EFFECTS OF ACTION LEARNING AND INQUIRY – BASED INSTRUCTIONAL STRATEGIES ON SECONDARY SCHOOL STUDENTS' LEARNING OUTCOMES IN PHYSICS

BY

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ABSTRACT

The importance of Physics in the development of science and technology has been emphasised in the literature. However, the enrolment and achievement of students in senior school certificate examination over the years keep dwindling as a result of the problem of selection of inappropriate and ineffective strategy of instruction and the abstract and practical nature of the subject, despite series of efforts of Physics educators and researchers aimed at addressing the issue. Thus, this study, therefore, investigated the effects of Action Learning Strategy (ALS) and Inquiry-Based Strategy (IBS), on secondary school students' achievement in and attitude towards Physics.

The study adopted the pretest-posttest, control group, quasi-experimental design, using a 3x3x2 factorial matrix. One hundred and Ninety-four senior secondary II students were purposively selected from six secondary schools in two local government areas of Kwara State as the sample. The six schools were randomly assigned to experimental and control groups. Six instruments were used in data collection, namely, Physics Attitude Questionnaire (r = 0.94), Achievement Test in Physics (r = 0.76), Numerical Ability Test (r = 0.77). Instructional Guide for Action Learning Strategy (experimental group I), Inquiry-Based Strategy (experimental group II) and Conventional Method (control group). Seven null hypotheses were tested at 0.05 level of significance. Data were analysed using Analysis of Covariance.

Experimental treatment (that is, instructional strategies) had a significant main effect on students' achievement in Physics ($F_{(3,190)} = 373.74; p<0.05$) and attitude towards Physics ($F_{(3,190)} = 106.19; p<0.05$). Students exposed to ALS attained highest post-test mean score ($\bar{X}$=79.59) in achievement in Physics, followed by the IBS ($\bar{X}$= 56.16) and control group ($\bar{X}$= 26.49). Also, the ALS group had higher mean score ($\bar{X}$= 83.15), than the IBS ($\bar{X}$= 79.30) and the control group ($\bar{X}$= 56.90) on attitude towards Physics respectively. There is a significant effect of numerical ability on students' achievement in Physics ($F_{(3,190)} = 11.20; p<.05$), and on their attitude towards Physics ($F_{(3,190)} = 23.51; p<0.05$). Students with high numerical ability had higher achievement score ($\bar{X}$=61.68) than those of the medium numerical ability ($\bar{X}$=53.21) and low numerical ability ($\bar{X}$= 47.90) students. Similarly, gender had a significant effect on students' achievement in Physics ($F_{(2,191)} = 10.52; p<0.05$) but not on their attitude towards Physics. Female students had higher mean score ($\bar{X}$=56.95) than their male counterparts ($\bar{X}$= 51.32).

Action learning and Inquiry-based strategies were effective in enhancing students' learning outcomes in Physics. The ALS particularly minimises the complexity of the Physics concepts. Therefore, Physics teachers should adopt the AL and IB strategies in enhancing students' learning outcomes. These strategies may also increase students' enrolment in Physics, particularly female students.

Key words: Action learning strategy, Inquiry-based strategy, Numerical ability, Physics, Students' learning outcomes

Word count: 443

DEDICATION

This work is dedicated to the **Almighty God** and My parent **Deacon and Deaconess Joseph Oladuntoye Afolabi**

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Folashade AFOLABI JULY, 2012.

CERTIFICATION

I certified that this work was carried out by Miss Folashade Afolabi in the Department of Teacher Education, University of Ibadan.

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TABLE OF CONTENTS

CHAPTER TWO: REVIEW OF RELATED LITERATURE

CHAPTER THREE: RESEARCH METHODOLOGY

CHAPTER FOUR: RESULTS AND INTERPRETATION

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Science has played a dominant role in the developmental efforts of nations. It has been identified as a potential instrument for solving socio-economic problems such as unemployment, hunger, poverty, population explosion and environmental degradation, which are problems facing developing nations like Nigeria (Cohen, 1994; Nwagbo, 2001; Omwirhiren, 2002; Adesoji, 2003). Ajewole (1991) opined that every country craves for science and technological advancement and this can only be achieved through science education. Iroegbu (2004) asserted that the driving force for change in the world is the knowledge of science and technology and these are integral parts of our everyday life activities and humanity’s best hope to acquire or achieve sustainable development. It is perhaps for this reason of sustainable development that for the past decade, the teaching of science in Nigeria schools has received tremendous attention by parents, teachers, scholars and policy makers (Okpala, 1995; Abd-El-Khalick and Lederman, 2000; Bainchini and Solomon, 2003; Graffit, 2004; Oludipe, 2012). This is reflected in section 8 of the National Policy on Education (FRN, 2004) where it is stated that not less than 60% of admission placement shall be allocated to science and science oriented courses in the conventional universities and not less than 80% in the universities of technology.

There are three core science subjects studied at the senior secondary school level (Physics, Chemistry and Biology (FRN, 2004)). Physics is the spring board for the other two. Physics plays a key role in the future progress of mankind and chosen career of young adults. It is one of the basic subjects in science curriculum that technological advancement and numerous inventions hinge on. Adepitan (2003) pointed out that Physics is the foundation on which scientific and technological development of a nation rest. The knowledge and principles of Physics have contributed immensely to inventions such as thermonuclear plants that have led to modern industrialization as well as hydroelectric power generated from the use of turbines, information and communication technology and sea transportation, nuclear energy for curing of cancer, computers and modern day electronics. It is evident from the foregoing that Physics is among the disciplines essential for national development.

In spite of all the advantages derived from and the recognition given to Physics as one of the core science courses in the school curriculum and as a pivot of technological and economic development, there is a wide gap between curriculum planning, and implementation, that is, what is prescribed differs to a large extent from what is practiced (Akinbobola, 2006). This gap has led students to perceive Physics as difficult. It is believed that this perception of Physics as a difficult subject might relate to poor achievement of students particularly in national examinations such as West African Examination Council (WAEC), National Examinations Council (NECO) and University Matriculation Examination (UME).

The poor achievement in Physics has become a major cause for concern to parents, researchers and stake-holders in Physics education (Adeoye, 2000; Raimi and Adeoye, 2002). Akinbobola (2004) opined that due to the specific priority of Physics as a subject in the development of scientific and technological programmes of a nation, backwardness and exploitation by other countries would only be the reward to a nation with such poor performance in Physics. It appears that any nation that fails to embrace the teaching and learning of Physics will be backward in development programmes. The achievement and enrolment statistics of students in Physics therefore may be used to determine the success or failure of Government efforts and investment as well as various efforts of Physics educators. Such data would reveal the extent to which a core science subject like Physics might be able to play its role in the training of experts and other professionals who would move the nation out of the present woods into realizing the dream of national development and economic emancipation.

The perception of students that Physics is a difficult subject has affected learners' interest and this has led to declining achievement in the subject (Iroegbu, 2004; Akinbobola, 2006; Afolabi, 2009). The WAEC chief examiners' report (2007) confirmed that candidates' achievement in Physics is generally poor as a result of lack of organisational skill, poor attitude and conceptual knowledge of the subject matter and weakness in arithmetic operations.

The result of Senior Secondary Certificate Examinations conducted by West African Examination Council (WAEC), over a ten year period (1999-2008). Table 1 below revealed empirical information on the poor performance of students in Physics.

Table 1 showed that for the first five years under review, the highest percentage of students that obtained A1-C6 is 47.56 percent in 2003 while the lowest is that of 2000, which 30.05 percent is. The next five years (2004-2008) under consideration have shown improvement with up to 58.03 percent of candidates obtaining A1-C6 in 2006. This analysis is concentrating on A1-C6 because any grade below C6 is not useful for the purpose of admission into tertiary institutions among other reasons for offering the subject. This is analysis is presented more vividly in the bar-chart in fig 1. Majority of candidates that fell below credit level did not meet the requirement for admission into tertiary institutions. Such candidates may lose out in their bids to become engineers, scientists, technologists, medical doctors or any other careers where a credit pass in Physics is a prerequisite for admission into tertiary institutions. It is apparent that it may not be possible for Nigeria to join the rest of the industrialized nations of the world, unless urgent steps are taken to redress the present situation (Akinbobola, 2006).

Table 1: Students' Achievement in West African School Certificate (WASC, MAY/JUNE) between 1999 and 2008 in Physics.

Year	Total entry	Total candidates that sat	Grade 1-6 Credit Pass		Grade 7-8 Pass		Grade 9 Failure	
			No. of candidate	%	No. of candidate	%	No. of candidate	%
1999	213,864	210,271	64,283	30.57	61,772	29.37	77,709	36.59
2000	193,052	188,312	56,604	30.05	72,471	38.48	59,237	31.45
2001	295,963	287,993	99,264	34.46	110,242	38.27	78,487	27.25
2002	261,687	254,188	120,768	47.51	81,814	32.18	51,606	20.30
2003	280,818	275,369	130,982	47.56	84,413	30.65	53,079	19.27
2004	270,028	265,262	135,359	51.02	97,590	29.25	52,313	19.72
2005	351,780	344,411	142,943	41.37	102,036	29.61	89,150	25.88
2006	384,477	375,823	218,199	58.03	87,025	23.15	62,119	16.52
2007	427,398	418,593	180,797	43.17	140,172	33.48	88,480	21.13
2008	424,893	415,113	200,345	48.23	91,116	21.94	116,776	28.13

Source: WAEC Annual Report, 2009
West African Examination Council Research and Statistical Unit, Yaba Lagos.

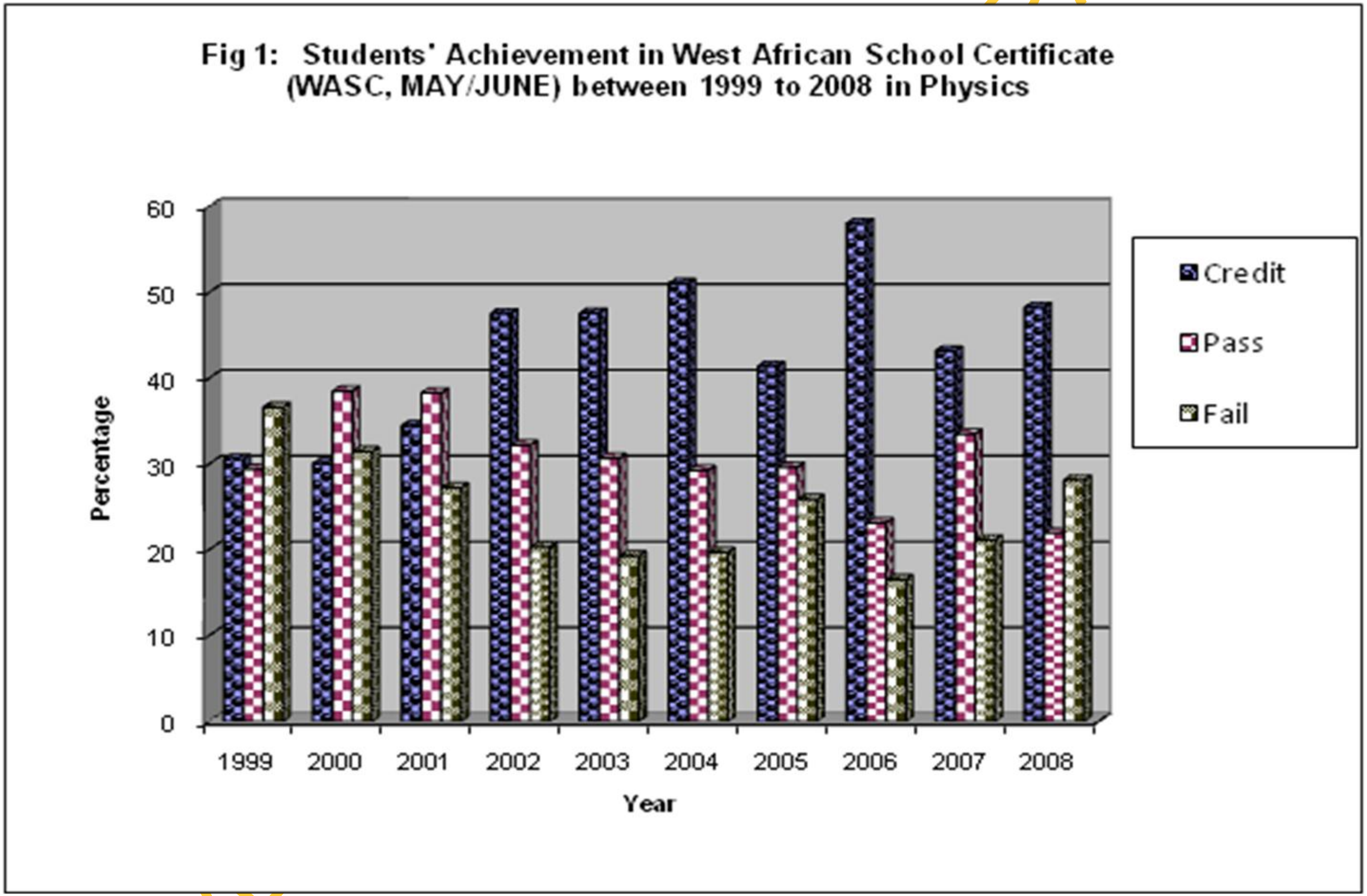


Fig 1: Students' Achievement in West African School Certificate (WASC, MAY/JUNE) between 1999 to 2008 in Physics
60
50
40
30
20
10
0
Percentage
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Credit
Pass
Fail

Table 2 below revealed the problem of poor enrolment in Physics. Physics is the least popular of the three basic science subjects, Physics, Chemistry and Biology. Despite advantages derived from the subject, the enrolment in Physics at the secondary school level is very low. Table 2 gives the total number of candidates that sat for Physics, chemistry and biology for the period of ten years (1999-2008). For every year considered, less than 30% of the total entry for biology entered for Physics. Also for every year considered the enrolment in chemistry is higher than the enrolment in Physics (see also bar chart in fig 2). To overcome the problem of poor enrolment and achievement, it is necessary that studies should be carried out in order to ascertain how to make teaching and learning of Physics more interesting and innovative in order to arrest the negative trend.

Table 2: Comparison of enrolment for Physics, Chemistry and Biology for WASSCE (1999-2008).

Year	Total no of Physics candidates for the exam	Total no of Chemistry candidates for the exam	Total no of Biology candidates for the exam
1999	210,271	223,307	745,102
2000	188, 312	195,810	620,291
2001	287, 993	301,740	995,345
2002	254,188	262,824	882,119
2003	275,369	282,120	909,101
2004	264,262	269,774	821,966
2005	344,411	349,936	1,051,557
2006	375,823	380,103	1,137,180
2007	418,593	422,681	1,238,163
2008	415,113	418,423	1,259,965

Source: WAEC Annual Report, 2009
West African Examination Council Research and Statistical Unit, Yaba Lagos.

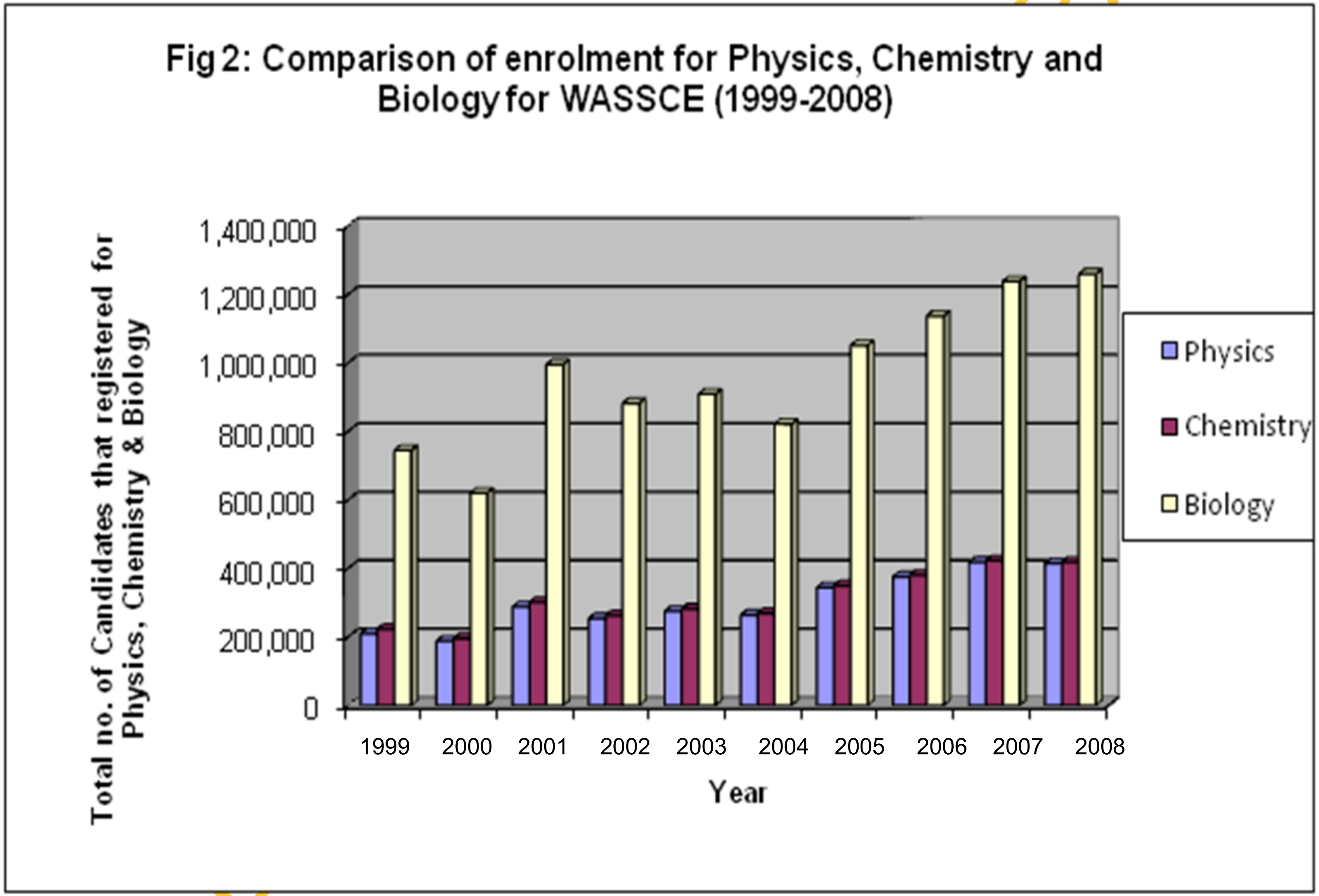


Fig 2: Comparison of enrolment for Physics, Chemistry and Biology for WASSCE (1999-2008)
Total no. of Candidates that registered for Physics, Chemistry & Biology
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Physics
Chemistry
Biology

The poor achievement of students in the sciences most especially Physics has caught some researchers' attention and interest in Nigeria and they have been able to identify some reasons and factors that are responsible for the poor achievement. These factors include among others: lack of hands-on and minds-on strategies in Physics classroom (Ownioduokit and Ikwa, 2000; Akinbobola and Ado, 2007); poor instructional strategies and teaching methods (Meyer and Font, 1992); abstract nature of Physics concepts (NERDC, 1994; Ikwa, 2002); poor students' attitude (Bolaji, 2000; Simon, 2000), student- related factors and teacher-related factors (Akinbobola, 2009); poor numerical ability (Iroegbu,1998; Okoronka, 2004). More specifically, these researchers have also identified the source of problems to include the use of lecture method which is characterized by monologue in teaching the subject despite the fact that there are highly qualified and motivated Physics teachers. Some researchers (Ibeagha, 1986; Ivowi, 1997; Okpala, 1998; Ukwungwu and Olarinoye, 2000; Nwagbo, 2001; Omwirhiren, 2002) stated that student centred strategies, which involve a lot of engaging activities where learners construct their own knowledge and understanding rather than the teacher-centred strategies will enhance learning of Physics. Researchers have acknowledged that the traditional lecture-style, non-student centred and non activity based instructional strategies in teaching Physics courses failed to impart rooted conceptual understanding of Physics contents (Reddish, 1994; Hakes, 1998; Kahn, 2004; Alant, 2004; Okoronka, 2004). Literatures have repeatedly drawn attention to the fact that teaching in secondary school science classes is very often highly teacher-centered and is characterised by lack of variety in teaching methods (Poepping and Mella, 2001).

Physics educators such as Finkelstein (2003) and Reid (2003) believe that students must be intellectually engaged and actively involved in learning and that conventional method of instruction has failed to provide this engagement in a situation where teachers transmit knowledge to students who sit passively in the classroom and listen. Ajelabi (1998) was of the opinion that the teaching methods adopted by teachers in order to promote learning are of utmost importance. Hence, he concluded that there is the need to introduce, adopt or adapt the latest instructional techniques that are capable of sustaining the interest of the learners. It is therefore, pertinent to look for instructional strategies which could involve active learning in order to improve achievement and also stimulate the interest of learners for a change of attitude towards Physics.

A critical look at the content of Physics curriculum indicates that the traditional teacher- centred approaches are not sufficient and appropriate to promote efficient learning of the content of the Physics programme. However, there is a need for the uses of teaching strategies that will not only maximize meaningful understanding of concepts in Physics but will also provide students the opportunity to interact with their environment and make them and their teachers to clarify their misconceptions. This position seems to be rooted in the ideas of the constructivists. Recent studies on children's learning science reveal that the learner is the architect of his own knowledge in line with the constructivists' view of learning (Lebow, 1995; VonGlasserfield, 1995). Ausubel (1968) stated that the single most important factor influencing learning is what the learner already knows, 'ascertain this and teach him accordingly'. An instructional strategy which is perhaps capable of meeting these new challenges by taking advantage of what the learner already knows and how he gets to know or learns about anything is what we require to improve attitude and achievement. To what extent will action learning and inquiry-based instructional strategies provide learner with this opportunity?

Action-learning strategy is an instructional strategy that has been recognized as an important strategy that enhances science learning in students (Sawchuk, 2003). Action learning is an educational process whereby the participants study their own actions and experience in order to improve performance (Marquardt, 2004; Chambers and Hale, 2007; Kramer, 2007). This is done in conjunction with others, in small groups called action learning sets. It is proposed as particularly suitable for all learners, as it enables each person to reflect on and review the action they have taken and the learning points arrived at, so as to guide future action and improve performance. The strategy stands in contrast with the traditional teaching methods that focus on the presentation of knowledge and skills. Action learning focuses on research into action taken, and the knowledge that emerges as a result, would lead to the improvement of skills and achievement. Action learning strategy was originated by Professor Reginald Revans (Ravens, 1998). He invented and developed this method in the UK in the 1940s, working in the Coal Board and later in hospitals, where he concluded that the conventional instructional methods were largely ineffective. He discovered that people had to be aware of their lack of relevant knowledge and be prepared to explore the area of their ignorance with suitable questions and help from other people in similar positions (Revans, 1998). Weinstein (1995) defined action learning as a strategy that is used to determine individual potential in a group and a way of learning from their actions and from what happens to them and around them by taking the time to question, understand and reflect, to gain insights and consider how to act in future.

