

Step I: he describes the nature of images formed in convex lens.
Step II : he explains the drawing of ray diagram using the 3 basic rays i.e

I. Ray parallel and close to the principal axis is refracted through the principal focus.
II. Ray coming through the principal focus is refracted parallel to the principal axis.
III. Ray passing through the optical centre is un -deviated.

Step III : he solves some numerical problems on lenses such as:

Question1. A real image of a pin formed by a converging lens of focal length 15cm is three times the size of the object. What is the distance of the object from the lens?

Solution: using Magnification $m = \frac{image\ distance\ V}{Object\ distance\ U}$ and $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

Where m = 3, f = 15cm hence $3 = \frac{v}{u}$ and v = 3u.

$\frac{1}{15} = \frac{1}{3u} + \frac{1}{u}$ and u=20cm.

Evaluation : the evaluation questions are as follows :

1. What are the characteristics of image formed by a diverging lens?
2. A converging lens of focal length 5cm forms a virtual image which 10cm from the lens. How far from the lens is the object?
3. An object is placed 5.0cm in front of a converging lens of focal length 10.0cm. Calculate the linear magnification.

Conclusion: Students questions are answered and emphasises are laid on the Salient points.