Marsick (1998) supported the view that action learning sets create the environment which can enable participants to critically reflect on their own personal development which is in line with the Physics curriculum objectives. According to O'Hara, Bourner and Webber (2004), action learning set is collectively based on the premise that participants are willing to share, whereas traditional learning is based on individualistic approach. Therefore action learning set can be a powerful vehicle for introducing students to collaborative learning, tapping into knowledge and learning together through shared experience. The principles of action learning sets as outlined by O'Hara, Bourner and Webber (2004) are:

1. participants meet in small groups called 'sets'
2. participants bring a problem to the set
3. participants meet regularly usually over a fixed period of time
4. problems are relevant to each person
5. a supportive sharing learning environment is created within the set sometimes with the aid of a facilitator in the early stages
6. the process includes questioning, reflection, discussion, and debate and
7. participants carry out action between set meetings

Action learning strategy is a learning by doing strategy, in which small group of people come together to identify a problem, develop an action plan to solve the problem, meet regularly for the implementation, and learn from the implementation in an attempt to change things. It appears that not much studies known to the researcher have been carried out and documented in our educational system on the use of action learning strategy most especially in Physics classroom in Nigeria, thus, this calls for more research into its selection, use and effects in Physics particularly for teaching abstract and difficult concepts. Based on this, the researcher will incorporate action learning strategy into classroom learning and observe whether or not it will improve the academic achievement and attitude of Physics students.

Inquiry - based instructional strategy is another key research area that has generated a lot of interest. It came to being in the mid 90s, with the publication of the National Science Education Standards (National Research Council, 1996), a key document guiding science education in the United States of America. The ideal of inquiry and inquiring–based science teaching was incorporated into this document, and this method was stated as one of the best ways of teaching science to children, It make use of the exclusive higher order cognitive skills, rooted in constructivist approach and equally enjoys special attention in the goals of science education (Hmelo-silver, Duncan and Chinn, 2007). Inquiry - based strategy is a teaching strategy with carefully selected and designed problems that demand from the learner acquisition of critical thinking, problem solving proficiency, self directed learning strategies and team participation skills. It reduces teacher's instruction where learners are seen as active listeners and passively involved in classroom activities as in the case of conventional method. Inquiry- based strategy is an example of constructivist learning strategy which possesses significantly contextualized real world situation and providing resources, guidance and instruction to learning as they develop content knowledge and problem solving skills (Yager, 1991, NRC, 1996, 2000).

Hmelo-silver, Duncan and Chinn (2007) described inquiry based science teaching as a way of acquiring knowledge through the process of inquiry where the student plays a major role in answering the question with the help of a teacher. It is organised with small cooperative groups of learners accompanied by a teacher, instructor or facilitator. During this process, a series of problems (starting with introductory problems) with guidance from the teacher, instructor or facilitator are provided to learners, and then later, guidance is faded as learners gain expertise. Guidance reduces as group members feel more confident with the subject matter and become more competent with learned procedures. In Inquiry-based strategy, the teacher starts by guiding the students to identify the problems and help them to link tasks with previous knowledge. Therefore, the students discuss the problem cooperatively among themselves in a small group, explain what they know, pose research questions, generate hypotheses, develop initial plans and organise their knowledge, attempt to solve the problems with several modifications, derive learning goals and organise further work. Finally, the results are presented to larger groups through the guidance of the teacher, instructor or facilitator and the students are allowed to reflect on the learning that has taken place. Hmelo-silver, Duncan and Chinn (2007) provided the following principles of inquiry-based learning strategy:

- Instruction must be concerned with the experiences and contexts that make the students willing and able to learn (readiness)
- Instruction must be structured so that it can be easily grasped by the students (spiral organisation)
- Instruction should be designed to extrapolate and or fill in the gaps (going beyond the information given)

A number of studies have reported the benefits of inquiry-related teaching approaches, suggesting that these techniques foster understanding of scientific processes, scientific literacy, and critical thinking among other competencies (Hodson, 1990; Cavallo, Potter, and Rozman, 2004). Inquiry-based teaching can also improve understanding of the scientific method (Kahle, Meece and Scantlebury, 2000). These and other studies imply that the use of inquiry-based learning could be an effective approach for teaching science at all levels ranging from primary level through higher degree in education (NRC, 2000). Since much research work and empirical data have not been investigated in Nigerian school Physics, the research hopes to provide some data in this area. This study will make use of structured inquiry method. This method consists of identifying and selecting problems, presenting and defining problems clearly and concisely before the learner and directing and guiding them to find solution (Akinlaye, 1998). When applied to teach difficult concepts in Physics it is believed that it will stimulate and improve achievement and attitude of students in Physics.

Based on the discussion above, what then is the difference between Action learning and Inquiry- based instructional strategies? In structured Inquiry- based strategy, the teacher guides or fashion out the problem for the students. That is, the teacher helps the students to identify the problem while the students provide solution to the problem. In action learning, both the problem and solution are discovered by the students.

It has been shown that students' attitude to a subject is directly related to the popularity of the subject and to students' cognitive achievement (Hodson and Hodson, 1998). The present research is also interested in finding out the effects of the treatment conditions on the subjects' attitude to Physics. Yara (2009) defined attitude towards science as interest or feeling towards studying science or the scientific approach assumed by an individual for solving problems, assessing ideas and making decision. Akinbobola (2009) stated that attitudes are acquired through learning and can be changed through persuasion using varieties of techniques.

Meyer (1999) defined attitude from a social-psychological perspective as a favourable or unfavourable evaluation reaction towards something or someone, exhibited in one's belief, feelings, or intended behaviour. In their studies, Ogunleye (1996), Abiakwo (2002), Akinbobola (2008) and Akinbobola and Afolabi (2009) independently found that the strongest factor affecting students' enrolment and achievement in Physics is the students' attitude. Iroegbu (1998), Onwuegbu (1998), Orji (1998), Okoronka (2004), Akinbobola (2008) and Yara (2009) investigated the effects of different instructional strategies on attitude and achievement among Nigerian secondary school Physics students and reported some significant effect. But Gardner's (1975) study showed little support for strong relationship between the two variables. Akinbobola (2008) showed that 64% of the total variance in the attitude of students towards the concept of heat energy in Physics is attributable to the influence of instructional materials used in teaching the students. Also, Akinbobola (2009) stated that 61% of the variance in the attitude of students in Physics is attributable to the influence of the instructional strategies. These studies seem to indicate that learners' interest/ attitude could be influenced negatively or positively by the various factors involved in the studies. It therefore, necessary to look at what could be done in empirical way to improve attitude and increase achievement of Physics students.

Gender has also been one of the prominent factors that influence achievement of students in Physics (Furner and Duffy, 2002). There have been conflicting findings by researchers (Baird, 1997; Colley, 1997; Iroegbu, 1998, Quiaiser-Pouland and Lehman, 2002; Donnellan, 2003; Hazari and Potvin, 2005; Laura, 2006) on the influence of gender on students' achievement in science subjects particularly in Physics. Iroegbu (2008) discovered that gender effect is significant on achievement in physics. He went further that male students performed significantly better than female students on achievement in physics. Quiaiser-Poul and Lehman (2002) opined similarly that male students performed significantly better than their female counterparts in physics. Erinosho (2005) stated that science is a male enterprise.

In contrast, Colley (1997) found that females achieve higher gains in science process in physics in the middle school than their fellow male students. Also, Birch and Sheila (1994) concluded that women have become more prominent in chemistry, biology and physics. Similarly, an anonymous 1996 report for American Physics Society (APS) member stated that women have made modest gains in physics. They also discovered that girls performed brilliantly in physics classrooms than males students in most of the schools visited. Keeves (1991) and Stephens (1991) also documented that disparity existed between male and female student's performance in science subjects. David and Stanley (2000), Arigbabu and Mji (2004) in their findings stated that there are no longer distinguishing differences in the cognitive, affective and psychomotor skills achievements of students in respect of gender.

However, with the conflicting findings on gender related research, it appears that the influence of gender on achievement of students has not been established. Since it has been found that gender factor has positive, negative or no contribution to academic achievement, it is therefore necessary in this study to find out if gender has any effect in this experiment

Apart from the foregoing variables which have been found to influence achievement and attitude towards physics, the nature of the subject matter of Physics itself could be another important factor. It has been perceived that numerical ability of students could have an effect on their achievement in Physics. This perception has been partially linked to the high quantitative demands in explicating some Physics concepts (Iroegbu, 1998). Physics is a subject that has a lot of mathematical calculations and generally regarded as difficult among the students (NERDC, 2008). Mathematical calculations are often used in the explanation of concepts and phenomena in Physics as well as in numerical problem solving (Okoronka, 2004).

Egbugara, (1986) reported that students' difficulties in mathematics affect learning in Physics. Iroegbu (1998) also found that poor numerical ability of students generates lack of confidence in handling numerical problems. Jones (2001) discovered that numerical ability influences achievement of students in Physics. Bassock (1990) suggested that mathematical difficulties affect learning in Physics and consequently achievement in Physics. He explained that in teaching quantitative aspect of Physics, there is acquisition stage, storage or processing stage and finally the retention or recall stage when it will be utilized. What is stored is in turn, dependent upon what is acquired and upon the condition at the storage stage (Omwirhiren, 2002).

It is therefore hoped that the results of this study will contribute some data that may be useful in linking action research with attitude to Physics and achievement in Physics for Nigerian secondary schools students.

1.2 Statement of the Problem

The different instructional strategies adopted in teaching Physics have not improved students' achievement in the subject to any appreciable extent. Of all the factors that could be responsible for poor students' achievement in Physics, the strategy of teaching often come under attack. When students are blamed, explanation is given only in terms of the students' cognitive and intellectual ability. Little attention is paid to the fact that learners' numerical ability, gender factors could influence their attitude and achievement in the subject. Hence, there is the need to have a clear picture of how certain factors relate to achievement of students' in Physics. Therefore, this study sought to determine the effect of action learning and inquiry-based instructional strategies on the achievement and attitude of students towards senior secondary school Physics. It examined the extent to which numerical ability and gender influence these learning outcomes.

1.3 Hypotheses

This study is designed to test the following null hypotheses at 0.05 level of significance.

$H0_1$: There is no significant main effect of treatment on students'

(a) Achievement in Physics

(b) Attitude towards Physics

$H0_2$: There is no significant main effect of gender on students'

(a) Achievement in Physics

(b) Attitude towards Physics

$H0_3$: There is no significant main effect of numerical ability on students'

(a) Achievement in Physics

(b) Attitude towards Physics

$H0_4$: There is no significant interaction effect of treatment and gender on students'

(a) Achievement in Physics

(b) Attitude towards Physics

$H0_5$: There is no significant interaction effect of treatment and numerical ability on students'

(a) Achievement in Physics.

(b) Attitude towards Physics

$H0_6$: There is no significant interaction effect of gender and numerical ability on students'

(a) Achievement in Physics

(b) Attitude towards Physics

$H0_7$: There is no significant interaction effect of treatment, gender and numerical ability on students'

(a) Achievement in Physics

(b) Attitude towards Physics

1.4 Significance of the Study

It is expected that findings from this study would provide relevant information on the main and interactive effects of action learning and directed inquiry strategies, numerical ability and gender, in influencing learning achievement of the senior secondary school students. Hopefully, findings from this study would enable teachers and students' device new approaches and strategies for improving on the current level of achievement and attitude towards Physics. The result emanating from this work would provide basis for future planning of in-service education for teachers in the area of instructional strategies and it would further provide impetus for further research project. The study would hopefully provide the basis for introducing action learning strategy and further support for inquiry based learning strategy among the pool of helpful teaching strategies for implementing the Physics curriculum by the curriculum planners.

1.5 Scope of the Study

The study is delimited to senior secondary school two students in nine schools in Ilorin, kwara state. The main concepts to be taught are based on the curriculum prescription on the concepts of waves as contained in the senior secondary two syllabus. The study is limited to investigating the effects of instruction, gender, and numerical ability on academic achievement and attitude of secondary school students towards Physics.

1.6 Operational Definition of Terms

Learning Outcomes of interest in this study are:

(i) Achievement in Physics

(ii) Attitude towards Physics.

Achievement in Physics: This refers to the measurable behavioural expectations from students as a result of treatment. The achievement in Physics was measured using scores on Achievement Test in Physics (ATP).

Attitude towards Physics: This refers to an individual's perception, feelings, opinions, beliefs, values, likes and dislikes, behaviour, and interest towards Physics. Students' attitudes are measured using Physics Attitude Questionnaire (PAQ).

Numerical Ability: This refers to the quantitative ability of students and it was measured using participants score on Numerical Ability Test (NAT). The results obtained from the administration of NAT were used to classify students into 3 groups using inter quartile range:

(1) Students that scored above upper quartile (Q_3) were classified as having high numerical ability.

(2) Students that scored between Q_1 and Q_3 were classified as having medium numerical ability

(3) Students that scored below lower quartile (Q_1) were classified as having low numerical ability

Where Q1= Lower quartile

Q2= between upper quartile Q_3 and lower quartile Q_1

Q3= Upper quartile Q_3

Action Learning: Instructional strategy: Action learning is an instructional strategy whereby the participants study their own actions and experience in order to improve performance

Inquiry-Based Learning: This is an instructional strategy in which students are encouraged and directed to solve issues and problems by asking questions, conducting research and verifying hypotheses in other to gather facts and information or values on the issues and make conclusions.

Conventional Method: This is also called teacher- centred teaching strategy. This is an instructional strategy that is commonly used in secondary schools, in which students are not allowed much participation in the classroom and require much teacher talk and note writing.

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

Related literature is reviewed under the following sub-headings:

- Theoretical frame work
- Constructivism and the teaching of Science
- Nature of Physics concepts and students' achievement
- Action learning strategy and students' achievement in Physics/Science
- Inquiry-based strategy and students' achievement in Physics/Science
- Numerical ability and achievement in Physics/Science
- Gender and students' achievement in Physics/Science
- Attitude of students towards Physics/Science
- Appraisal of Literature Review

2.1. Theoretical Framework

The underlying premise for this study is founded in constructivist theory of learning, Brunner's theory of Personal Discovery and Cognitive learning theory.

Constructivist theory of Learning

Constructivism is an approach to teaching and learning based on the premise that learning is the result of "mental construction". In other words, learners actively construct or build new ideas or concepts based upon current and past knowledge already acquired. Constructivists believe that learning is affected by the context in which an idea is taught as well as by student's beliefs and attitudes (Piaget, 1965). Most of the works done in the paradigm of constructivism in science education are concerned with developing teaching approaches that facilitate students' conceptual development (Solomon, 1989; Cobb, 1996). Piaget (1954) held the view that children construct knowledge of the world through assimilation and accommodation, but he emphasised biological maturity as a necessary condition.

Lev Vygotsky, a Russian philosopher and educational psychologist, agreed with many aspects of Piaget's work but emphasises cultural and social influences on cognitive development (Vygotsky, 1986). Vygotsky's theory of social constructivism emphasises the interaction of children with other people in cognitive development. His theoretical concept of the zone of proximal development embodies his belief that learning is directly related to social development. The discrepancy between a child's actual mental age and the level he or she reaches in solving problems with assistance indicates the zone of his proximal development (Vygotsky, 1986). Vygotsky felt good instruction could be provided by determining where each child is in his or her development and building on that child's experiences (Vygotsky, 1986). In terms of cognitive development Vygotsky's theory supports that learning proceeds development. He believes that developmental processes lag behind the learning processes pointing out that children can often complete tasks with the help of others that they could not accomplish working independently. The abilities that children can demonstrate when given assistance are in the process of becoming internalized, which implies that cognitive development is limited to this certain time span which he calls the "zone of proximal development" (ZPD) (Vygotsky, 1978).

The zone of proximal development is the difference between an individual's current level of development and his or her potential level of development. The range of skill that can be developed with adult guidance or peer collaboration exceeds what can be attained alone. Full development during the ZPD depends upon full social interaction.

Most constructivists advocate instructional intervention that will not only match but also accelerate students' cognitive development. According to Copley (1992) constructivism requires a teacher who acts as a facilitator whose main function is to help students become more active participants in their learning and make meaningful connections between prior knowledge, new knowledge and the processes involved in learning. Omrod (1995) stated that teachers could encourage students' cognitive development by presenting tasks that they can complete only with assistance that is, within each student's zone of proximal development. In the constructivist classroom, learning is viewed as a social, collaborative activity. Brooks and Brooks (1993) discussed the characteristics of educational settings that encourage active construction of meaning and listed them as follow:

- They free students from dreariness of fact-driven curriculum and allow them to focus on large ideas.
- They place in students' hands the exhilarating power to follow trails of interest, to make connections to reformulate ideas, and to reach unique conclusion
- They share with students the important message that the world is a complex place in which multiple perspectives exist and truth is often a matter of interpretation
- They acknowledge that learning and the process of assessing learning are at best elusive and messy endeavour that are not easily managed.

Willis, Stephens and Mathew (1996) discussed four principles that are applied in a classroom that incorporates the theory of social constructivism:

(a) learning and development are social collaborative activities, (b) the zone of proximal development can serve as a guide for curricular and lesson planning, (c) learning should occur in meaningful contexts and (d) learning should be related to a child's own experiences.

In constructivist classroom, learning is promoted through collaboration among the students and with the teacher, higher order thinking and problem solving are encouraged; the teacher attempts to relate subject matter to the students' lives, the students are allowed to construct their own knowledge and avoid repeating a right or wrong answer and the teacher acts as a facilitator and guide. Most constructivist theories stress earning through exploration rather than by simply giving a correct answer.

The relevance of this theory to this study is on the premise that through the use of action learning and inquiry-based instructional strategies, learners would actively engaged through a personal and collective interaction with materials and ability to gather information and connect it to the previous knowledge to build a new idea (s).

Brunner's theory of Personal Discovery

Jerome .S. Brunner's discovery learning is generally associated with constructivist teaching principles with its emphasise that students learn best when engaged in active social learning processes that help them to form new ideas based on existing knowledge (Clabaugh, 2009). Discovery learning, according to Bruner (1960), is an inquiry-based, constructivist learning that takes place in problem-solving situations where the learner draws on his or her own past experience and existing knowledge to discover facts and relationships and new truths to be learnt, in essence, "obtaining knowledge for oneself" (Schunk, 2008). When children interact with their environment through exploration of objects and then work together to form hypotheses, they are actively engaged in the process of developing problem-based learning skills (Clabaugh, 2009; Schunk, 2008).

Bruner believed that as a result of this learning process, students were more likely to remember concepts and knowledge discovered on their own (Clabaugh, 2009). Further, Schunk emphasizes that the discovery model is a type of inductive reasoning that allows students to move from studying specific examples to formulating general rules, concepts, and principles through a minimally guided instructional approach that involves direction; teachers arrange activities in which students search, manipulate, explore, and investigate (Schunk, 2008).

According to Bruner's theory of cognitive growth, as children's cognitive abilities mature, they progress through three stages of learning that he termed "enactive", "iconic," and "symbolic" that describe how "people represent knowledge" (Clabaugh, 2009; Schunk, 2008). He described further that, the *enactive* stage involves motor responses that opportune learning through active manipulation; the *iconic* stage involves the "capability to think about objects that are not physically present and to recognize objects;" and, the *symbolic* stage allows for the understanding of abstract concepts (Schunk, 2008).

In a constructivist classroom, Bruner's "scaffolding theory" promotes learning through these three developmental stages with sufficient support in the form of resources, tasks, guidance, and social interactions when concepts and skills are first introduced (Schunk, 2008). Bruner advocated learning through inquiry with the teacher providing guidance to accelerate children's thinking, and recommended that the early teaching of any subject should emphasize grasping basic ideas intuitively. After that, he believed, the curriculum should revisit these basic ideas, repeatedly building upon them until the pupil understands them fully as is defined by his *spiral curriculum* (Schunk, 2008).

Brunner advocated that instruction should be presented to learners in real life setting while allowing them to discover and generate ideas through hands-on activities, answer questions and interact with materials for meaningful learning. This is representative of the activity phase in action learning and inquiry based instructional strategies.

Cognitive theory of Learning

Cognitive theories of learning emphasize complex, abstract, intellectual processes such as thinking, problem solving, perception, insight and soon (Gagne, 1980). The cognitive learning perspective indicates that knowledge acquisition is not relevant unless the information is learnt and understood in a meaningful way. Cognition and Technology Group at Vanderbiit (1996) believed that learners process information elaborates on it and interpret the information based on their past experience as well as their interaction with the world. They further stated that the teacher is not a transmitter of knowledge but rather a facilitator and provider of experiences from which learners will learn. Also, students are not absorber of knowledge but rather active participants in constructing their own meaning based on previous knowledge. Cognitive principles feature the learner as an active participant in the learning process.

All these theories are relevant to this research work in the sense that the teacher and the students construct and share knowledge together through interaction which supports action learning and inquiry based instructional strategies.

2.2. Constructivism and the Teaching of Science

Constructivism view knowledge as being constructed by individuals through their own experience within the world. This approach to learning emphasizes the use of authentic, challenging problems where learners make meaning through active participation (Jonassen, 1991). The author further stated that thinking is grounded in perception of physical and social experiences and that learning is a function of how the individual creates meaning from his or her experiences. In a constructivist learning environment, the role of the teacher, learner, content/ context and assessment vary significantly from the traditional class setting. The constructivist approach to teaching and learning is based on a combination of a subset of research within cognitive psychology and a subset of research within social psychology. The underlying principle is that an individual learner must actively engaged, building knowledge and skills. Information exists within these built constructs rather than in the external environment (Jonassen, 1991).

Baker and Piburn (1997) working definition of constructivism is as follows:

- Constructivism is a theoretical position based on the argument that knowledge is constructed by individuals and cultures.
- Experience is mediated by schemata that are structured by the psychological and background characteristics of the individual and by the norms and values of the culture.
- The conceptual framework resulting from the application of a schema to experience cannot be said to be correct or incorrect. It is simply an alternative framework.
- The process of knowledge construction consists of movement from one schema to another, through a period of conflicts induced by anomaly
- Adoption of a new schema will, of necessity, require a reorganization of existing knowledge into a new conceptual framework.
- In principle, there is no end to this process of knowledge construction. No absolute knowledge is possible. All knowledge is context bound and will change with context.

Moving from constructivist philosophy, psychology and epistemology to the characterization of constructivist learning environments presents the challenge of synthesizing a large spectrum of somewhat disparate concepts. An appropriate analogy for the way in which constructivist concepts have evolved is that of a prism with many facets. While the facets reflect the same light and form one part of a whole, each nonetheless present distinct and finely delineated boundaries (Baker and Piburn, 1997).

The presentation of characteristics in this section aim to remain true to this analogy in that it recognizes and attempts to represent the variety of ways in which constructivism is articulated in the literature. Situated cognition, anchored instruction, apprenticeship learning, problem-based learning, generative learning, constructionist, exploratory learning are all approaches to learning that are grounded in and derived from constructivist epistemology. Each approach articulates the way in which the concepts are operationalized for learning. The researchers and theorists whose perspectives are listed below suggest links between constructivist theory and practice. They provide the beginnings of an orienting framework for a constructivist approach to design, teaching and learning. Learning points to a relatively permanent change in the behaviour of an individual. In other words, when an expected change in behaviour is observed, this is perceived as an indication of learning.

Jonassen, Peck and Wilson (1999), explained the conditions under which learning takes place and to what extent. They stated further that there is a general expectation that a learning theory should explain how learning takes place both within and outside the boundaries of schools. However, no learning theory is capable of fully unfolding all learning situation. Constructivism is not an instructional theory rather it is concerned with learning and the construction of knowledge. Initially, constructivism was aimed at exploring how learning takes place. However, with time, it turned into an approach manifesting the construction of knowledge. The main proposition of constructivism was that learning means constructing, creating, inventing and developing our own knowledge. They explained further that books and media can provide information, but as important as information receiving it are, getting it and hearing it does not necessarily equates learning.

Constructivism believed that knowledge results from individual constructions of reality. The theory emphasises active learning, the linking of new knowledge to knowledge learners already possessed and the application of understanding to authentic situations. Experience, interaction between teachers and students and students' interacting with each other are instructional tools for constructivists.

Although information is important, passively accumulating disconnected information is not learning. Passively receiving readymade knowledge from someone or something else is not learning to learn, a student has to be mentally and often physically active. Students learn better when they discover their own knowledge.

The teaching approach that incorporates these features has come to be called constructivist teaching. Some of its characteristics are:

- Less whole-class, teacher-directed instruction, for example, lecturing
- Less student passivity: sitting, listening, receiving and absorbing information.
- Less attempt by teachers to cover large amounts of material in every subject area thinly
- Less rote memorization of facts and details.
- Less tracking or levelling students into ability groups.
- More experimental, inductive, hands- on learning
- More emphasis on higher- order thinking
- More responsibility transferred to students for their work
- More enacting and modelling of the principles of democracy in the school
- More cooperative, collaborative activity, developing the classroom as an interdependent community (Marlowe and Page, 1998).

In constructivist learning environments, the learner is expected to be proactive and have effective communication skills. In addition, the learner is supposed to be equipped with higher order thinking skills such as critical and reflective thinking, as well as being capable of transferring all these skills to real life situations. Constructivist learning is a decision making process which is shaped by the skills, drives, beliefs, attitudes and experiences of the students. Students construct knowledge through exploring, interpreting and interacting with their environment. Thus, they learn the content and the process concurrently.

Guthrie (2004) compared three instructional methods for third-grade reading: a traditional approach, strategies instruction only approach, and an approach with strategies instruction and constructivist motivation techniques including student choices, collaboration, and hands-on activities. The constructivist approach, called CORI (Concept-Oriented Reading Instruction), resulted in better student reading comprehension, cognitive strategies, and motivation.

Kim (2005) found out that using constructivist teaching methods for 6th graders in science subject resulted in better student achievement than traditional teaching methods. This study also found that students preferred constructivist methods over traditional ones. However, Kim did not find any difference in student self-concept or learning strategies between those taught by constructivist and traditional methods.

Doğru and Kalender (2007) compared science classrooms using traditional teacher-centered approaches to those using student-centered, constructivist methods. In their initial test of student performance immediately following the lessons, they found no significant difference between traditional and constructivist methods. However, in the follow-up assessment 15 days later, students who learned through constructivist methods showed better retention of knowledge than those who learned through traditional methods.

Zarotiadou and Tsaparlis (2000) compared two methods of teaching at the lower secondary chemistry in a longitudinal study: a constructivist method (CM), based on Piaget's theory of cognitive development; and a meaningful-receptive method (MRM), based on Ausubel's theory of meaningful learning. In CM, students played an active involvement, while MRM was applied as a teacher-centred method with a number of improvements from learning theory for example, in the use of advance organisers and of concept maps. 144 students of an urban experimental lower secondary school in Athens were divided into two groups and taught chemistry according to the two methods respectively. Teaching lasted two school years (grades eight and nine). One test on knowledge and simple application of basic chemical theory, and another test on stoichiometric calculations were used. At the end of the two grades, for the comparison of the two methods, although the overall student achievement was low, the CM group scored statistically higher in chemical theory in both grades, while in stoichiometric calculations, the superiority of the CM group occurred only in grade nine.

Traditional methods of teaching are *verbal* (*expository*, *didactic*) and *formal*, that is teacher-centred, with the teacher lecturing and the student being the passive recipient of knowledge. Research on concept acquisition has revealed that children learn by active interaction initially with concrete objects and later with abstract entities (Dogru and Kalender, 2007). In addition, Piaget has suggested that cognitive development itself occurs through such an active involvement, an interaction of the child with objects and phenomena that leads to *cognitive conflicts* and subsequently to equilibration *or self*-regulation (Piaget, 1964). On the other hand, Ausubel has suggested that meaningful learning can be achieved only when there is pre-existing necessary relevant concepts in the mind of the learners and cognitive structures (*subsumers*) that will subsume the new knowledge; otherwise, rote learning will be invoked (Ausubel, 1968).

The empirical findings and theoretical positions on constructivism have led to a strong criticism of the prevailing formal methods of instruction, and the advocacy of student-centred (*concrete*) methods, in which the student has an active part in the construction of new knowledge. For instance, *discovery methods* and their variants (*guided discovery*) were used as a replacement of purely verbal methods, but their effectiveness has been controversial (Rowell, Simon, and Wiseman, 1962; Hermann 1969). Hermann evaluated researches about discovery learning and found almost equal numbers of studies claiming a superiority of discovery learning over expository teaching, respectively. On the other hand, the application of Piagetian theory to teaching and learning, as well as the foundation of the student alternative conceptions movement on the philosophical-epistemological theory of constructivism has led to the advocacy of so-called *constructivist methods* of teaching. Strictly speaking, guided-discovery methods fall also into constructivist methodology.

A question that is often asked by both science-education researchers and practitioners is whether the use of constructivist methods instead of the traditional didactic methods is actually more effective. Moreira (1978) compared two teacher-centred methods, one based on Ausubel's theory, the other a traditional one, with respect to the ability of pre-college students to apply and correlate concepts of electromagnetism. Although, no statistically significant difference was found, there were indications in favour of the Ausbelian approach. Also, Schneider and Renner (1980) studied for twelve weeks, the relative effectiveness an active (a *concrete*) method that made use of karplus' (1997) learning cycle and a traditional (*formal*) lecture-type method and found that the active method was superior with respect to achievement and concept retention.

Kletzy (1980) used an experimental method that was based on Piaget's theory for the teaching of the abstract concepts of the mole and atomic theory, and found that it was superior to a traditional expository method; in addition, it was found that formal students (in the Piagetian sense) were not affected by the instructional method. On the other hand, the use of a method based on Ausubel's theory with a small sample for preparatory college chemistry resulted in certain cognitive changes that were correlated with students' preference for meaningful learning.

Kempa and Diaz (1990a; 1990b) carried out a particularly useful analysis. They determined the motivational traits of their subjects according to the classification of Adar (1969), by using an adaptation of Adar's questionnaire. Accordingly, 390 students, aged 15, from five Spanish schools, were classified as *achievers*, *curious*, *conscientious*, or *social* and their preference for various instructional methods were examined. Well-pronounced distinct links for all but the achievers students were reported. Achievers were found to have no special preference, except that they require specific learning objectives. Curious learners prefer to be actively involved in learning activities that require them to discover, to seek information, and to make decisions. Consequently, they dislike formal methods. Conscientious students, on the other hand, are happier with expository methods with clear and precise instructions about what to do, while they do not like discovery methods unless they are provided with clear objectives and supported by adequate guidance; these students then are more teacher-dependent.

Finally, social students have a moderate preference for discovery learning and for practical work, because generally these learning situations provide them opportunities for personal/social interactions (with students working usually in groups). Of particular interest are the gender differences, with girls being more conscientious and social; on the contrary, boys are more achievers and curious and less co-operative and social.

Robinson and Niaz (1991) studied the effect of a ten-week intervention on the solution of stoichiometry problems by students in a preparatory college course in the US. They used a method in which students were allowed to interact, and compared it with the traditional lecture method. It was found that students in the interacting group were more successful in solving stoichiometry problems than the lecture group. In addition, students with lower information-processing capability in the interactive group performed better than students in the lecture group with higher such capability.

Odubunmi and Balogun (1995) compared a laboratory-based method with one based on lecture for the teaching of biology and geology concepts. The laboratory-based method was found superior with respect to student achievement, and especially for students with lower abilities. On the other hand, boys demonstrated a liking for the laboratory, while girls had a preference for the lectures. Positive results in affecting changes in conceptual structures with a laboratory-based method were reported by Westbrook and Rogers (1996), after a study in which grade-nine students worked under the instructor's guidance, using karplus's learning cycle and drawing their own concept maps for the concept of flotation.

On the teaching of biology was related the study of Ajewole (1991) that compared guided discovery with the expository method, and found more favourable attitudes in the case of the guided-discovery method, but no difference in the achievement of boys and girls. The latter finding contradicts that of Raghurbir (1979) that girls are more interested than boys in biology. Returning to chemistry, we have a two-year long study by Hand and Treagust (1991) of the effect of a constructivist versus a conventional, non-constructivist method, with tenth graders studying acids and bases. The students were of average and below-average achievement, and had no special desire to study science. Students of the constructivist method had superiority not only in the understanding of the concepts but also in their application for solving relevant problems.

Cohen (1992) carried out a six-week study of the effect of two methods for the teaching of the geology concepts of rocks and weather to twelve-year olds (grade seven). In one method instruction was provided through purely verbal means, while in the other method use was made of activities and manipulations of objects along with some verbal interactions. The second method was found superior especially with average and low-achieving students, but not in the case of high achievers.

Finally, Cavallo and Shafer (1994), working with tenth graders on the biological concept of meiosis, suggested that meaningful- learning orientation of students contributed to their attainment of meaningful understanding, independent of aptitude and achievement motivation. In addition, meaningful learning orientation interacted with previous knowledge to predict student attainment of meaningful understanding, while the instructional treatment had little relationship with student acquisition of meaningful understanding, except for learners' midway between meaningful and rote.

2.2.1. Classroom Examples of Constructivist Approach

Preliminary and Engage Phases of Learning

In constructivist learning and teaching, young children are actively engaged in constructing knowledge about a topic or theme chosen by the teacher or generated by a class discussion about what students would like to study. For example, if the children and/or the teacher select the earth science theme of rocks to study, the first task for the teacher is to find out what children already know about the topic to identify their existing ideas. There are many ways for a teacher to access children's prior knowledge about rocks. One example is to ask the children to bring their favourite rocks to school on the first day of the unit. (It may be a good idea to limit the size of the rock to the size of the fist.) Individually or in small groups, the children share stories about the rocks that they brought to school. This activity provides the teacher with a tremendous amount of information about what the children already know about rocks.

Focus and Explore Phases of Learning

Exploration and discovery are two important elements of constructivism. In a unit about rocks, during the focus or explore phase of learning and teaching, the teacher provides motivating experiences and discrepant events to engage learners; while at the same time, modeling certain attitudes such as wonder, curiosity, and respect toward nature. An example of a motivating experience for children studying rocks is reading the book, Everybody Needs a Rock (Biggs, 1995). This book describes rules about a perfect rock and encourages children to think about how the rules apply to their rocks. An example of a discrepant event during the study of rocks is to ask children if rocks, sink or float. After collecting data about their predictions, provide children with pieces of pumice and provide the materials for them to test their predictions. During this phase of learning, the children become familiar with rocks as they make discoveries about rocks, think about the ideas presented by the teacher, and listen to the views shared by the other children in the class.

Challenge, Explain, and Elaborate Phases of Learning

After engaging children in experiences to accomplish the objectives of the unit or lesson, the teacher provides experiences to confirm the scientist's view of properties of rocks. Children compare their discoveries about properties of rocks to the tests scientists do to classify and sort rocks. Books and Internet resources that identify and describe the properties of rocks can help provide additional information for children's questions. One example of an information book about rocks is Usborne Spotter's Guides to Rocks and Minerals, VonGlasserfield, 1989). Children compare their discoveries about rocks to the scientist's view of rocks and construct knowledge about their explorations and discoveries. They also test the validity of the views of other children in the class by seeking evidence about the ideas.

Application and Evaluation Phase of Learning

In constructivism, the final phase of learning happens when the newly constructed knowledge is applied to a new problem or situation. After constructing knowledge about the experiences with rocks during the focus and challenge phases of learning, the children apply content knowledge and science process skills to novel situations and evaluate the outcome of the solutions. One example of a new problem is asking the children to use sequencing to sort rocks. Using serration, children apply what they learned about the properties of rocks to arrange them from lightest to heaviest, smallest to largest, or lightest to darkest (colour). An additional assessment of knowledge and skills of identifying properties of rocks is to ask children to create the sequence and then ask another child to identify the attribute(s) used to serrate the rocks.

2.2.2 Teacher and Student Characteristics in Constructivist Contexts

The traditional concept of a teacher is the one who is standing in front of the classroom either teaching some basic rules or monitoring the class in finishing a task. Students, on the other hand, are the ones sitting at their desks, either listening attentively to the teacher or engaged fully in completing a task in silence. Constructivist classes, opposed to the traditional ones differ much in terms of teacher and student characteristics. Interaction in constructivist learning environment is not limited to the teacher and the students, but rather occurs among all the individuals' diverse cognitive abilities. Constructivist tasks are based on social interactions or active learning tasks. Thus, "noise" becomes unavoidable. Noise rises in active learning environments and noise becomes externalised into "chores of meaningful sharing and expressions of problem-solving" (Marlowe and Page, 1998).

Cohen, Manion and Morrison (2004) argued that when teachers are unaware of students' interests and life experiences, they not only fail to build on local knowledge but essentially avoid their participation in classroom discourse. Active learning empowers learners to meet the educational needs of teachers and students (Wilen, Ishler, Hutchison and Kindsvatter, 2000).

According to Marlowe and Page (1998), effective constructivist teachers provide opportunities for students to help them become successful orators, storytellers, historians, mathematicians, or scientists. Students need to be given the opportunity to do science. This process consists of "doing and reflecting, more doing and reflecting, and then more doing and reflecting" (Marlowe and Page, 1998). Then, it can be argued that pre-service teacher education students can become great teachers by giving them the opportunity to explore the real teaching environments in their classes.

In higher education, constructivist teachers are challenged to engage students in problem solving and decision making under ill-structured and complex circumstances so that they can explore about the real teaching environments. Instead of telling them what to know about specific content areas, teachers are suggested to engage them in their own active construction. They need to be encouraged to revisit content and problems from different perspectives, and given a variety of different perspectives (Mclnnis, James, Hartley, 2000, Freed, 2002). However, it is crucial to highlight that constructivism in practice involves phenomena distributed across multiple contexts of teaching. That is, it binds together teachers, students, administrators, parents and community members (Cohen, Manion and Morrison, 2004).

Providing learning environments in which students take the responsibility of their own learning, does not indicate that they have complete freedom of decision-making based on their learning. The teacher's role is mainly to guide, focus, suggest, facilitate, and evaluate the process to guarantee that the learning process is heading to a relevant and academically productive conclusion. It may be that direct instruction is needed. In such situations the teacher has to determine the limits to direct instruction, and give floor to students (Marlowe and Page, 1998). Consequently, becoming a constructivist teacher who helps learners to search rather than follow is rather challenging, yet, not impossible to attain. Such attainment can be based upon the following principles that are based on in-depth studies and interactions with students (Brooks and Brooks, 1993, Merill, 2007). Constructivist teachers:

1. Encourage student autonomy and initiative
2. Use authentic data with manipulative, interactive, and physical materials
3. Use cognitive terminology such as create, predict, analyse, in framing tasks
4. Allow students' goal setting, and choice of instructional strategies and content

5. Inquire students' understandings of concepts before sharing their own understandings
6. Encourage students in dialogue both with the teacher and peers
7. Ask students questions that utilise their critical thinking and encourage them to ask questions
8. Seek elaboration of students' initial responses
9. Engage students in experiences that might engender contradictions to their initial hypothesis
10. Allow wait time after voicing questions both for constructing relationships and metaphors.

The teacher is expected to be prepared to manage the interaction among groups of students. She or he needs to know the problems and its solution, and the common errors, preconceptions, and misconceptions that arise. The teacher helps learners notice attributes of the rich, realistic context that had not been attended to before and for the possibility of constructive solutions; and guides student interactions as they work cooperatively to solve complex problems that no learner student could manage alone.

In order to help student understanding when they as engaged with problem-based activities, teachers can use several strategies that can make components of complex tasks easier by having the teacher guide the problem-solving process. For instance, she or he can approach a problem by coaching, guiding or advising, through providing prompts, probes, or suggestions at varying degrees or explicitness. Overall, the teacher can mediate in providing the necessary guidance for the learners when they are stuck in the zone of proximate development (Egen and Kauchak, 1999; Cohen, Manion and Morrison 2004, Meltzer, 2002).

2.3. Nature of Physics concepts and students' achievement

Physics is a physical science that studies energy and matter together. The concepts of energy and matter adopt atomistic and wholistic explanation frameworks. The atomistic view described the mechanism of unknown processes on the ideal of a multiple of independently existing, occasionally interacting units. The units called atoms are usually very small to be seen and felt. They are sub-divided electronically into proton, neutron and electrons. The wholistic explanation of phenomenon holds the view that there is a continuum of which every part affects everything (Hestenes, 1987; Okoronka, 2004). The continuum may equally assume such a maroscopic level that cannot be comprehended at once or as one whole. These inherent characteristics of most concepts in physics have resulted in making it a difficult and abstract subject to learners. In addition, there is the highly mathematical/ quantitative aptitude required in explicating most principles in physics and in solving problems (Iroegbu, 1998; Akinbobola, 2004). The perception of students that physics is a difficult subject could be envisaged as one of the major reasons for the already documented low performance as well as poor enrolment recorded (Egbugara, 1986; Okpala and Onocha, 1998; Iroegbu, 1998; Akinbobola, 2004; Hmelo-Silver, Duncan, and Chinn, 2007).

According to Piaget (1965) what is needed for effective learning to take place in the classroom is for the learner to actively constructs or builds new ideas or concepts based upon current and past knowledge acquired. One of the methods for such is constructivist methods of learning that is, inquiry based and action learning strategies. O'Hara, Bourner and Webber (2004) and Chambers and Hale (2007) enumerated three reasons why constructivist learning strategies should be adopted in physics classroom they are the methodological, psychological and the educational reasons.

- Methodological reasons: it involves the process of trial and error which is in agreement sometimes with approaches in science.

- Psychological reasons: it helps physics to understand the physical world around them.

- Educational reasons: it provides a conceptual bridge between theory and observation and between particular and general.

Sopiah and Merza (2006) identified Physics students as a field that involves the study of physical phenomena, and that students are continuously required to identify the hidden concepts, define adequate quantities and explain underlying laws and theories using high level reasoning skills. In other words, students are involved in the process of constructing qualitative models that help them understand the relationships and differences among the concepts. They reported that a number of studies have found that students who lack reasoning skills do more poorly on measures of conceptual understanding than their more skilled peers. For example, the concrete operational students or empirical-inductive (EI) reasoners, whose thinking are largely limited to direct observation were found it difficult to understand the formal concepts of physics (Lawson, 1975). Gas Laws, for example, is a topic that was found to be difficult for both high school and college students to understand because it requires the understanding of the behaviours of particles at the microscopic level (Nurrenbern and Pickering, 1987; Nakhleh, 1993; Chiu, 2001) and involves the use of direct and inverse ratios which require proportional reasoning, the ability to identify and control variables, and probabilistic thinking. These reasoning skills are essential for understanding the concepts involved because gas laws can only be defined in terms of other concepts (temperature, pressure, and volume), abstract properties, and mathematical relationships. Thus, methods of instruction in physics must emphasize the development of scientific reasoning skills as these skills are required for conceptual understanding.

Das (1985) stated that the study of Physics involves the pursuit of truth; hence it inculcates intellectual honesty, diligence, perseverance and observation in the learners. Physics education therefore enables the learner to acquire problem-solving and decision-making skills that provides ways of thinking and inquiry which help them to respond to widespread and radical changes in industry, health, climatic changes, information technology and economic development. These changes demand knowledge of scientific principles in order to tackle them (Kleeves and Ai-kenhead, 1995; Mohanty, 2003). The teaching of Physics provides the learners with understanding, skills and scientific knowledge needed for scientific research, fostering technological and economic growth in the society where they live thus improving the standards of living.

Changeiywo (2001) found out that in Kenya, for a long time, Physics has been mystified as difficult and hence, some schools have not offered it in the last two years of secondary school education. His recent findings showed that students who hold negative stereotype images of scientists, science and technology in society are easily discouraged from pursuing scientific disciplines and usually performed poorly in science subjects. This situation does not favour Kenya's move towards developing a scientific and technological nation. The concern is that the performance in Physics is poor and the subject is less popular among students in Kenyan secondary schools as compared to other science subjects. The recurrent complain aired every time the National examinations are released is that performance in science is low. He went further, that since 2003 Kenyan government has been implementing a new curriculum in both primary and secondary schools, and has a new examination format (Kenya National Examination Council, 2005). This new format makes a deliberate attempt to lure students to take physics (Orende and Chesos, 2005). Although the government has done its part but, the role of the teacher in the classroom is equally important. The teaching approach that a teacher adopts is one factor that may affect students' achievement (Mills, 1991). Therefore, the use of appropriate teaching method is critical to the successful teaching and learning of Physics.

2.4. Action Learning and Achievement in Physics/Science

Action Learning (AL) involves working on real problems, focusing on learning and actually implementing solutions. It is a form of learning by doing. Pioneered by Professor Reg Revans and developed worldwide over the last 50 years, it provides a well-tried method of accelerating learning which enables people to handle difficult situations more effectively (Revans, 1998). Action learning has suddenly emerged as a key training and problem-solving tool for companies as diverse as Nokia, United Technologies, Motorola, Marriott, General Motors, the US Department of Agriculture, Deutsche Bank and British Airways. These and hundreds of companies around the world now employ action learning for strategic planning, for developing managers, for identifying competitive advantages, for reducing operating costs, for creating high-performing teams and for becoming learning organisations (Chartered institute of personnel and development CIPD, 2007).

What exactly is action learning? Simply described, action learning is a dynamic process that involves a small group of people solving real problems, while at the same time focusing on what they are learning and how their learning can benefit each group member, the group itself and the organization as a whole (Mumford,1996). Revans was very clear about the principles of action learning but he never defined what action learning meant preferring to suggest that it was more about teaching little and learning a lot. (Pedlar Brook and Burgoyne, 2003) Revans said further that L (learning acquired through engagement in action) comprise P (programmed knowledge which is the traditional stuff of lectures or formal instruction or accepted authorities) and Q(the ability to pose appropriate questions to fully explore the unknown so that it becomes known). Revans believed that far too much emphasis was placed on P and far too little on Q (Smith and O'Neil, 2003), and suggested the use of action learning sets to encourage more of Q. Perhaps action learning's most valuable capacity is its amazing, multiplying impact to equip individuals, especially leaders, to more effectively respond to change. Learning is what makes action learning strategic rather than tactical. Fresh thinking and new learning are needed if we are to avoid responding to today's problems with yesterday's solutions while tomorrow's challenges engulf us (Robinson, 2001)

Literatures on action learning suggest that it can provide a powerful vehicle for bringing people together to work in collaboration to solve problems. Lawson, Beaty, Bourner and O' Hara (1997) opine that the growth and development of action learning has been in line with changes in higher education towards a focus on capability as well as knowledge and a need to bring the worlds of employment and education closer together. However, action learning can be viewed as intimidating and a high risk strategy for academics whose traditional role is often assumed to be one of disseminating knowledge. Lawson et al, 1997 found that recent survey by Chartered Institute of Personnel and Development (CIPD, 2007) noted that action learning has been used in 47% of organisations including Royal Mail, Whitbread, Prudential, and the BBC. There is little published evidence to suggest that academic institutions have been as enthusiastic to embrace it.

The impact of action learning on elementary school students' achievement and attitudes towards science was measured by Kaptan and Korkmaz (2002). The action learning tasks were designed with regard to multiple intelligences. The findings indicated that the science achievement scores of the experimental group is better them that of the control group. The author also found significant differences with respect to students' attitudes toward science in favor of the experimental group. Consequently, Kaptan and Korkmaz shows evidence that action learning impacts positively on student achievement at elementary level in a Turkish context. Consequently, it is critical if action learning also impacts positively on the achievement and attitudes of higher education learners.

Lawson, et al (1997), stated that at Buckinghamshire Chilterns University College (BUC), a fast track master's level taught programme offered to students wishing to gain membership of the CIPD made use of action learning strategy. The programme is highly traditional in design and delivery and to ensure coverage of the broad national examination syllabus includes sessions which focus on the acquisition of knowledge at the expense of more experiential approaches to learning with time built in for reflection. To formalise and capture the essence o f such learning the course team decide to pilot the use of action learning sets to provide a process for capturing and sharing knowledge and creating a supportive learning culture. Mumford (1996) suggests that one of the purposes of action learning sets can be to provide an on-going process through which projects are design, implemented and written up to meet the requirement of a programme.

According to Gupta, Ashley and Rosenstein (2005) that both undergraduates and graduate students preferred the Action Learning mode (of teaching Marketing), to the more traditional lecture and discussion mode of instruction. However, the efficacy of Action Learning seemed more pronounced for graduate than for undergraduate students. The *hypothesis* generated from the data was that the undergraduates, while also preferring the Action Learning mode, missed the familiar structure of traditional pedagogy, more so than did the graduate students.

Action learning was intriguing for its potential to offer opportunity to promote shared learning, small self supporting groups, the reinforcement of a set of values and behaviour linked to attendance and retention, and a process for reflective learning while providing a social work environment for students (Kaptan and Korkmaz, 2002). Furthermore, research suggests that action learning can generate creativity and innovation as an outcome of a joint intellectual effort (Smith and Macgregor, 1992). It was also anticipated that action learning set would become self-sustaining throughout the life of the CIPD programme and such networks may also continue beyond the life-cycle of the programme itself.

Components of an Action Learning Programme

Developed by Professor Reg Revans in England in the middle of the 20th century, action learning was slow to be understood and applied until Jack Welch began using it at General Electric. Over the past 20 years, various approaches to action learning have appeared, but the model that has gained wide-spread acceptance is the Marquardt Model (Marquardt, 1999), which incorporates the successful elements of both European and American forms of action learning. This model contains six interactive and interdependent components that build upon and reinforce one another.

1. A problem, project, challenge, opportunity, issue or task

Action learning centres on a problem, project, challenge, issue or task, the resolution of which is of high importance to an individual, team and/or organization. The problem should be significant, urgent and be the responsibility of the team to solve. It should also provide an opportunity for the group to generate learning opportunities, to build knowledge and to develop individual, team and organizational skills. Groups may focus on a single problem of the organization or multiple problems introduced by individual group members.

2. An action learning group or team

The core entity in action learning is the action learning group (also called a set or team). Ideally, the group is composed of four-to-eight individuals who examine an organizational problem that has no easily identifiable solution. The group should have diversity of background and experience so as to acquire various perspectives and to encourage fresh viewpoints. Depending upon the action learning problem, groups may be volunteers or appointees, may be from various functions or departments, may include individuals from other organizations or professions, and may involve suppliers as well as customers.

3. A process that emphasizes insightful questioning and reflective listening

Action learning emphasizes questions and reflection above statements and opinions. By focusing on the right questions rather than the right answers, action learning focuses on what one does not know as well as on what one does know. Action learning tackles problems through a process of first asking questions to clarify the exact nature of the problem, reflecting and identifying possible solutions, and only then taking action. The focus is on questions since great solutions are contained within the seeds of great questions. Questions build group dialogue and cohesiveness, generate innovative and systems thinking, and enhance learning results.

4. Taking action on the problem

Action learning requires that the group be able to take action on the problem it is working on. Members of the action learning group must have the power to take action themselves or be assured that their recommendations will be implemented (barring any significant change in the environment or the group's obvious lack of essential information). If the group only makes recommendations, it loses its energy, creativity and commitment. There is no real meaningful or practical learning until action is taken and reflected upon because one is never sure an idea or plan will be effective until it has been implemented. Action enhances learning because it provides a basis and an anchor for the critical dimension of reflection. The action of action learning begins with taking steps to reframe the problem and determining the goal, and only then determining strategies and taking action.

5. A commitment to learning

Solving an organizational problem provides immediate, short-term benefits to the company. The greater, longer-term, multiplier benefit, however, is the learning gained by each group member as well as the group as a whole and how those learning are applied on a systems-wide basis throughout the organization. Thus, the learning that occurs in action learning has greater value strategically for the organization than the immediate tactical advantage of early problem correction. Accordingly, action learning places equal emphasis on the learning and development of individuals and the team as it does on the solving of problems; for the smarter the group becomes, the quicker and better will be the quality of its decision-making and action-taking.

6. An action learning coach/teacher

Coaching is necessary for the group to focus on the important (that is, the learning) as well as the urgent (resolving the problem). The action learning coach helps the team members reflect both on what they are learning and how they are solving problems. Through a series of questions, the coach enables group members to reflect on how they listen, how they may have reframed the problem, how they give each other feedback, how they are planning and working, and what assumptions may be shaping their beliefs and actions. The learning coach also helps the team focus on what they are achieving, what they are finding difficult, what processes they are employing and the implications of these processes. The coaching role may be rotated among members of the group or may be a person assigned to that role throughout the duration of the group's existence (Robinson, 2001).

Action learning power is at its peak when all six of these components are in operation. In addition to these six components, the Marquardt Model of action learning has two ground rules:

(1) Statements can only be made in response to questions, and

(2) The action learning coach has the power to intervene whenever he/she sees an opportunity for learning. Action learning, when systematically implemented, can effectively and efficiently solve problems with innovative and sustaining strategies, develop teams that continuously improve their capability to perform and apply valuable knowledge at the individual, group and community levels.

Action learning is an approach to learning and development which at the same time is capable of resolving significant business, organizational and social problems (Robinson, 2001). It is a form of learning through experience, "by doing", where the job environment is the classroom. It is based on the premise that we can only learn about work at work, just as we can only learn how to ride a bicycle by riding a bicycle. It permits risk taking within a psychologically safe environment; much like the safe practice area we choose when learning to ride a bike. Again, like riding a bike, it emphasizes personal responsibility for learning, although supportive but challenging learning partnerships are made available. Nothing else feels how action learning feels. No traditional training program can prepare a person for the first time they fire someone, or are blocked by a politically motivated colleague, or are confronted with an angry customer. In the end, we can only learn about it by doing it, and then reflecting carefully on what happened, making sense of the lessons, and working through how the learning can be built on and used next time around (Robinson, 2001).

It is well known that experience itself is a very slippery teacher; most of the time we have experiences from which we never learn. But even so, experience, albeit combined with a deep understanding or requisite theory, is the only valid teacher. Action learning is such an experience-based group learning process which provides this mix of practice-field experience using real issues, combined with a drawing-down of theory where appropriate. In this way it accelerates learning and personal development whilst providing on the job leverage of participants' competencies. Action learning has a framework designed to capture and build on what is, rather than operate in a pure, detached, analytical and rational world of what should be. It maps over existing structures and development plans, and supports the aspirations of non-traditional managers. By promoting reflection and insightful inquiry with perceptive partners in situations where solutions are not always obvious, and by leaving responsibility for implementation of the solution in the participant's hands, it is particularly suited to enhancing leadership capabilities. Since Action Learning is intended to add little if anything to the participant's in-tray this approach effectively resolves the dilemma which management faces when development opportunities are offered; where to find time to learn to drain swamps when up to here in alligators (Marquardt, 1999).

Action learning programs are built around the points highlighted below. A programme starts with syllabus determination, rather than a given syllabus. The syllabus can only be the key issues facing an organization and an individual within it. From there, people are encouraged to draw from the body of knowledge - books, journals, other people, company literature, other firms - appropriate, targeted and contextualised information. This approach is elective, in that it *elicits* relevant information, rather than *disseminates* what a trainer or designer thinks is good for the participants.

The Typical Action Learning Programme

Action learning usually involves:

- Tackling real problems in real time in a tight learning community
- Executives and/or managers sponsored to small stable groups called a "Set"
- each set is facilitated by a "Set Adviser"
- each set holds intermittent meetings over a fixed program cycle
- Set members who
- are challenged to resolve an individual or a group problem set by the sponsor(s)
- target the realities at their own field level
- must take action to resolve the problem
- are exposed to appropriate risk and "stretch"
- work in the set in a supportive social process
- proceed via questioning, conjecture and refutation
- can take advantage of training and other interventions as the need arises
- report final results to the sponsor(s)
- Whole person development
- Natural mentoring
- Defined and accidental learning (Marquardt, 2004)

By these means, action learning seeks to throw a net around slippery experiences, and capture them as learning, that is, as replicable behaviour in similar and indeed differing contexts. An action learning program of development forces reflection. The individual makes sense of an experience by conceptualizing it and generalizing the replicable points; and plans for future actions based on the learning gathered. The set provides the forge in which an individual's actions are shaped through their own personal reflection and the questioning insight of fellow set members.

A key point is that actions and outcomes still remain the responsibility of the individual participant. Action learning provides the safe environment or 'practice field' for learning to occur, whilst recognizing that real responsibility lies outside any classroom environment: it lies with the participants who must own the business outcomes. What is more, in using the organization itself as a learning laboratory, it does not require any special set of conditions to be in place before it can be effective. Action learning works well in a bureaucracy, in a flat organization, in a firm culturally hostile to education and development and in a firm encouraging self-actualization. It does so because its whole ethos is learning about the surrounding context, and learning to be effective within it, thus leveraging the prevailing culture to its own advantage (Robinson, 2001).

As a result, the development needs of the organization's managers, executives and high-potentials are satisfied through activities which are focused on the articulated significant current and future needs of the organization. This leads to the justifiable charge of action learning as a narrow (but deep) learning agenda, rather than a broad but superficial one. This is development addressed as a business service provision; geared to provide in a precisely targeted way what is required, when it is required, where it is required, in the form in which it is required.

The distinction between an emergent, elective syllabus and a trainer-directed one is a profound one, going deeper than a change of tone. In designing action learning interventions we admit that we do not hold all the answers. In this sense we become one with the business climate of today. Whilst the job of the skilled action learning architect will be to create the conditions for learning to take place which delivers the expectations of both individual learner and organizational client, in the end, learners themselves must adopt, own and ultimately live with the consequences of their program. Irrelevance does not exist within the well-designed action learning intervention, albeit that learner can (in some circumstances) create irrelevant outcomes for themselves, of their own choosing. Not all of those in an organization, or even in an organization's fast-track stream, will have the inclination or will to make it as leaders.

An effective leader in today's organization is able to work alone and as part of a team. We ignore these two facets at our peril. Executives schooled solely as team players may never learn to take personal responsibility, and can find them unable to act, only to advice. But likewise, the lone wolf executive schooled to think and act alone will find himself or herself increasingly alienated in organizations calling, rightly, for shared vision. Action learning recognizes that future managers and executives must develop self-direction and self-reliance. At the same time, action learning programs always work with groups which encourage participants to discuss, share, pool their ambitions and experiences, and therefore create something else, a gestalt, where the group yields a better result than individuals could.

Does this developmental methodology provide the key to an organization's requirements for customer value-laden management and executive development? We believe it does. Does this development methodology provide the key to the development requirements of high-potentials? Again we believe it does. Action learning fulfills the development expectations of these various communities whilst also fulfilling the organization's expectations. Some of the benefits associated with action learning programmes are shown below.

Benefits of Action Learning Programme

- Programme designed to suit the organization
- Brightest people challenged to solve critical problems
- Contributions are visible, practical, and active
- Emphasizes getting things done in the organization
- Leadership is naturally developed
- New hires and seasoned individuals develop together
- Mentoring and nurturing skills develop instinctively
- Network of current and future leaders is nurtured
- Diversity is addressed naturally
- Capability/career assessment is based on real results
- Development is rapid (Marquardt, 2004).

Probably no two organizations use action learning in the same way. Action learning is used worldwide, in large and small companies, and in a multitude of forms. Companies as varied as Volvo in Sweden, Prudential Insurance Company in the UK, and Hewlett-Packard in the USA have run extensive action learning programs which they all found appropriate to their businesses. The approach has not been confined solely to individual in-company initiatives. In the "Rolling Programme" run in the UK, groups of companies nominate senior executives to work on projects in each other's firms over a 6 month period. Companies experimenting in this way include Courage, Cable & Wireless, Foster Wheeler, & Southern Gas among others. In the public sector, action learning has been applied in government and in healthcare. There is now widespread use of action learning in universities and business schools. This use of action learning in educational environments is a fast growing application of the approach. A leading exponent in the US has been Noel Tichy who uses action learning as part of University of Michigan MBA student programs. The revised McGill University MBA program in Canada, managed by Henry Minzberg, is based on the principles of action learning (Smith and O'Neil, 2003).

In North America, as in the rest of the world, action learning development programs have been set up for many different reasons. Dow Chemical Co. in Midland is reported to have introduced action learning programs for executive development because their needs seemed to be so "soft" that it was difficult to address them any other way. AT&T in Morristown uses action learning in "gap group" programmes. AT&T's aim is to surmount the gaps in performance or output that a division faces whilst developing its employees. In AT&T's case, high-potentials bring in business problems which they work through with peers from other divisions and functions. Corning Inc. of New York actually offers courses in action learning to help its work teams apply the method. Corning also uses action learning for diversity training at its State College plant. In this example groups are gender and race balanced and deals with issues involving sexual and racial harassment. Cigna International Property & Casualty Corp. of Philadelphia includes clients in its action learning groups. Whirlpool Corp. in Benton Harbor utilizes an unusual extension of action learning; line managers include front-line workers in their action learning groups. In programmes run by Digital Equipment Corporation (DEC) in their Burlington operation both executives and supervisors participate. DEC's programs are in part expected to help participants frame and solve problems more effectively. GE Medical Systems in Milwaukee mixes 2/3 stakeholders and 1/3 high-potentials in its action learning groups. Companies such as GE, Whirlpool, Coca Cola and Northern Telecom have successfully used action learning to facilitate global executive development and leadership (Marquardt, 2004).

In the early 90s, Boston College studied a number of executive development programmes based on action learning. Two of the programs involved high-potential junior executives. Colleagues of the participants reported some significant changes. Among the research findings, participants increasingly questioned behaviour, especially at the strategic level, developed a renewed openness to new experiences, and demonstrated greater sensitivity to others. Greater intellectual curiosity also seemed to be stimulated. These competencies are all related to leadership capability. The study concluded that these competencies were unlikely to be learned through a passive educational experience. After the programmes, 87 percent of participants committed themselves to continue the learning process (Marquardt, 2004). It is believed that incorporating action learning into the classroom setting will probably bring about a success story and improve students' achievement.

2.5. Inquiry- Based Strategy and Achievement in Physics/Science

The development of thinking ability in individuals has always been recognised to be of great importance to enable them to take decisions wisely and to solve a problem efficiently. From the early ideas of Dewey (1910), Brunner (1960, 1968) to Entwistle (1993), it appears there is not yet a consensus on the best approaches or principles to be applied in motivating active, productive and analytic thinking in the learner. Brunner (1968) highlighted the importance of using inquiry-based strategy for teaching, he then emphasised that the strategy will stimulate intuitive thinking, not only in formal academic disciplines but also in everyday life.

Hmelo-silver, Duncan and Chinn (2007) cited several studies supporting the success of the constructivist problem-based and inquiry learning methods. For example, they described a project called GenScope, an inquiry-based science software application. Students using the GenScope software showed significant gains over the control groups, with the largest gains shown in students from basic courses.

Hmelo-Silver et al (2007) also cited a large study by Geier on the effectiveness of inquiry-based science for middle school students, as demonstrated by their performance on high-stakes standardized tests. The improvement was 14% for the first cohort of students and 13% for the second cohort. This study also found that inquiry-based teaching methods greatly reduced the achievement gap for African-American students.

NRC (2006) stated that inquiry nature of science is important because scientific inquiry encourages students to actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. They discovered that reaching all students is always a challenge to educators and the best way to get all students involved is through inquiry- based method. Kirschner, Sweller and Clark (2006) suggested that students are more likely to remember concepts if they discover them on their own. However, Sweller and Clark (2006) claimed that there is little empirical evidence to support this claim. Nguyen, Clark and Sweller (2006) described inquiry method as an effective method of teaching learners procedural acquisition. Inquiry-based learning refers to the activities of and how they develop understanding of scientific ideas and how scientists study the natural world (NRC, 1996). Using inquiry in the classroom, as an instructional strategy can help achieve understanding of scientific concepts by having practice and participate in the activities typical of a working scientist. When engaged in inquiry-based learning, they should

(a) be engaged in scientifically-oriented questions;

(b) give priority to evidence, allowing them to develop and evaluate explanations that address scientific questions;

(c) formulate explanations from evidence to address scientific questions;

(d) evaluate their explanations in light of alternative explanations, particularly those that reflect scientific understanding and evidence; and

(e) communicate and justify their proposed explanations. These five elements are essential characteristics of an inquiry-based learning environment (NRC, 2006).

Sopiah and Merza (2006) investigated the effects of inquiry-based computer simulation with heterogeneous-ability cooperative learning (HACL) and inquiry-based computer simulation with friendship cooperative learning (FCL) on (a) scientific reasoning (SR) and (b) conceptual understanding (CU) among form four students in Malaysian Smart Schools. The study further investigated the effects of the HACL and FCL methods on performance in scientific reasoning and conceptual understanding among students of two reasoning ability levels, namely empirical inductive (EI) and hypothetical-deductive (HD). A quasi-experimental method was employed using 3 x 2 factorial designs. The sample consisted of 301 form four students from 12 pure science classes in four Smart Schools which were all randomly selected and assigned to treatment (HACL & FCL) and control (TG) groups. The results showed that students in the HACL group significantly outperformed their counterparts in the FCL group who, in turn, significantly outperformed other students in the TG group in scientific thinking and conceptual understanding. The findings of this study suggested that the inquiry-based computer simulation with heterogeneous-ability cooperative learning method is effective in enhancing scientific reasoning and conceptual understanding for students of all reasoning abilities, and for maximum effectiveness, cooperative learning groups should be composed of students of heterogeneous abilities.

Sweller and Clark (2006) stated that despite the robust rationales for using an inquiry-based pedagogy in the university and at college-level science courses, it is conspicuously absent from many of today's classrooms. Inquiry-based learning is crucial for developing critical-thinking skills, scientific problem solving ability, and developing scientific content knowledge. Inquiry-based pedagogy provides with opportunities to participate and practice the activities involved in science. There are a number of dimensions that are integral to the creation of an inquiry-based learning environment that are applicable to the geological sciences. They considered the dimensions in the design of an inquiry-based undergraduate geology course and collected quantitative and qualitative data that documents the successful implementation of this redesigned course.

Their findings showed that when appropriately structured, inquiry-based learning can help develop critical scientific inquiry skills, suggesting that inquiry-based learning is essential for teaching geology at the university or college level. With the proper alignment of course objectives, content, pedagogical design, tasks, assessment strategies, and instructor and student roles, geosciences instructors at the university or college level can create inquiry-based learning environments in which students are able to successfully develop skills in scientific inquiry as well as geological content knowledge. Inquiry-based learning has received much attention since the National Research Council (NRC) released the National Science Education Standards (NSES) (NRC, 1996) for K-12 education.

There are a number of undergraduate geosciences educators that have utilized inquiry-based teaching methods in their courses (Keller, Allen-King and O'Brien, R., 2000) , but integrating inquiry-based learning activities can be challenging.

For undergraduate geosciences instructors, integrating inquiry-based approaches raises issues of

(1) Finding time to shift pedagogical styles,

(2) Choosing content to exclude to accommodate time-intensive inquiry approaches, and

(3) Developing the background and skill with using inquiry-based instructional strategies (Field, 2003).

Despite these challenges, in inquiry activities throughout their undergraduate careers is of utmost importance if are to graduate with the 21st-century outcomes that are expected, such as robust scientific-mental models, the capacity for solving ill-structured problems, sustained intellectual curiosity, and a commitment to lifelong learning (Hersh and Merrow, 2005). Engagement in inquiry at the undergraduate level promises to help prepare for further education experiences such as graduate school or later professional opportunities (Field, 2003).

White, Todd and John (1999) found out that middle school Physics students taught through inquiry-based strategy outperformed high school students taught with conventional methods. Also, as reported by Kahle, Meece and Scantlebury (2000) that middle school teachers used an inquiry-based strategy to African American students and discovered that the strategy was able to increase the achievement scores of the students and narrow the achievement gap between male and female students. Further more, Applebee, Judith, Martins and Adam (2003) carried out a research on over 1400 students and found out that inquiry approaches in middle and high school language arts classrooms allow low-and high –achieving students to make academic gains.

Scruggs, Mastropieri (1993) used inquiry-based strategy and text book approach and discovered that inquiry-based strategy yielded significantly higher achievement for high school students with special needs. This research work was carried out on twenty-six junior high school students with learning disabilities that studied two science units via inquiry-based oriented approach and textbook approach. The pre- and post-tests revealed that students that were taught with inquiry-based approach performed significantly better than those taught with text book approach. More so, students were asked about their impressions of the two instructional methods. 96% reported that they enjoyed the inquiry approach more, and over 80% considered the activities more facilitating of learning and more motivating. It therefore believed that when inquiry-based strategy is used to teach Physics and science related courses this perhaps improve the academic achievement of students in Physics.

2.6. Gender and Achievement in Physics/Science

Gender issue in Nigeria has become an issue of concern in the past few years. As schools and educational institutions are becoming more structured, sex differences in education and academic achievement assume new and more focus of researchers. However, some research and writings have addressed this issue in the attempt at establishing linkages between gender differences and learning achievement in classroom setting. Stephen and Sandra (2006) described gender as the social and historical constructions of masculine and feminine roles, behaviours, and attributes. Researchers such as (Erinosho, 1997; Adeyemi and Akpotu, 2004, Afuwape and Oludipe, 2008) have been able to establish that relationships exist between gender and achievement of science students. The effect of gender on achievement in Physics and Science in particular has been investigated by many researchers (Onadeko, 2009). Iroegbu (1998) concluded that gender effect is significant on achievement in Physic. He reported that male students performed significantly better that female student in achievement in Physics. To buttress his findings the West Africa Senior Secondary Schools Examination (WASSCE, 1999-2008) also indicated clearly the difference in achievement by gender (as also represented in Bar chart 2)

Table 3: Performance at West African Senior School Certificate Examination in Physics According To Gender between 2000-2008.

Entries				% Passed at credit and above						
Year	Total no of stds that sat for the exam	Boys	Girls	Total passed	Boys			Girls		
					Total	% of total Boys	% of total sat	Total	% of total Girls	% of total sat
2000	188,321	119,032 (63.21)	69,280 (36.79)	56,604 (30.05)	37,487	31.49	19.19	19,117	27.59	10.14
2001	287,993	181.326 (62.69)	106,667 (37.04)	99,264 (34.46)	64,356	35.49	22.35	34,908	32.73	12.12
2002	254,188	161,822 (61.65)	92,366 (38.35)	120,768 (47.51)	78,188	48.32	30.76	42,580	46.10	16.75
2003	275,369	166,007 (60.29)	109,362 (39.71)	130,982 (39.71)	78,262	47.14	28.42	52,720	48.21	19.15
2004	265,262	158,402 (59.72)	106,860 (40.28)	135,359 (51.02)	80,007	50.51	30.16	55,352	51.79	20.87
2005	344,411	206,931 (60.08)	137,480 (39.92)	142,943 (41.47)	98,051	47.38	28.47	57,738	42.00	16.76
2006	375,823	225,531 (60.00)	150,310 (39.99)	218,199 (58.03)	128,748	57.09	34.24	89,450	59.51	23.80
2007	418,593	248,021 (59.25)	170,572 (40.75)	180,797 (43.17)	104,145	41.99	24.88	76,652	44.94	18.31
2008	418,113	244,565 (58.92)	170,548 (41.08)	200,345 (48.23)	114,841	46.96	27,66	78,304	45.91	18.86

Source: WAEC (Test Development Division), 2009, WAEC Head Office, Yaba, Lagos.

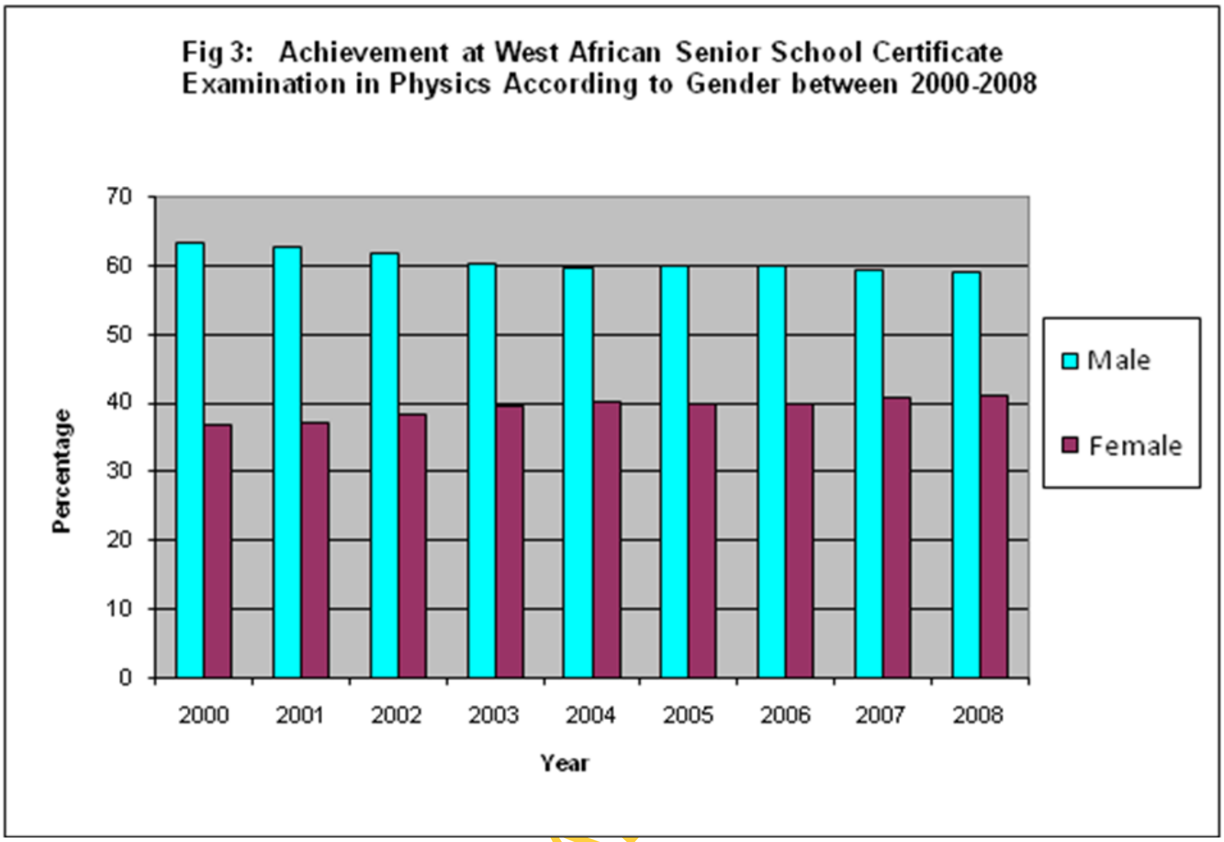


Fig 3: Achievement at West African Senior School Certificate Examination in Physics According to Gender between 2000-2008
70
60
50
40
30
20
10
0
Percentage
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Male
Female

For all the years considered, the percentage passes for girls is lower than that of the boys. In the year 1999, 27.88% of girls passed out of the 39.56% that sat for the exam while 32.08% of boys passed out of the 64.04% that sat for the exam. This shows a significant difference between the performance of the boys and girls with (X^2 = 402.7, $p<0.05$). Similarly, 31.49% of boys and 27.59% of girls in 2000 passed. Although, there is a steady improvement in the result of girls from year 2001-2008 but this is insignificant when compared with that of the boys and the total enrolment. However, the percentage of girls that sat for the examination in year 2004 (51.79%) while that of the boys is (50.51%) but it is quite unfortunate that the number of boys that passed in that year is more than that of the girls despite the difference in their enrolment.

Dean (2000) conducted a study to determine why females are underrepresented in physics and what can and should be done to address this imbalance. According to Dean, the reasons for this imbalance are not fully understood, although conjecture is abundant. High school and college teachers are generally aware of the gender imbalance in Physics course enrolment and the growth of this imbalance at higher levels of study. Their assessment of the causes of the imbalance reveals differences between male and female Physics teachers. Male teachers are more likely to cite society, culture, lack of role models, and differences in ability or aptitude while female teachers cite lack of interest among girls caused by male-oriented instruction and the abundance of applications of Physics devoted to male- oriented topics. He concluded that there are no compelling reasons for the continuing under representation of females in physics.

Most of the reasons cited in the literatures and in the field research are obstacles that have been overcome by women in every other field of academic work. However, Physics teachers can change their pedagogy to provide encouragement for greater female participation. He then recommended that in the grand scheme of achieving gender balance in physical science, teachers play a small role but they do play a role. It falls upon parents to encourage their daughters in the exploration of things, mechanical and electrical. And it falls upon counsellors to encourage girls to engage in physical science coursework. Also, it falls upon teachers in physical science to provide an environment in which female students can learn and achieve.

To this end, Physics teachers can begin or continue along a number of courses of action. Physics teachers must never ignore, belittle, or harass female students. They must instead demonstrate a belief that female students have an appropriate and legitimate place in the physics classroom and hold high expectations for their female students. They should use examples and applications familiar to both females and males instead of drawing mainly on sports and military applications familiar in greater part to males. They should encourage more collaborative than competitive work in class. They should place greater emphasis on written and verbal assessments rather than relying primarily on numerical and analytical assessments.

Ukwungu and Nworgu (1999) studied the effective and cognitive correlates of achievement in Pre- NCE Physics course. This study sought to determine the relationship among achievement pre – NCE Physics course, interest in Physics and final grade point average (GPA) and to explore the influence of gender these relationships. The subjects were 162 pre- NCE science and vocational students drawn from four colleges of education in the South East of the country. The study adopted a correlation design. Two instruments were developed and used for collection of data. The results showed that only the GPA was a significant predictor of achievement in the pre-NCE Physics course. This was however, moderated by gender. The predictor was higher for males than for females.

Yildirim and Eryilmaz (1999) investigated the combined and individual effects of certain variables (gender, cognitive development and social economic status) (SES) on physics achievement. A physics achievement test, logical thinking ability test and a socioeconomic status questionnaire were used to assess 35 high school second grade students' achievement, cognitive level and socioeconomic level. Multiple regression and correlation analysis were used for analysing data. The data analysed revealed that male students generally got higher scores in physics than female students. The cognitive level of students did not affect their score on achievement test.

Ukwungu (2002) applied metal-analytic techniques to 34 studies assessing the magnitude and direction of gender differences in performance in integrated science using d statistics. The results indicated that gender difference in performance in integrated science in Nigeria is small (d = 0.13) and in favour of males. The value d = 0.13 translating to r = 0.06 which implies that only 0.4% of the variance in performance of integrated science is accounted for by gender.

However, the Binomial Effect Size Display (BESD) shows that this proportion of variance accounted for by gender is equivalent to increasing success rate from 47% to 53%. A difference of 6% would provide an advantage over girls in a final or selection examination. Girls therefore require greater attention during integrated science classes.

Oludipe (2012) investigated the influence of gender on junior secondary school students' academic achievement in basic science using cooperative learning teaching strategy. The total number of one hundred and twenty students obtained from the intact classes of the three selected junior secondary schools in the three selected Local Government Areas of Ogun state south west Nigeria, participated in the study. The study employed a quasi-experimental design. Lesson note based on the jigsaw II cooperative learning strategy and achievement test for basic science students (ATBSS) were the instruments used to collect the relevant data. The data collected was analysed using descriptive and independent samples t-test statistical methods. The study revealed that there was no significant difference in academic achievement of male and female students at the pre and post test and delay postest levels respectively.

Hacker (1992) reviewed some selected studies concerned with gender differentials in learning achievement. He concluded partly that real gender differences do exist especially in science. Woodhouse and Ndongko (1993) and Haggerty (1995) found out that females are not less likely to choose to study science or to choose a scientific career than males; but with in science classes, males are more active participants than females. Keeves (1991) investigated the disparity among females and males in science classroom. He discovered that male performed significantly better than their female counterparts. Also, Afuwape and Oludipe (2008) and Gaigher (2004) worked on the significant gender difference in science courses, they ascertained that a significant difference exist and is in the favour of the boys. Basu and Charkroborty (1996) and Okpala and Onocha (1998) discovered that boys performed significantly better than girls in Physics. However, Iroegbu, (1998), Akinbote (1999), Raimi and Adeoye (2002) and Akinbobola (2004, 2008) ascertained that there is no significant difference in the performances of boys and girls in science classroom. This is in contrast with the findings of Adedipe (1986) that female science students performed significantly better than their male counterpart sciences.

Ibitoye (1998) compared the achievement of male and female secondary school candidates in Agriculture Science in Kwara State. The WASC Agricultural Science results of 1,224 students from ten schools in Kwara State for the years 1985 to 1989 were collected and analysed using t-test and ANOVA. The result showed that gender parity is most important in the achievement in Agricultural Science. A pair-wise comparison of four categories of candidates also showed that girls from co-educational schools achieved significantly better than other three categories of candidates- boys from singles sex schools, girls in single sex schools and boys from co-educational schools.

Al-Methen and Wilkinson (1988), Humrich (1988), Skaalvick (1990) and Young and Fraser (1994) stressed gender variation in science and mathematics cognitive activities. However, Nwagwu (1981), Imobekhai (1988) and Skaalvick (1990) concluded that gender differences are negligible, and that female achieved significantly and considerably higher than the males in languages, whereas there was no significant gender difference in mathematics. Moreover, they found that there was no difference between male and female students in general academic self-esteem.

Ukwungwu and Ezeike (2000) studied gender and Physics achievement disparity in Nigeria. The aim of this research synthesis was to obtain a composite figure of the gender difference in Physics achievement in Nigeria. The results showed a mean effect size of 0.32 in favour of males corresponding to a correlation co-efficient of 0.16. The square r showed that 2.6% of the variance in Physics achievement was accounted for by gender. This variance is equivalent to increasing the success rate of males from 42% to 58% on the Binomial Effect Size Display (BESD).

In the report of Balogun (1985), Benedict (1990), Skaalvick (1990) and Walding, Faghani, Over and Bain (1994), there is a close association of the influences of factors that co vary with sex types, teaching methods, school types and performance. Furthermore, they concluded the analyses of their findings that gender differences in science achievement are influenced by socio-cultural factors. On the other hand, the review of the studies of Soyemi (1985), Diejomoh (1986) and Ande (1990) did not reveal significant interaction between method of instruction and gender. It must be noted, somehow, that research into gender differences and achievement has rarely examined the interaction between the school environment and processes of student performance. When school effects are ignored, the student variances become confounded by school differences, resulting in probably biased statistically significant tasks. Invariably, differences abound in the specific findings of the studies reviewed above. For example, although Balogun (1985) and Young and Fraser (1994) indicated that males achieved considerably and significantly better than females, irrespective of the methods adopted, Oduro–Mensah (1987) has shown contrarily, that while males learn better in process skills, there was no significant gender difference in the cognitive achievement.

Ugwanyi (1998) investigated the effects of guided discovery and expository teaching methods on students' achievements in Physics in selected secondary schools in Nsukka, Enugu State, Nigeria. The results, which were subjected to a 2x2 factorial design, showed that female students performed better than their male counterparts.

Kelly (1994) observed that there are considerable problems when attempting to relate specific intellectual abilities to achievements in specific subject areas, and that gender differences and intellectual abilities can be a result of gender role stereotype. Gender difference in examination cannot therefore, be assumed to be due to inherent biological differences between the genders even if they exist. Lovell and White (1995) noted that the theory of innate gender difference in examination performance has weak evidence and that in many psychological areas, it is virtually impossible to separate completely the innate from the acquired. Bolderg and Lewis (1996) in their studies of early sex differences of American pupils and students discovered that on the average, the American boys performed better than girls in all sciences and mathematics related subjects, but than the girls read more.

Studying sex differences in instruction, Leiuhardt, Seewald, and Engelra (1997) also found that boys do better in mathematics tests while their girls counterpart performed better in reading tests. Angrist (1999) reporting on gender roles also noted that girls performed better in verbal tests and obtain higher grades than boys while boys excel in mathematics and in all science related subjects. Angrist observed that girls are herolines and fearful while the boys show greater courage, achievements needs and higher aspirations. In western societies, women are higher in verbal ability than men, but are lower in mathematics and spatial ability. Men are superior to women in problem solving tasks and on specific abilities related to problem solving (Guetzkey, 1998). Okeke (1999) in his studies concerning the understanding of some important biology concepts noted that there is no significant difference in the performance of boys and girls in understanding these biological concepts. On analyzing his data, Okeke suggested that ability or inability to comprehend these concepts was not dependent on the use or application of formal reasoning, but that the difference might be attributed to cultural influence.

Turner (1997) contended that girls are more likely to achieve better grades than boys in early years (primary) of schoolings and score higher in science tests but these trends are reversed in the secondary schools. Girls also achieve a similar standard in all subjects, whereas boys being more autonomous and selective do well in subjects they like and poorly in those they do not like. Turner concluded that boys are more realistic when they judge their own performance whereas girls are more afraid of failure and often retreat for intellectual challenges.

Onyehalu (1996) in his study of performance in technical subject used two hundred and forty-seven (247) students, 118males and 129 females randomly sampled from selected co-educational secondary schools in Enugu. The t-test analysis of the results showed that the mean performance of the boys and girls was not significant at 0.05 level of significant.

Milton (1995) found out that women are higher in verbal ability than men. The female perform lower in mathematically based subjects like the technical subjects. Milton's findings showed that men are superior to women on problem solving. According to Milton, women who performed most poorly on problems solving tasks have the ability to score the highest on a test of feminity. .

Fennema and Sherman (1996) argued that stereotyping of certain subjects as male subjects make the male students show a higher cognitive achievement in those subjects than their female counterparts. Amogu (1993) worked on sex and attitudes as factors in mathematics performance in Kastina Local Government Area of Kastina State. In his study, 4 out of 15 secondary schools were randomly selected to constitute the population of the study. A sample of 240 students (120 boys and 120 girls) was used. A Teacher Made Mathematics Test (TMMT) was used as one of the instruments. The Analysis of Variance (ANOVA) was used as statistical tool or data analysis. The result of the study indicated that there was no significant difference between the mean performance of male and female students on the Teacher Made Mathematics Test (TMMT). The conclusion as the sex of the students in junior secondary school seems not to affect students' performance in mathematics.

Eryılmaz (1992) in a study of 435 university students, points out that male students do better in physics than females. The results of the study in which the data obtained from Second International Science Study (SISS) were used to indicate parallel results: Male students get higher scores than female students in physics (Chandavarkar, Doran and Jacobson, 1991). The data used in the study were obtained from a sample of 2719 12*ıh* grade students studying physics for the first time and 485 advanced physics students.

Ehindero (1985) also points out the same result in another study. 35 male and 35 female high school students participated in the study. Result of the study is the same as the results of previously mentioned studies. Young and Fraser (1993) by using the results of Australian SISS, point out the same result. There is a gender difference in science achievement in favor of males. In the study, 4917 14-year-old Australian students' data were analyzed.

Bilesanmi-Awoderu (2002) carried out a study on the concept-mapping, students' locus of control, and gender ass determinants of Nigerian high school students' achievement in Biology using Analysis of Covariance to analyse the data collected. She found out that there are was no significant main effect of gender on students' achievement in biology

Young and Fraser (1993) indicate the same result that there is statistically significant sex difference favoring boys in physics achievement. They used the data obtained in the Australian SISS. In that study, 13057 (6574 males, 6432 females and 51 unknown) students participated. Viann (2002) by analyzing the data obtained from 51,014 14-year-old students from 12 countries who participated in SISS, indicates the difference between males and females. In that study, it is cited that males consistently and significantly outperform females in science achievement. Young (1992) points out the same result: boys are outperforming girls in both science and mathematics achievement. In this study, data were obtained from 3397 students.

Ogunleye (1996) in a study to ascertain the levels of acquisition of process skills among SS1 physics students observed that male and female students gain equally on acquisition of science process skills. Onwioduokit (1996) after investigating the effect of gender difference among undergraduate students' enrolment and academic performance in science concluded that women's performance in science is not significantly different from that of men.

Viann (2004) investigated the effects of cooperative learning mathematics classroom setting. The researcher used quasi-experimental design to compare a control section using individualized learning method with three treatment sections using cooperative learning strategy based on the learning together model of Johnson, Johnson (1991). The results revealed no significant gender-related differences, but females achieved slightly higher grades than males.

One would have thought that the observed differences in performance between male and female students in the sciences and related subjects. Many have been due to the methods used on teaching subjects, Samuel and John (2004) examined how the cooperative class experiment (CCE) teaching methods affect students' achievement in chemistry. They found that there was no significant difference in gender achievement between the experimental and control groups, but girls had a slightly higher mean score than boys did. More so, the girls taught through CCE method performed better than girls taught through the conventional teaching method in the post-test scores. Similarly, boys who were taught using CCE method performed significantly better than the boys in the control groups in the post-test scores. The researchers also pointed out that there was no significant difference in achievement between boys and girls exposed to CCE method, both performed significantly better than those taught through conventional lecture method. But Babikan (1994) contended that irrespective of the methods used in teaching science concepts, boys usually achieved significantly better than girls. Science writers seem to agree that both males and females could do well in science if exposed to similar learning conditions (Erinosho, 1994, Nwasofor, 2001). However, in an earlier study carried out by Akpan (1987). It was noted that girl's scores in almost all the factors investigated, indicated that conditions for pursuing studies in science favour the boys and girls would perform equally well if exposed to the same condition.

In another study by Putman, Hosie and Hansen (1978), Hales and Hartman (1978) and Trembath and White (1979), there was the consensus that gender differences occur in personality and work value, early in life and tend to increase with age throughout the primary and secondary school years. However, the similarities in learning outcomes appear to be greater than the differences, particularly during the primary school years. They concluded that female possessed significantly higher vocational attitude maturity scores, suggesting that females tended to be more involved with education and vocational planning and the decision- making process.

Generally, the heritable attribute factor as can be deduced from this review, is a strong variable, to some extent, physical scientific academic achievements, as well as ability which distinguished gender differences on spatial and field independence learning tasks. The issue of gender disparity in the enrolment and achievement in the senior secondary school Physics points to the need for more research work on gender and academic achievement in Physics, thus the inclusion of gender as an intervening variable in this study.

2.7. Numerical Ability and Achievement in Physics/Science

Numerical ability is a component of the general mental ability or aptitude. It comprises the verbal and quantitative aptitudes. Numerical ability is the ability to calculate, divide, measure and determine proportion, sum or amount of something (Iroegbu, 1998). It is synonyms include mathematical ability, mathematical knowledge and mathematical skills (Akinbobola, 2006). Iroegbu (1998) in his work ascertained that a significant main effect of numerical ability exists on the achievement of secondary school students in physics, line graphing and problem solving skills. In addition, students with high levels of maths anxiety and visual preference or proportional reasoning ability have been found handicapped in problem solving (Thomas, 1990). Bassock (1990) found that students who do not display good mastery of mathematical skills usually have significant difficulty in physics problems. He then advocated for instructional strategy that will enable students to transfer the mathematical procedures and skills learned from mathematics to physics.

For evidences, it could be reasons that successful mathematics learners engaged in meta cognitive behaviours that is, checking their own understanding procedures, monitoring for consistency and trying to relate new material to prior knowledge during mathematics learning. These behaviours are also the very ones necessary for successful problem solving in physics. The problem with mathematics as observed by mathematics cognition researchers is that mathematics learning like language learning involves the imposition of meaning by making senses of formal symbols and rules that are often taught as if they were arbitrarily convention rather than expressions of fundamental regularities among quantities and physical entities (Resnick, 1986). Furthermore, mathematic skill are part of the general reasoning and higher order thinking requirements of problem solving skill for high level performances in mathematics, are important to those required in science and reading. These will ask questions about material presented, reinterpreting the problem, recasting it or construct a mental model of complex systems and they use these to reason about observed phenomenon to solve the problem. This is against the case of writing disjointed equations and using routine procedures for manipulating them.

Osokoya (1998) identified mathematical skills as necessity for passing introductory chemistry when she investigated some of the determinants of secondary school students' academic achievement in chemistry. Gardner (1995) stated that logical and mathematical intelligence involved formal operation of symbols according to accepted rules of logic and mathematics in line with Piaget's theory of intellectual development. It is said to form a major components of intelligence quotient (IQ) tests. Since intelligence must be susceptible to encoding in symbol system then, the three most accepted symbol systems globally are language, picturing and mathematics.

Poor female representation in science oriented courses is one of the most frequently addressed problems (Byrne, 1978). Although there are different formulations of the problem, the general issue is that females less often study mathematics, physical sciences, engineering, computer studies, and allied fields at every level of education from elementary school to graduate school (Robertson, 1988; Statistics Canada, 1989). Consequently, women are under-represented in occupations requiring knowledge or qualifications in these fields. For example, in 1986, women were 29% of the employed science and technology labour force in Canada, compared to their overall labour force participation of 43%. Moreover, many of these women are social scientists: only 7% of the workers in architecture, engineering, and related fields were women (Statistics Canada, 1989). Such patterns must be approached with some caution, because they have been changing over the years in the direction of greater equity. Some sex differences in performance on mathematics tests, which once prompted complex bio-psychological theories of innate cognitive differences between males and females, have all but disappeared over time (Chipman and Thomas, 1987; Linn and Hyde, 1989; Sadker, Sadker and Klein, 1991). The extent to which sex differences in performance or representation occur varies from country to country (Brandon, Newton, and Hammond, 1987; Tamir, 1988; Hanna, 1989). Within countries, social class and ethnic differences complicate the picture (Linn, 1985; Chipman and Thomas, 1987; Oakes, 1990). For example, in the United States, Black and Hispanic high school and college students are relatively unlikely to specialize in mathematics and science (Oakes, 1990).

In contrast, Asian-American men and women are disproportionately found in university science and technology courses. Asian-American women "over select" computer science (Chipman and Thomas, 1987). Although we lack comparable figures for Canadians of diverse ethnicity, it appears that patterns of participation in mathematics, science, and technology are complex, and that the role of schooling in deepening or mitigating disadvantage needs much closer examination. There is certainly evidence that educational inequality on grounds of gender, ethnicity and region. This underscores the important role of mathematics in the learning of science subjects which though so much touted in the air has not been adequately researched into, most especially, at the secondary school level of physics education. This study therefore, will consider the possible effect of numerical ability on the achievement and attitude of senior secondary school physics students in the learning of some abstract physics wave concepts.

2.8. Attitude of Students towards Physics/Science

One of the key aims of teaching science at the secondary school is to promote enthusiasm and enhancement of interest in science and scientific activities. This is at variance with what is observed in most cases where people may leave school with the feeling that science is difficult and in accessible (Simon, 2000; Okoronka, 2004). Researchers into attitude towards science have shown lack of clarity and agreements about what attitude are. This is due to the fact that attitude does not consist of a single construct, definition or meaning. Rather it has different sub-constructs, all of which contributes to an individual's attitude to science in varying degrees. Thus, attitude has been defined by different authors in different ways depending on their background, interest and concern. Yara (2009) defined attitude towards science as interest or feeling towards studying science or the scientific approach assumed by an individual for solving problems, assessing ideas and making decisions.

Ani (1993) defined attitude as a learned disposition or tendency on the part of the individual to respond. Smith (1998) defines attitude from the psychological point of view as a relatively enduring predisposition to respond in a relatively consistent manner towards a person, object, situation or idea. Ramsden (1998) offers a definition of attitude which include cognitive, emotional and action tendency to particular behavioural intents. Thus, he believed that attitude is best viewed as a set of affective reactions towards the attitude object, derived from concepts of beliefs which the individual has concerning the object and predisposing him/her to behave in a certain manner towards the object.

Meyer (1999) and defined attitude from social-psychological perspective as a favourable or unfavourable evaluation reaction towards something or someone, exhibited in one's belief, feelings, or intended behaviour. Also, Adesina and Akinbobola (2005) described as a state of readiness, a tendency on the part of individual to act in a certain way. These two definitions would be more suitable in focusing the meaning of attitude as it pertains to this study. These definitions imply that attitude could be positive or negative and may involve subjectivity on the part of the person expressing it and in its measurement. Simon (2000) listed the following components as relevant in the measure of attitude towards science:

- The perception of the science teacher
- Anxiety towards science
- The value of science
- Motivation towards science
- Enjoyment towards science
- Attitude of peers and friends
- Attitude of parents towards science
- The nature of classroom environment and
- Fear of failure on a course

The purpose of research into attitude is to identify how young people's experiences or perception of science appear to alienate them from science as well as how their attitudes affect their choice of science and science related careers. In addition, there is said to be a relationship between attitude and achievement which such researches are equally interested in probing further.

Three most important factors revealed in literature affecting/influencing students' attitudes toward science and its choice are teaching method, perceived difficulty and gender. There is however, agreement from these studies on how each of these factors influence attitude but not on how attitude in turn affects achievement. Ebenezer and Zoller (1993) reported that the most important variable affecting students' attitude towards school science was the kind of science instruction they experienced. This is supported by the findings of Alao (1990), Sunberg and Dini (1994); Ogunleye (1999) and Akinbobola (2008). On perceived difficulty of science, studies by Crawley and Black (1992) and Havard (1996) have all identified students' perception as being a determinant of subject choice. These suggest that science is only chosen by students who do well it reinforcing the notion that it is for the intelligent students. This has implications for students' self image and career choice.

The relationship between attitude and achievement has been investigated by several researchers in the past. Gardner's (1995) reviewed of such research evidence offered little support for any strong relationship between the two variables. Ajewole (1991) opined that the relationship between attitudes and achievements is certainly the consequence of reciprocal influence, that attitude affects achievement and achievement in turn affects attitude. Schunk and Hanson (1985) suggested that the attitude of pupils is likely to play a significant part in any satisfactory explanation of variable level of achievement shown by students in their school science subject. Ogunleye (1993) in his finding reports that many students developed negative attitudes to science learning, probably due to the fact that teachers are unable to satisfy their aspiration or goal. Alao (1990) showed that there is positive correlation between attitudes and achievement in the science subjects.

Schibeci (1984) drew a strong link between the two while Shrigley and Kobella (1987) argue that attitude and achievement scores correlate moderately. Weighburg's (1995) meta-analysis of research on this theme suggests only a moderate correlation between attitude towards science and achievement. This supported by Talton and Simpson (1990). Simpson and Oliver's (1990) findings were contrary to these views. Their longitudinal study shows a strong relationship between attitude towards science, motivation to achieve and the self concepts of an individual, of his own ability and their achievement in science. The attempt here to measure motivation to achieve is said to be a more significant factor than attitude towards science in determining achievement. In the present study where action learning and teacher-directed inquiry based instructional strategies will be adopted to teach some abstract physics concepts, it is expected that this will combine with ability of the learner as well as gender to determine attitude towards physics. This in turn is expected to affect achievement of the students as well as their attitude.

2.9. Appraisal of Literature Reviewed

The literature reviewed suggested that two major types of factors play the most prominent roles in determining students' attitude towards Physics as well as their level of academic achievement on the subject. These are teacher-related factors and student-related factors (Ogunleye, 1999; Okoronka, 2004; Onadeko, 2009). The teacher- related factor of instructional strategy adopted in teaching the learner is said to be the singular most factor important variable in deciding the attitude, as well as achievement of a learner in a subject (Bloom, Benjamin and Krathwohl, 1956; Iroegbu, 1998). Literature reviewed that when an excellent teaching strategy has been adopted learners automatically develop positive attitude or perform optimally (Anderson and Krathwohl, 2001). The learner related factors that ranked top most in affecting attitude in Physics education literature are, perceived difficulty of Physics which stems for quantitative demands of its concepts or the abstract oriented nature of concepts, gender, attitude of learners (NERDC,1994; Okoronka 2004, WAEC, 2007). The evidence from the literatures suggests that when knowledge is presented to the learner in a manner that they would be engaged in, the knowledge construct will tend to approximate expert knowledge and learning becomes more meaningful to them. Literature also showed dearth of research studies on instructional uses of action learning and inquiry- based strategies in Physics and in Nigeria. But cases where the strategy was applied, evidence of improved performance and attitude over conventional method are recorded.

Numerical ability has shown from literatures to be the most prominent factor that determines the level of achievement in physics (Bassock, 1990; Onadeko, 2009). This implicit numerical nature of Physics as well as the abstract nature of its concepts constitutes part of the reasons why students regard Physics as difficult (NERDC, 1994; WAEC, 2007).

Literatures that have been reviewed on gender effect showed clearly inconclusive and they did not reveal significant gender differences in the cognitive achievement and modes of instruction in Physics. Therefore, it does appear that a problem with necessary critical mass exists which can be tackled by investigating the effects of action learning and inquiry - based instructional strategies on learning outcomes of secondary school students in Physics.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter contains the research design, sampling techniques and sample, selection of concepts, instrumentation, general research procedure, data collection and method of data analysis.

3.1 Research Design

This study adopted a pretest-posttest control-group quasi experimental research design with a 3x3x2 factorial matrix. The instructional strategy was manipulated at three levels (Action learning, Inquiry-based, and conventional (control) strategies) moderator variables, numerical ability and gender, were divided into at three levels (low, medium and high), and gender at two levels (male and female) respectively.

The design is represented symbolically as follows:

$\mathbf{O_1} \quad \mathbf{X_1} \quad \mathbf{O_2}\ (\mathbf{E_1})$

$\mathbf{O_1} \quad \mathbf{X_2} \quad \mathbf{O_2}\ (\mathbf{E_2})$

$\mathbf{O_1} \quad \mathbf{X_3} \quad \mathbf{O_2}\ (\mathbf{C})$

Where 01, represents the pre-test given to the treatments 1, 2 and 3 (control group) respectively while 02 represents the post-test given to the treatment and control groups and

$\mathbf{X_1}$ represents treatment for experimental group1

$\mathbf{X_2}$ represents treatment for experimental group2

$\mathbf{X_3}$ represents treatment for control group

$\mathbf{E_1}$ (Action learning instructional strategy)

$\mathbf{E_2}$ (Inquiry-based instructional strategy)

C (Control group)

The factorial arrangement was chosen to ensure matching of the variable involved and it allowed for separate determination of the main and interaction effects of numerical ability and gender on attitude and achievement (Iroegbu, 1998). Factorial arrangement, according to Ownioduokit and Ikwa (2000), is an arrangement that is made up of many factors at different levels and is the layout in an investigation to establish the combined effects of two or more independent variables. An important characteristic of factorial design is that several hypotheses can be tested simultaneously. The design layout is as shown in Table 4:

Table 4: 3x3x2 Factorial Matrix Research design layout.

Treatment		**Numerical Ability**		
	Gender	**Low (L)**	**Medium (M)**	**High (H)**
Action learning Strategy X_1	Male			
	Female			
Inquiry- based Strategy X_2	Male			
	Female			
Conventional X_3	Male			
	Female			

3.2 Variables in the Study

Independent variable: The independent variable which is instructional strategy was manipulated at three levels namely:

(i) Action learning strategy

(ii) Inquiry- based strategy and

(iii) Conventional strategy as control

Moderator variables: The moderator variables are of two types:

(i) Numerical Ability at three levels (low, medium, high)

(ii) Gender at two levels (male and female)

Dependent variables: are the learning outcomes which consist of

(i) Achievement in Physics

(ii) Attitude towards Physics

Table 5: Display of variables in the study

Independent variable	Moderator variables	Dependent variables
Instructional Strategy 1. Action learning strategy 2. Inquiry-based strategy 3. Conventional strategy	**A. Numerical Ability** 1. Low 2. Medium 3. High **B. Gender** 1. Male 2. Female	1. Achievement in Physics 2. Attitude towards Physics

3.3 Selection of Participants

Participants for this study comprised all the senior secondary two (SS2) Physics students in two Local Government Areas of Kwara State. The SS2 students are considered for the study because of the following reasons:

1. They have acquired some vital basic concepts and skills in Physics (unlike the SS1 students)**.**

2. SS2 students are likely to be more receptive than SS3 students who will be under pressure of preparation for external examinations..

3. Students have enough time to carry out practical work.
4. Public and co-educational secondary schools that have at least one class of SS2 physics
5. The content to be used is in SS2 syllabus

3.4. Selection of schools and subjects

Nine secondary schools were purposively selected for the study in two Local Government Areas of Kwara State (four schools in Ifelodun Local Government Area with fewer number of well equipped laboratories and five schools in Ilorin east Local Government Areas which has more well equipped number of laboratories). The participating Local Government Areas were stratified according to distance. The researcher chose the area for the study because she is quite familiar with the educational problems in the area. A purposive sampling technique was used to select schools from the target schools. The following criteria were used for the selection of schools.

(1) Schools that have at least one graduate Physics teacher with not less than three years of teaching experience and teaching Senior Secondary II classes.

(2) Schools that have well equipped and functional Physics laboratory.

(3) Schools that are currently presenting candidates for Senior Secondary School Certificate Examination (SSCE).

(4) Public and co-educational secondary schools that have at least one class of SS II Physics students.

Six schools that met the criteria were selected for the main study out of the nine purposively selected schools by distance stratification i.e three schools from Ifelodun Local Government Area and three schools from Ilorin east Local Government Area. Two schools each from the selected Local Government Area (Ifelodun and Ilorin east) were assigned by balloting to each treatment condition. Two intact classes were randomly selected from each school making a total number of twelve intact classes and where researcher met a single arm of SS II class, the class was divided into two arms with the permission of the head of department of science in such a school and kept in empty classrooms. The remaining three schools from the two Local Government Areas were used for the preliminary study. The researcher made sure that the schools selected for the preliminary study and main studies were far apart from each other to avoid contamination. In all 194 SS2 Physics students participated in the study.

3.5. Selection of Concepts

The selection of wave concepts was based on the observation that most empirical studies on difficult concepts in Physics had dealt with some aspects of motion and conservation principles (Clement, 1993; Iroegbu, 1998; Onwuegbu, 1998; Orji, 1998). Also, according to Okoronka, (2004), some Physics concepts required hands on strategy to create and support meaningful learning and to aid understanding. The researcher selected the concepts of wave in line with the documentation of the Nigeria Educational Research and Development Council (NERDC, 1994; 2008) which described waves as one of the abstract and difficult concepts. To support the findings, the present researcher sampled the opinions of sixty SSII students from five schools to write and submit a list of four topics each found to be most difficult in the SSII syllabus.

Table 6: Students' Rating of Physics Concepts Difficulty.

N= 60

	Motion	**Nuclear Physics**	**Waves**	**Conservation Principle**
Frequency of Occurrence	9	10	29	12
Percentages	15	16.7	48.3	20

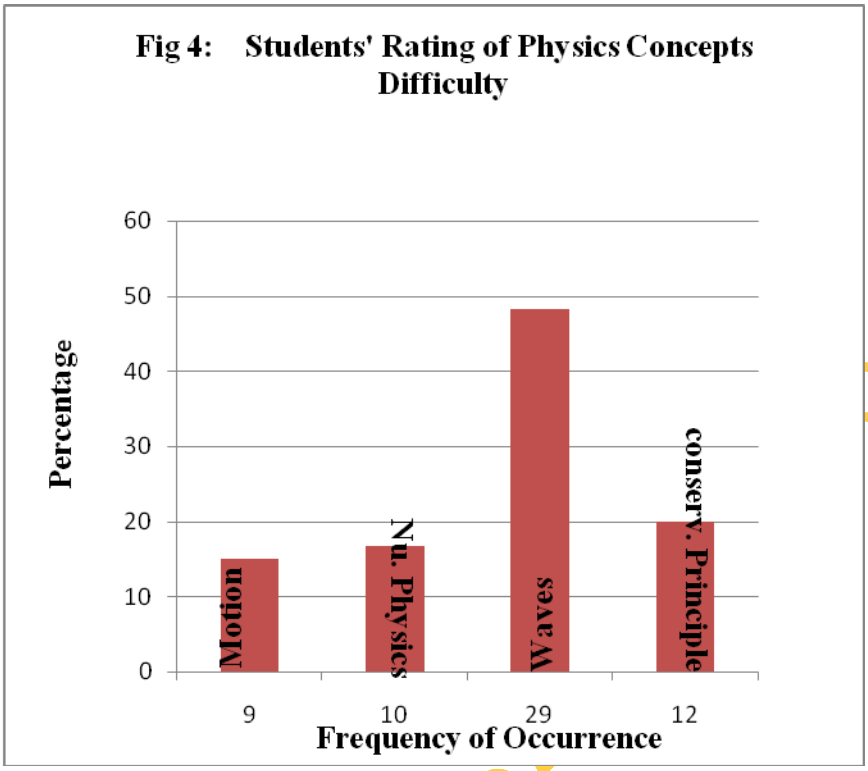


Fig 4: Students' Rating of Physics Concepts Difficulty
Percentage
60
50
40
30
20
10
0
Motion
Nu. Physics
Waves
conserv. Principle
9
10
29
12
Frequency of Occurrence

Table 6 shows that waves has the highest frequency (29) and highest percentage (48.3%) as the most difficult topics listed by the students. This is in support of the findings of (Ownioduokit, 2000) which pointed out that waves is a concept involving a function of two variables-distance and time whereas most other concepts or situations encountered by students at the secondary level require the concept of a function of a single variable.

Topics under wave concepts are:

1. Wave in motion as energy, types and classifications of waves, mechanical and electromagnetic, transverse and longitudinal, progressive and standing waves.
2. Wave profile and diagrammatic representation of waves, sinusoidal and co sinusoidal waves.
3. Terms associated with waves and definitions- crest, trough, amplitude, period, frequency, wave length, velocity, phase, phase difference, phase lead, phase lag, wave front.
4. Mathematical representation of waves and progressive wave equation.
5. Wave properties (reflection, refraction, diffraction, interference and polarization

3.5.1. Instruments

The following instruments were used to collect data for the study.

1. Teachers' Instructional Guide for Action Learning Strategy (**TIGAL**)
2. Teachers' Instructional Guide for Inquiry- Based Learning Strategy (**TIGIL)**
3. Teachers' Instructional Guide for Conventional Strategy (**TIGCM**)
4. Numerical Ability Test (**NAT**)
5. Physics Attitude Questionnaire (**PAQ**)
6. Achievement Test in Physics (**ATP**)

3.5.2. Teachers' Instructional Guide for Teaching Waves (TIGTW):

This contains the procedural statements for teachers to use in teaching the selected concepts. The instructional guides that were used to teach selected concepts are outlined below namely:

The teachers' instructional guide for teaching waves using Action learning strategy **(TIGAL)**

The teachers' instructional guide for teaching waves using the Inquiry – based teaching strategy **(TIGIL)**

The teachers' Instructional guide for teaching waves using Conventional method **(TIGCM)**

3.5.3. Teachers' Instructional Guide for Action Learning Instructional Strategy (TIGAL).

The teachers' instructional guide was developed by the researcher as a teaching guide written out for the participating subject teachers in action learning strategy to ensure uniformity. This is divided into stages as described by the researcher as adopted from Marquardt (2004) action learning process. Each lesson involving action learning strategy lasted for 40 minutes because of the nature of the strategy.

Stages in Action Learning Process according to Marquart, (2004)

Step1: Group formation. The teacher helps in the forming of the action learning sets from the four intact classes. The sets are grouped based on their performances in the pre- test and each set comprises of five students of mixed ability. Action learning sets met twice daily to discuss the problem based on the time available for its resolution.

Step2: Presentation of the problem or the task to the set. A set may handle one or many problems.

Step3: Analyze the issue(s): this involves identification of action learning for resolving them.

Step4: Presentation of the problem: the leader of the set represents the problem briefly to the set and awaits the group's recommendations.

Step5: Reframe the problem. After a series of questions, the sets, often with the guidance of the action learning teacher, reach a consensus on the most critical and important problem the sets should work on. The sets establish the crux of the problem, which might differ from the original presented problem.

Step6: Determine goals. Once the key problem or issue has been identified, the set seeks consensus for the goal. The achievement of the goal would solve the restated problem for the long-term with positive rather than negative consequences on the individual and team.

Step7: Develop action strategies. Much of the time of the sets is spent on identifying, and pilot testing, of possible action strategies. Like the preceding stages of action learning, strategies are developed via reflective inquiry and interaction.

Step8: Take action. Between action learning sessions, the whole sets and individual members collect information, identify the support status, and implement the strategies developed and agreed to by the sets.

Step9: Repeat the cycle of action and learning until the problem is resolved or new directions are determined.

Step10: Capturing learning. Throughout and at any point during the sessions, the action learning teacher may intervene. He asks questions to the set members, which enable them to:

a) Clarify the problem.
b) Find ways to improve their performance as a set.
c) Identify how their learning can be applied to develop themselves and the team.

After a period of time, reconvene all the sets to discuss progress, lessons learned, and next steps. They document the learning process for future reference and record the concept after each phase of learning. This process is repeated until all the problems are solved and learning is effected.

3.5.4. Teachers' Instructional Guide for Inquiry-Based Strategy (TIGIL)

The teachers' instructional guide was developed by the researcher as a teaching guide for participating teachers in the inquiry-based teaching strategy to ensure uniformity. This is divided into stages as described by Beyer (1971) and Akinlaye (1998) and adapted for this study. Each lesson involving inquiry- based strategy lasted for forty minutes because of the nature of the strategy. The procedure for teaching is as follows:

Stage1. (5 Minutes)

Introduction and discussion of the basic concepts, waves as energy in motion, and the teacher presents and defines basic concepts clearly to the students.

Stage2. (10minutes)

The teacher posed thought-provoking questions to clarify issues. Five questions were asked to stimulate and direct the inquiry.

Stage3. (10 minutes) The teacher directs students to identify sources of information

Stage4. (5 minutes) The teacher divides the class into small groups

a. The teacher helps in the division of the class into small groups. Each group comprised of mixed ability and consists of 5 to 7 students.

b. Each group selected their leader who presented the findings.

c. Each group is directed to develop plans on how to involve all the members in the group in collecting facts, arranging and assessing the findings and

d. Each group developed and proceeded to information gathering

Stage5. (5minutes) Each group leader presents findings to answer questions.

a. The teacher directs each group leader to present findings to the whole class.

b. The teacher asks probing and analytical questions with, 'what', when, why, who, and how on each controversial points.

c. The teacher uses chalkboard to conclude based on the data generated.

Stage6. (5minutes) Students draw conclusion and make decisions on issues.

a. The teacher directs the class to conclude in the light of evidence from the data

b. The teacher further directs students to re-examine their conclusion with a view to take a rational decision, leading to future inquiry.

Total = 40mins

3.5.5. Teacher's Instructional Guide for Conventional Strategy: (TIGC)

This was developed from the course content outline of classroom activities in the school curriculum. The purpose is to ensure uniformity in the implementation and dissemination of the conventional instructional strategy.

Stage1: A statement of the topic to be taught
Stage2: Listing behavioural objectives
Stage3: Learning resources
Stage4: Entry behaviour
Stage5: Introduction of the concepts to be taught
Stage6: Presentation, Step by step presentation of the class activities
Step7: Summary
Step8: Evaluation

3.5.6. Validity of the Teachers' Instructional Guide for Teaching Waves in Physics

The validity of the three instruments was ascertained by giving the teachers' instructional guide to three secondary school teachers and two Physics educators to validate and to determine the suitability of the instrument for classroom use.

3.5.7. Numerical Ability Test (NAT)

This is a multiple choice test with 5 options provided on each item. The instrument was constructed by the researcher. A total of 55 items were originally constructed and after calculating the difficulty and discrimination indices, 25 items were finally selected. The test lasted for 30 minutes.

The validity of the instrument was ascertained by five Physics teachers that have at least five years teaching experiences and two physics educators. Their comments and suggestions were taking into consideration. The instrument was then trial-tested on 50 SSII students from a secondary school that did not take part in the main study. The reliability coefficient of the instrument was calculated to be 0.77 using Kuder-Richardson formular 20 (K-R 20). On the basis of the high reliability index, the instrument was deemed suitable to be used in conducting the research.

The average difficulty and discrimination indices of numerical ability test (NAT) items were 0.54 and 0.53 respectively.

Scoring of NAT

Each question on NAT carries a maximum of 4marks while a wrong answer scores zero. This test was designed and used to categorize students into low, medium and high ability levels.

3.5.8. Physics Attitude Questionnaire (PAQ)

The questionnaire was developed to cover the following 7-sub scaled variables following the examples of Okpala (1995), Orji (1998) and Okoronka (2004). They are attitude of friends and self towards Physics; social implications of Physics, classroom/laboratory environment; Physics teachers' characteristics; enjoyment of Physics and Physics lessons/leisure interest towards Physics; attitude towards and normality of Physicist; career interest and anxiety towards Physics as well as attitude towards Physics content and experiment. The questionnaire comprised both extremely positive and extremely negative attitude towards Physics items. PAQ consists of two sections A and B. Section A comprise of demographic data such as age, sex, class, and school and section B involve rating scale consisting of 25 items, that the students responded to by circling the option most suitable to them from Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SA),. Each item clearly revealed the attitude of students towards Physics.

The face validity of the instrument was done by giving the instrument out to four experienced Physics teachers to ascertain the validity. The instrument was trial tested to establish its reliability with 50 Physics students in schools within the population but were not used for the main study. The data obtained was subjected to Cronbach Alpha Coefficient. The result showed that Physics Attitude Questionnaire (PAQ) has a reliability coefficient of 0.94. On the basis of high reliability index, the instrument was deemed suitable to be used in conducting the research.

Scoring of Physics Attitude Questionnaire (PAQ)

The positive statements were scored as follows:

Options available	**Points to be awarded**
Strongly Agree (SA)	4
Agree (A)	3
Disagree (D)	2
Strongly Disagree (SD)	1

The negative statements were scored as follows:

Optioned available	**Points to be awarded**
Strongly Agree (SA)	1
Agree (A)	2
Disagree (D)	3
Strongly Disagree (SA)	4

3.5.9 Achievement Test in Physics (ATP)

The test consist of two sections A and B. Section A comprise of students personal information such as age, sex, gender, and school, while section B comprise 25 multiple-choice questions with four alternative answers A, B, C and D with only one correct answer and three distracters. The content covered different levels of cognitive domains namely knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom, Engelhart, Furst, Hill and Krathwohl, 1956), but the researcher made use of the new revised Bloom taxonomy which are remembering, understanding, applying, analysing, creating, evaluation (Anderson and Krathwohl, 2001). It comprises multiple choice items constructed by the researcher from senior secondary school Physics examination syllabus. The questions on remembering on Achievement test in Physics (ATP) constitute 24 percent of the total questions. This is to enable the researcher to determine the extent to which the materials learnt on the concept of waves can easily be recalled or remembered. Also, questions on application in the Achievement test in Physics (ATP) constitute 32 percent of the total questions. This is to enable the researcher to determine the extent to which the materials learnt on the concept of waves can be applied to new and concrete situations (Table 7).

Table 7: ITEM SPECIFICATION FOR SS11 ACHIEVEMENT TEST IN PHYSICS (ATP)

TOPIC/ CONCEPT		Cognitive Domain						
S/N		Remembering	Understanding	Applying	Analysing	Creating	Evaluation	Total
1.	Wave motion and types of waves.	18, 20	1, 15	16	8		25	7
2.	Waves profile /representation	21		4, 19	10		23	5
3.	Waves equation /nomenclature	6, 22	11, 13	24, 5		3		7
4.	Properties of waves	9	17	2, 7, 12			14	6
	Total/Percentage	**6 (24%)**	**5 (20%)**	**8 (32%)**	**2 (8%)**	**1 (4%)**	**3 (12%)**	**25**

The draft questions originally comprised of 32 questions drawn by the researcher from the West African Examination Council Physics syllabus and was given to three experienced teachers in Physics and the supervisor for construct and for face validity of the test items. The recommendations and suggestions from the supervisor and Physics experts were put into consideration in the final form of the instrument. To further strengthen the validity of the instrument, the twenty-five (25) multiple-choice test items were administered to a trial testing group of (50) fifty students who were not part of the main study but who were found to be equivalent in all respects to the students in the study. The researcher made use of one of the schools that met the criteria for sampling but was not used for the main study. The results obtained in this administration were subjected to Kuder-Richardson’s formular-20 (K-20) to establish the internal consistency of the items. The result showed reliability coefficient of 0.76. On the basis of the high reliability index, the instrument was deemed suitable to be used in conducting the research.

After administration of the test items to students, the average discriminating power and difficulty indices of the items were computed to be 0.52 and 0.52 using the formula,

$$d = \frac{U25\% - L25\%}{N25\%}$$

Where

U25% = number in the 25% upper segment that score the item correctly.

L25% = number of students in the lower segment that score item correctly.

N25% = number of students in either the upper or lower 25%.

The items with value below 0.40 and above 0.60 were discarded from the total number of items as they indicate poor discriminating power.

The difficulty level or index D, was also computed using

$$D = \frac{Nr}{Nt} \times 100\%$$

Nr = Number of students scoring an item correct.

Nt = Total number of students that took the test.

The items found to possess between 40%-60% difficulty indices were selected.

Scoring of ATP

Each correct answer attracts 4marks in multiple choice sections B. The total (maximum) mark for all the twenty-five questions was one hundred (100) and the minimum was zero.

3.6 Data Collection Procedure

The data were collected according to the following procedural steps:

1. Selection and training and of participating subjects Teachers and Schools.
2. Pre- test administration
3. Treatment implementation
4. Post-test administration

The work schedule for the period of data collection is summarized below.

Selection and Training of teachers				---	---	---	---	---	---1week
Pre- test	---	---	---	---	---	---	---	---	-- 1week
Treatment	---	---	---	---	---	---	---	---	-- -6weeks
Post-test-	---	---	---	---	---	---	---	---	---1week

3.7. Selection and Training of participating subject teachers:

In each of the selected schools, one Physics teacher was randomly selected and trained for one week in the use of appropriate strategies and the already prepared teaching materials. For a teacher to be qualified for selection, he/she must be a graduate Physics teacher with at least three years of teaching experience, currently presenting candidates for senior secondary school certificate examination (SSCE) and teaching SS II students.

First, selected the teachers were briefed on the strategies and modalities of the instructional strategy and materials to be used, and then the investigator gave demonstration lessons, using some of the teachers and students not involved in the main study as the selected subjects. Lastly, the teachers were asked to teach, using the students that are not involved in the main study as subjects. This was done to ensure that teachers in the experimental and control groups possessed the initial entry behaviours and would comply strictly according to the instructional guides for each strategy. The training lasted for one week.

3.7.1 Preliminary Study

Before the commencement of the main study, a pilot study was conducted which lasted for one week. This serves as a measure to determine the efficiency of the instrument for the main study and helped in calculating the reliability of the instruments used for the main study.

3.7.2 Pretest.

The pre-test was conducted during the first week. The instruments were administered in the following order, Physics Attitude Questionnaire, followed by the Achievement Test in Physics and finally, the Numerical Ability Test. The Attitude questionnaire was administered first in order to avoid the influence of Achievement Test in Physics on students' attitude. The scores of the subjects in the NAT was used to classify them into low, medium, and high numerical ability levels.

3.7.3 Treatment stage (Procedure for Data Collection)

During this period, students were taught the main concepts of the topic; the researcher first notified all the target school's head about the proposed investigation. This was done through a letter personally delivered to each head of the selected target schools. After the approval, the researcher held discussion with teachers handling Physics courses in each of the target schools as a premise to teaching the subjects. Thereafter, a brief discussion was held with the students to acquaint them with the objectives, nature and requirements of the study. Shortly after this, the pre-test measurement was administered on the subjects.

Teaching in both the experimental and control group were done simultaneously by institution-based teacher for six weeks. The researcher was however, directly involved with the administration of both pre and post tests. This is to ensure that norms associated with examination exercise are strictly maintained. The first three schools located in the same local government had their pre and post test administered on the same day while the remaining three schools in the other Local Government Area had their pre and post test the second day. This allowed the researcher to monitor the conduct of the test administration since the Local Government Areas are far apart to allow the research to cover them the same day. The researcher was present in all the schools to monitor the teaching and testing sessions. The whole experiment lasted for 9 weeks.

Table 8: Time table for Treatment Procedure

Week	Activity carried out and length of time	Stage
1	Training of teachers to handle the 2 experimental groups using the appropriate instructional materials. This was conducted in various schools. It lasted for one week.	Preliminary and training stage.
2	Administration of pre-test. All the tests was administered on the subjects in the following order: PAT, NAT, and ATP. This lasted for the duration of one week.	Pre- treatment stage(pre-test)
3	General briefing and training by the researcher. The researcher trained the teachers who in turn trained the subjects to acquaint them with the objectives and major ideals of study.	Pre-treatment stage, general briefing and further training.
4-8	Six weeks of instruction/ teaching using the respective instructional guides for each experimental group by a trained teacher. This lasted for six weeks.	Post –treatment
9	Revisions, corrections and completion of selected concepts. This lasted for one week and administration of instruments namely PAT, NAT, ATP	Post-test

The Treatment groups for the study

Experimental group 1: Two schools used consist of four intact SSII classes of which two classes were selected from each school and were exposed to action learning instructional strategy. The researcher adopted the work of Marquardt (2004), according to Marquardt the following steps were followed:

Step1: Clarify the objective of the Action Learning set. Presentation of the problem or the task to the set. A set may handle one or many problems.

Step2: Group formation. The teacher helps in the forming of the action learning sets from the four intact classes. The sets are grouped based on their performances in the pre- test and each set comprises of five students of mixed ability. Action learning sets met twice daily to discuss the problem based on the time available for its resolution.

Step3: Analyze the issue(s): this involves identification of action learning for resolving them.

Step4: Presentation of the problem: the leader of the set represents the problem briefly to the set and awaits the group's recommendations.

Step5: Reframe the problem. After a series of questions, the sets, often with the guidance of the action learning teacher, reached a consensus on the most critical and important problem the sets should work on. The sets establish the crux of the problem, which might differ from the original presenting problem.

Step6: Determine goals. Once the key problem or issue has been identified, the set seeks consensus for the goal. The achievement of the goal would solve the restated problem for the long-term with positive rather than negative consequences on the individual and team.

Step7: Develop action strategies. Much of the time and energy of the sets was spent on identifying, and pilot testing, of possible action strategies. Like the preceding stages of action learning, strategies are developed via reflective inquiry and interaction.

Step8: Take action. Between action learning sessions, the whole sets and individual members collect information, identify the support status, and implement the strategies developed and agreed to by the sets.

Step9: Repeat the cycle of action and learning until the problem is resolved or new directions are determined.

Step10: Capturing learning. Throughout and at any point during the sessions, the action learning teacher may intervene. He will ask questions to the set members, which enabled them to:

a) Clarify the problem.

b) Find ways to improve their performance as a set.

c) Identify how their learning can be applied to develop themselves and the team.

After a period of time, reconvene all the sets to discuss progress, lessons learned, and next steps. They document the learning process for future reference and record the concept after each phase of learning. This process is repeated until all the problems are solved and learning is affected.

Experimental group 2: Two schools used consist of four intact classes of SSII classes selected from each school. They were exposed to inquiry- based teaching instructional strategy. The special characteristics of an inquiry based strategy took the following steps in a classroom setting.

Step1: Teacher presents and defines the issue/ problem clearly to the students.

Step2: Teacher asks thought- provoking questions to clarify problems and states hypotheses to show relationship that will direct inquiry.

Step3: Teacher and students identify sources of information, both teacher and students identify or devise strategies for data collection.

Step4: Teacher divides the class into groups and directs groups where to collect information

Step5: Each group proceeds to gather data and information on the issue or problem.

Step6: Each group leader presents finding to the whole class. Teacher asked thought provoking / analytical questions on the findings to test hypotheses.

Step7: Students' conclusion and decision making.

Control group: Two schools in which the intact classes are to be taught with conventional instructional method.

Stage1: A statement of the topic to be taught

Stage2: Listing behavioural objectives

Stage3: Learning resources

Stage4: Entry behaviour

Stage5: Introduction of the concepts to be taught

Stage6: Presentation, Step by step presentation of the class activities

Step7: Summary

Step8: Evaluation

Administration of the Posttest

At the end of the six week of treatment, students in both the experimental and control groups were administered the Physics Attitude test (PAT) and Achievement test in Physics (ATP).

3.8 Data analysis

The data collected were analysed using the following statistical procedures. A 3x3x2 Analysis of Covariance (ANCOVA) was computed for each dependent variable for the three instructional groups using pretest scores as covariates. Also, Multiple Classification Analysis (MCA) was used to examine the magnitude of the differences among the various groups. In case of significant main effects, the scheffe's Post-hoc analysis was used to determine the sources of such significant differences.

CHAPTER FOUR

4.0 Results and Discussions

The results obtained in this study are presented and discussed below. The sequence of the presentation and the discussion of the results are in accordance with the hypotheses formulated for the study.

4.1 Presentation of the Results

Hypothesis One (a)

There is no significant main effect of treatment on students' achievement in Physics.

Table 9: Summary of ANCOVA of Posttest Achievement Scores of Students by Treatment, Numerical Ability and Gender

Source	Sum of Squares	DF	Mean Square	F	Sig.	Remark
Covariates	3991.78	1	3991.78	35.10	.00*	Sig.
Main effects	88751.21	5	17750.24	156.08	.00*	Sig.
Treatment	85008.05	2	42504.03	373.74	.00*	Sig.
Ability	2546.99	2	1273.50	11.20	.00*	Sig.
Gender	1196.17	1	1196.17	10.52	.01*	Sig.
2-Way Interactions	1565.32	8	195.67	1.72	.09	n.s.
Trtgrp x Ability	763.35	4	190.84	1.68	.16	n.s.
Trtgrp x Gender	584.34	2	292.17	2.57	.08	n.s.
Ability x Gender	337.48	2	168.74	1.48	.23	n.s.
3-Way Interactions	189.20	4	47.30	.416	.80	n.s.
Trtgrp x Ability x Gender	189.20	4	47.30	.416	.80	n.s.
Explained	94497.51	18	5249.86	46.16	.00	
Residual	19905.16	175	113.73			
Total	114399.67	193	592.74			

*** Significant at $p < 0.05$**
n.s = Not significant

The result of treatment in Table 9 reveals that the main effect of treatment on students' achievement in Physics was significant at 0.05 alpha level ($F_{(3,190)} = 373.74$; $p < 0.05$). This implies that the posttest scores of students in Physics differ significantly across the two experimental groups and control. Therefore, hypothesis 1a is rejected. Consequent upon the observed difference in the effect of teaching strategies, Multiple Classification Analysis (MCA) was considered to determine the index of relationship and also to determine the variance of the dependent variable (achievement) in Physics that is attributable to the influence of the independent variable (teaching strategies) as shown in Table 10.

The Multiple Classification Analysis (MCA) in Table 10 shows the magnitude of the post-test, mean achievement scores of subjects exposed to the different treatment conditions.

Table 10: Multiple Classification Analysis (MCA) of Posttest Achievement Scores According to Treatment, Numerical Ability and Gender

Grand Mean = 53.96

Variable + Category	**N**	**Unadjusted variation**	**Eta**	**Adjusted for independent + covariates deviation**	**Beta**
Treatment groups					
Action Learning	59	25.63		25.72	
Inquiry Based Learning	74	2.20		2.13	
Control	61	-27.47		-27.46	
			.86		.86
Ability					
Low	62	-6.06		-5.51	
Medium	76	-.75		.39	
High	56	7.72		5.31	
			.22		.18
Gender					
Male	103	-2.64		-2.34	
Female	91	2.99	.12	2.65	.10
Multiple R-squared					.81
Multiple R					.90

In the Table 10, the adjusted mean scores of the different Treatment groups are: Action Learning (79.68), Inquiry Based Learning (56.09), Control (26.50), High (59.27), Medium (54.35), Low (48.45), Male (51.62), and Female (56.61) respectively.

This shows that the Action learning group had the highest adjusted mean score (53.96+25.72) or $\bar{x}$=79.68, followed by the Inquiry Based Learning group (53.96+2.13) or $\bar{x}$=56.09 and the Control group (53.96 +-27.46) or $\bar{x}$= 26.50. The teaching strategies have an index of relationship of 0.74 (0.86^2), hence the observed relationship in favour of teaching methods, shows that the teaching strategies have a significant relationship of 0.74 (Beta value of 0.86^2) with achievement of students in Physics. Table 10 also shows a Correlation Coefficient (R) of 0.90 with square coefficient of determination (R^2) of 0.81. This implies that 81% of the total variance in the achievement of students in Physics is attributable to the influence of teaching methods. This implies that the treatment given has significant effect, hence H_{01a} is rejected.

To find the order of effectiveness of teaching strategies and direction of significance under investigation, the post test scores were subjected to Scheffe Post-hoc analysis was carried out in Table 11:

Table 11: Pairwise Multiple Scheffe Post-Hoc Analysis of Treatment Effect on Students' Achievement

Treatment group	N	Mean	Control	Action group	Inquiry group
Control	61	26.50		*	*
Action Grp	59	79.68			*
Inquiry Grp	74	56.09		*	

***Pairs of groups significantly different at p< 0.05**

Table 11 reveals that the post-test achievement of students mean score of the conventional group ($\bar{x}$= 26.50) is significantly different from each of the action learning (79.68) and inquiry based group ($\bar{x}$= 56.09). Also, the action learning group and inquiry based group are significantly different from one another in the post-test students' achievement. This implies that action learning strategy is the most effective in facilitating students' achievement in Physics. This is followed by inquiry based strategy while conventional method is seen to be the least effective in facilitating students' achievement in Physics.

Table 12: Summary of ANCOVA of Post-test Attitude Scores of Students by Treatment, Numerical Ability and Gender

Source	Sum of Squares	DF	Mean Square	F	Sig.	Remark
Covariate	4180.14	1	4180.14	40.58	.00*	Sig.
Prett	4180.14	1	4180.14	40.58	.00*	Sig.
Main Effects	26780.27	5	5356.06	51.99	.00*	Sig.
Treatment group (Trtgrp)	21876.94	2	10938.47	106.19	.00*	Sig.
Ability	4843.44	2	2421.72	23.51	.00*	Sig.
Gender	59.90	1	59.90	.58	.45	n.s.
2-Way Interaction	613.25	8	76.66	.74	.65	n.s
Trtgrp x Ability	393.63	4	98.41	.96	.43	n.s
Trtgrp x Gender	126.84	2	63.42	.62	.54	n.s
Ability x Gender	26.43	2	13.21	.13	.88	n.s
3-Way Interaction:	930.62	4	232.66	2.26	.07	n.s
Trtgrp xAbility x Gender	930.62	4	232.66	2.26	.07	n.s
Explained	32504.29	18	1805.79	17.53	.00	
Residual	18027.20	175	103.01			
Total	50531.49	193	261.82			

*** Significant at p< 0.05**
n.s = Not significant

Hypothesis One (b)

There is no significant main effect of treatment on students' attitude towards Physics.

Table 12 shows that there is a significant main effect of treatment on students' attitude towards Physics ($F_{(3,190)}$ =106.19; $p< 0.05$). The result implies that the posttest attitude scores of the students exposed to the different conditions were significantly different. Thus, the null hypothesis (H_{01b}) was rejected.

To find the magnitude of the posttest mean attitude scores of subjects exposed to the different treatment conditions, the Multiple Classification Analysis (MCA) presented in Table 13 was computed.

Table 13: Multiple Classification Analysis (MCA) of Posttest Attitude Scores by Treatment, Numerical Ability and Gender.

Grand Mean =73.43

Variable + Category	**N**	**Unadjusted variation**	**Eta**	**Adjusted for independent + covariates deviation**	**Beta**
Treatment:					
Action Learning Strategy	59	9.72		10.26	
Inquiry Based Learning	74	5.87		5.82	
Control	61	-16.53		-16.99	
			.70		.72
Ability:					
Low	62	-6.25		-6.26	
Medium	76	-.84		-.41	
High	56	8.05		7.50	
			.35		.33
Gender:					
Male	103	-.95		-.53	
Female	91	1.08	.06	.60	.04
Multiple R-squared					.61
Multiple R					.78

On the Table 13, the adjusted mean scores of the different Treatment, Numerical Ability and Gender groups are: Action Learning (83.69), Inquiry Based Learning (79.25), Control (56.44), High (80.93), Medium (73.02), Low (67.17), Male (72.90), and Female (74.03) respectively.

The results show that the Action learning group had the highest adjusted mean score (73.43+10.26) or $\bar{x}$=83.69, followed by the Inquiry Based Learning group (73.43+5.82) $\bar{x}$= 79.25 and the Control group (73.43 +-16.99) or $\bar{x}$= 56.44. The teaching strategies have an index of relationship of 0.52 (0.72^2), hence the observed relationship in favour of teaching strategies, shows that the teaching methods have a significant relationship of 0.52 (Beta value of 0.72^2) with attitude of students towards Physics.

Table 13 also shows a coefficient of magnitude (R) of 0.78 with a coefficient of magnitude (R^2) of 0.61. This implies that 61% of the total variance in the attitude of students in Physics is attributable to the influence of teaching methods. This implied that the treatment given has significant variation, hence H_{01a} is rejected.

To find the order of effectiveness of teaching strategies and direction of significance under investigation, the post test scores were subjected to Scheffe Post-hoc analysis in Table 14

Table 14: Pairwise Scheffe Post-Hoc Analysis of Treatment Effect on Students' Attitude towards Physics

Treatment group	N	Mean	Action group	Inquiry group	Control
Action Grp	59	83.69			
Inquiry Grp	74	79.25			*
Control	61	56.44	*	*	

***Pairs of groups significantly different at p <0.05**

Table 14 reveals that each of the two treatment groups viz: Action learning ($\bar{x}$ = 83.69), Inquiry based ($\bar{x}$ = 79.25) is significantly different from the control group that is conventional method ($\bar{x}$ = 56.44).

Hypothesis Two (a)

There is no significant main effect of gender on student's achievement in Physics.

Table 9 reveals that there is a significant main effect of gender on students' achievement in Physics ($F_{(2,191)}$ =10.52; $p<0.05$). On this basis, hypothesis 2a is rejected. Table 10 shows that female students had higher adjusted mean score (56.95), than their male counterparts (51.32).

Table 10 also shows a correlation coefficient (R) of 0.10 with a coefficient of determination (R^2) of 0.01. This implies that 1% of the total variance is attributable to the influence of gender.

Hypothesis Two (b)

There is no significant main effect of gender on students' attitude toward Physics.

Table 12, shows that gender had no significant main effect on students' attitude towards Physics ($F_{(2,191)}$ = 0.58; $p>0.05$. Hypothesis 2b is therefore not rejected.

Table 13 however reveals that female students obtained a higher post test mean score than the male counterparts. This is however not significant statistically.

Hypothesis Three (a)

There is no significant main effect of numerical ability on students' achievement in Physics.

From Table 10, shows that there is a significant main effect of treatment of numerical ability on students' achievement in Physics ($F_{(3,190)}$ =11.20; p<0.05). This means that there is a significant difference in the post test score of students of low, medium and high numerical levels. Hence, hypothesis 3a is rejected.

Table 9 also shows that students of high numerical ability obtained the highest adjusted mean achievement score (53.96+5.31) or $\bar{x}$=59.27 followed by those of medium numerical ability (53.96+0.39) or $\bar{x}$= 54.35 while the students of the low numerical ability level obtained the least achievement score (53.96+-5.51) or $\bar{x}$= 48.45. The source of the significant effect of numerical ability obtained on students' achievement was probed further through Scheffe post -hoc analysis.

Table 15: Pairwise Scheffe Post-Hoc Analysis of Effect of Numerical ability on Students' Achievement in Physics

Numerical Ability	Mean	Low	Medium	High
Low	48.45		*	*
Medium	54.35	*		
High	59.27	*		

***Pairs of groups significantly different at p< 0.05**

Table 15 which reveal that the low numerical ability students mean (48.45) differ significantly from both the medium ability students mean (54.35) and the high numerical ability students mean (59.27). Thus the pair of low and medium as well as low and high numerical ability contributed to the significant effect of numerical ability on students' achievement in Physics.

Hypothesis Three (b)

There is no significant main effect of numerical ability on students' attitude towards Physics

Table 12 shows that numerical ability on students' had a significant effect on their attitude ($F_{(3, 190)}$ =23.51; $p<0.05$. This implied that students differ significantly in their attitude towards Physics across the two treatment groups and control. Therefore, hypothesis H_{03b} is rejected.

MCA result of Table 13 shows that the high numerical ability students as having the highest post test adjusted mean attitude score (73.43+7.50) or $\bar{x}$= 80.93 followed by the medium numerical ability (73.43+-.41) or $\bar{x}$=73.02 while the low numerical ability students had the lowest posttest adjusted mean attitude score (73.43+-6.26) or $\bar{x}$= 67.17.

Table 13 also shows a correlation coefficient (R) of 0.33 with coefficient of determination (R^2) of 0.11. This implies that 11%of the total variance in the attitude of students towards physics is attributable to the influence of numerical ability.

Scheffe Post-hoc Analysis Table 16 reveals that each of the possible pairs of groups was significantly different from each other. This account for the observed significant effect.

Table 16: Pairwise Scheffe Post-Hoc Analysis of Effect of Numerical ability on Students' Attitude towards Physics

Numerical Ability	Mean	Low	Medium	High
Low	67.17		*	*
Medium	73.02			
High	80.93	*	*	

***pairs of groups significantly different at P< 0.05**

Hypothesis Four (a)

There is no significant interaction effect of treatment and gender on student's achievement in Physics.

Table 9 shows that there is no 2-way interaction effect of treatment and gender on students' achievement in Physics ($F_{(6,187)}$ =2.57; p>0.05). Hence, hypothesis 4a is not rejected.

Hypothesis Four (b)

There is no significant interaction effect of treatment and gender on students' attitude towards Physics.

Table 12 shows that there is no 2-way interaction effect of treatment and gender on students' posttest attitude towards Physics. The difference is not significant ($F_{(6,187)}$ = 0.62; p>0.05). Hypothesis 4b is not rejected.

Hypothesis Five (a)

There is no significant interaction effect of treatment and numerical ability on students' achievement in Physics.

Table 9 reveals that the interaction effect of treatment and numerical ability on students' achievement in Physics is not significant ($F_{(9,184)}$ = 1.68; p>0.05). Therefore, hypothesis 5a is not rejected.

Hypothesis Five (b)

There is no significant interaction effect of treatment and numerical ability on students' attitude towards Physics.

Table 12 shows that the interaction effect of treatment and numerical ability on students' attitude towards Physics is not significant ($F_{(9,184)}$ = 0.96;p>0.05). Hence, hypothesis 5b is not rejected.

Hypothesis Six (a)

There is no significant interaction effect of gender and numerical ability on students' achievement in Physics.

Table 9 reveals that gender and numerical ability had no significant interaction effect on students' achievement in Physics ($F_{(6,187)}$ =1.48; p>0.05). Therefore, hypothesis 6a is not rejected.

Hypothesis Six (b)

There is no significant interaction effect of gender and numerical ability on students' attitude towards Physics.

Table 12 shows that gender and numerical ability had no significant interaction effect on students' attitude towards Physics ($F_{(6,187)}$=0.13; p>0.05). Hypothesis 6b was therefore not rejected. This result shows that the attitude of students in different numerical ability groups do not vary significantly between male and female students.

Hypothesis Seven (a)

There is no significant interaction effect of treatment, gender and numerical ability on students' achievement in Physics.

Table 9 reveals that the 3-way interaction effect of treatment, gender and numerical ability on students' achievement in Physics is not significant ($F_{(18,175)}$ =0.42; p>0.05). Hypothesis 7a is thereby not rejected.

Hypothesis Seven (b)

There is no significant interaction effect of treatment, gender and numerical ability on students' attitude towards Physics.

The result of the 3-way interaction effects presented in Table 12 reveals that there is no significant 3-way interaction effect of treatment, gender and numerical ability on students' attitude towards Physics ($F_{(18,175)} = 2.26$; $p > 0.05$). Hence, hypothesis 7b was not rejected.

4.2 Discussion of Results

Main Effect of Treatment, Numerical Ability and Gender

The data revealed that action learning strategy is a potential tool that can be used to improve students' achievement in secondary school Physics. Action learning strategy was found to be more effective as a teaching strategy than the Inquiry based strategy. This might be due to the fact that in action learning, students study their own actions and experiences in order to improve achievement. It focuses on research into actions taken and as a result, knowledge emerges which lead to the improvement of skills, achievement, self-understanding, self-development and systematic learning occurs which becomes self-sustaining in the long term. Furthermore, action learning involve small groups that meet regularly to take action on critical problem using the collective experience of group members to create learning opportunities which include discussion of goals, share ideas and information, seek additional information, make decisions about the results of their findings and present it to the whole class. It enhances appropriate behaviour in organising work, asking questions, encouraging social interaction, demonstrating self management and facilitating better study habit and retention of knowledge. Action learning strategy was able to reduce the abstract nature of the concept by presenting it real to the students.

This study is in agreement with the findings of Dixon (1998), Marquardt (2004); Chambers and Hale, (2007) and Kramer (2007) that action learning is a viable strategy that improves performance, promotes learning and position groups or organisations to adapt better in turbulent times. It is also away to develop the capabilities of individuals, groups, team and overall organisations. The study is also in line with the findings of Mumford (1994) that action learning has the potential of offering opportunities to promote shared learning, small self supporting groups, the reinforcement of a set of values and behaviours linked to attendance and retention, and a process for reflective learning whilst providing a social network for students. Mumford states further that action learning offers an interesting perspective on the preferences people have for different learning behaviours. That is, if every member recognises their preferences and how individuals differ then it enables sets to recognise individual strengths and use the strengths to provide enthusiasm and energy which can ensure a broader more critical perspective through questioning, listening actively, feedback and reflection.

Although, Physics students achieved higher in action learning (79.59) than inquiry based strategy (56.16) and lastly the conventional strategy (26.49), inquiry based strategy can equally be used to teach difficult concepts in Physics in a situation where action learning is not realistic due to certain constraints. Inquiry strategy exposes the students to more realities of life and tends to work as scientist and acquire knowledge by themselves in which the teacher serves as a guide and correct their misconceptions (Afolabi and Akinbobola, 2009).

From the findings, Action learning strategy can also be used effectively to improve students' attitude towards Physics. This can be attributed to the fact that students did all the learning exercise together throughout the treatment period and learners constructed their knowledge at their individual pace. A good number of research works have shown that the information that is self – discovered is best retained (Adesoji, 2003; Ikitde, 2008; Afolabi, 2009). This probably may be responsible for the students showing more positive attitude than students in other groups.

Data analysis showed that gender has a significant effect on students' achievement in Physics. Female students had the higher achievement mean score than their male counterparts. The significant gender related difference in achievement could be explained. Applying appropriate teaching approaches helped female students learn and remember facts, apply skill, comprehend concepts, analyses and synthesis principles which are cognitive objective for Physics education. Also, the enthusiasm exhibited by female students who showed zeal when they were taught using action learning may have led to higher performance at given tasks. This might be due to the fact that female students interact better with group member freely and have led to increasing the depth of understanding, enhancing motivation, developing positive attitude toward later use of material presented in the course, develop problem solving skills and generating greater involvement of female students than the male with the concept.

The result is contrary with the findings of Akinbobola (2006), Akinbobola (2008) and Afolabi and Akinbobola (2009) that showed no significant difference in the mean performance between boys and girls in the manipulation of the same instructional materials as well as in their rate of contribution and class participation. He noted that every child, both male and female must be given the opportunity to display his/her ability as fully as possible, be they quick or slow, deep or superficial in thinking, once they are taught with the same teaching approach. This is because the good performance of a student depends on his interest as well as the techniques used by the teacher and the types of instructional materials involved.The result is consistent with the findings of Dagoli (2000), Ukwungwu and Ezeike (2000), that gender difference really exist in science classroom and that females displayed higher mean scores than their male counterparts when appropriate instructional strategy is used. Jones (1990) concluded that ability correlated significantly with science achievement while gender was not identified as predator of science improvement.

The next finding showed that gender has no significant effect on students' attitude towards Physics. The insignificant effect of gender could be attributed to the effect of the strategies used to teach the students. These strategies are less abstract and more practical in nature, participatory and involving the learners more in active way. There is the tendency that both male and female students acquire knowledge, attitude and practices at the same rate when exposed to this type of learning environment. This result is in line with the findings of Ikitde (2008), Onwioduokit , Akinbobola and Ado (2007) that gender has no significant effect on students attitude when they are exposed to good and motivating instructional strategies.

This study revealed that there was statistically significant main effect of numerical ability on student achievement in Physics. Student of high ability performed better than those of medium ability and also performed better than those of low ability. This is as a result that the instructional strategies used helped students to engage in meta-cognitive behaviours that are, checking their own understanding procedures, monitoring for consistency and trying to relate new materials to prior knowledge during learning. The instructional strategies also helped them to recognise the imposition of meaning by making senses of formal symbols and rules that are often taught as if they were arbitrarily convention rather than expressions of fundamental regularities among quantities and physical entities. This is in agreement with that of Bassock (1990) that found that students who do not display good mastery of mathematical skills usually have significant difficulty in Physics problems. Iroegbu (1998) in his work he ascertained that a significant main effect of numerical ability exists on the achievement of secondary school students in Physics, in line graphing and problem solving skills.

The study showed that high numerical ability students develop more positive attitude than those of medium and low ability levels. This could be explained from the point of view that improved performance leads to interest in the subject and positive attitude.

The data analysis also revealed that there is no significant interaction effect of treatment and gender on students' achievement and attitude towards Physics. This shows that gender has no effect on the achievement and attitude of students towards Physics. That is, the three instructional strategies groups, there was no significant difference in the performance of both male and female students. As discussed earlier, this could be as a result of the nature of these strategies. The students were able to learn through many senses most especially the two treatments applied. The two learning strategies are more effective and the concepts learnt are more retained. The strategies are more suitable for both sexes.

This study further shows that the interaction effects of treatment and numerical ability on students' achievement and attitude towards physics were low and not significant.

The data analysed revealed that the 3-way interaction effect of treatment, numerical ability and gender is not significant on students' achievement and attitude towards physics. However, the interactive effects taken together show no appreciable consequences on students' performance. What made the significant difference was the main effect. Despite the fact that various teaching methods and strategies have been recommended for the teaching of secondary school science subjects in Nigeria (Ikwa, 2000) this study is in support of the use of learning of hands-on and minds-on strategies as parts of the strategies for imparting knowledge to learners. This study embraces learner-centered and active participation by the students. This study emphasised active intellectual involvement of learners by providing opportunities for students to meaningfully talk and listen, write, read and reflect on the content, ideas, issues and concerns of an academic subject. It is also made clear here that the treatment administered are more practical and more involving capable of inculcating the concept of waves effectively, irrespective of gender or numerical ability of the learner.

4.3 Summary of findings

The results of this study are summarized thus:

1. There is a significant main effect of treatment on students' achievement in Physics. Students taught with action learning strategy had higher achievement score than those taught with inquiry-based strategy and followed by the conventional method. In the same vain, there was a significant main effect of treatment on variation of students' attitude towards Physics.

2. Gender has a significant main effect on students' achievement in Physics. Female students performed significantly better than their male counterparts. However, there was no significant main effect of gender on students' attitude towards Physics.

3. There was a significant main effect of numerical ability on students' achievement in and attitude towards Physics. Students with numerical ability obtained the highest achievement score followed by students of medium numerical ability while students of the low numerical ability level obtained the least achievement score. Also,

numerical ability of students' had a significant effect on their attitude towards physics across the treatment group and control.

4. The 2-way interaction effect of treatment and gender on students' achievement in and attitude towards Physics was not significant.
5. There was no significant interaction effect of treatment and numerical ability on students' achievement in and attitude towards Physics.
6. The interaction effect of gender and numerical ability on students' achievement in and attitude towards Physics was not significant.
7. The 3- way interaction effect of treatment, gender and numerical ability on students' achievement in and attitude towards Physics was not significant.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The major issue addressed in this study was to find out the effects of action learning and inquiry-based instructional strategies on secondary schools students' learning outcomes in Physics. In addition, the study sought to find out any interaction among treatment, numerical ability and gender of students.

The research design adopted for this study was a pretest-posttest control-group design with 3x2x2 factorial arrangement. The participants of the study were 194 senior secondary two (SSII) students in two Local Government Areas of Kwara State. A purposive sampling technique was used to select schools from the target population. Nine secondary schools were purposively selected for the study. Six schools were selected for the main study out of the nine purposively selected schools. Two intact classes were selected from each school making a total of twelve intact classes. Six research instruments were used for data collection. Fourteen null hypotheses were tested in the study. Data collected were analysed using Analysis of Covariance (ANCOVA), Multiple Classification Analysis (MCA) and Pairwise Scheffe's Post-hoc Analysis.

From the results obtained, significant difference was found to exist in the achievement of students in Physics when taught using action learning, inquiry-based strategies and conventional method. The order of effectiveness of the teaching methods was obtained with the help of Scheffe multiple comparison tests. The result showed that action learning was the most effective in facilitating students' achievement in Physics. This was followed by inquiry-based while conventional method was seen to be the least effective in facilitating students' achievement in Physics. The analysis of Beta values obtained from the Multiple Classification Analysis (MCA) indicated that the coefficient of magnitude is 0.74 (0.86^2), hence, the teaching methods generally enhance students' achievement in Physics.

The result also indicated that significant differences were found to exist on numerical ability of students on their learning outcomes. Multiple Classification Analysics (MCA) was used to find the deviation of the adjusted posttest score of students from the grand mean. The results showed that students with high numerical ability level performed better that students of medium ability and followed by the low ability level.

The result also showed a significant difference existing between achievement of male and female Physics students taught with action learning, inquiry-based strategies and conventional method. Also, the result indicated a non significant difference between attitude of male and female Physics students taught with the instructional strategies.

The results also showed that interaction effect among teaching methods, gender and numerical ability were not significant irrespective of the dependent variables (achievement, attitude). This implies that the effects of teaching methods, numerical ability and gender on each other were the same at all levels of the other factors.

5.2 Educational Implications of Findings

The study has provided a useful insight into the effects of teaching methods on students' achievement in secondary school Physics. In the light of the findings discussed, this study has the following implications for Physics teaching.

The researcher concluded that action learning strategy enhances students' achievement in Physics more than inquiry based strategy. Also, gender has a significant effect on the academic achievement of students taught with action learning and inquiry based learning strategies.

As used in the context of this study, the teacher guides or fashioned out the problem to the students in inquiry based strategy. That is, the teacher helped the students to identify the problem while the students provide solution to the problem. In action learning strategy, both the problem and solution are discovered by the students. The study reveals that action learning provides a way of bringing learners together to work in a small group to solve problems. Through this joint intellectual effort; resourcefulness, innovation, creativity, student-centred activities, reflection, social interaction, construction of knowledge, respect for other people's view, problem-solving skills, initiative, curiosity and critical thinking can be created, developed and sustained in physics classrooms. It is therefore, the responsibility of science educators, educational practitioners and practising science teachers especially Physics to embrace the use of action learning strategy in the classrooms that would promote and enhance the achievement of educational objectives most especially in this era of technology.

Result from this study indicate that students exposure to action learning enhances the ability to master the subject matter, apply the concepts to various situation and render unnecessary much of the rote memorization of concept or propositions without the recognition of the meaning of the words in the concepts which the students often resort to.

The findings of this investigation have implications for the improvement of science and technology in Nigeria. The action learning strategy has been found in this study to be the most effective in enhancing the achievement of Physics students. Therefore, the sustenance of students' interest in science and technology can be achieved by the adoption of action learning strategy, which if well planned, can encourage and motivate the students to practise and apply the scientific knowledge gained to new situation by making use of the process skill of science. This could lead to the acquisition and development of technology in the country.

5.3 Contribution to Knowledge

The study provided a useful insight into the effects of teaching strategies on students' learning outcomes in physics. The action learning is a strategy which facilitates meaningful learning, retention and transfer of knowledge of physics concepts and enhances the ability to master the subject matter, apply the concepts to various situations.

The inquiry-based strategy is a strategy in which the teacher could help the students makes connections to new materials to be learnt by highlighting the organizational structural patterns of the materials and indicating how they relate to other materials already learnt.

The findings of this investigation have implications for improvement of science and technology in Nigeria. The action learning strategy has been found in this study to be found the most effective in improving the achievement and attitude of students in physics. Therefore, the sustenance of students' interest in science and technology can be achieved by the adoption of action learning strategy of instruction which if well planned can be encouraged and motivate the students to practice and apply the scientific knowledge gained to new situation by making use of the process skills of science. This could lead to the acquisition and development of technology in the country.

The two instructional strategies used had been adopted as option for creating understanding and meaning and to enhance learning. The result showed that not only the ability students benefited, the low and average appreciate physics more.

The result from this study also indicated that inculcation of actively engaged instructional strategies will improve the performance of students in physics particularly female students. When this is done the present alarming rate of students' failure and poor representation of female students in physics classroom will be reduced.

5.4 Conclusion

The result of the study have found out that the use of action learning and inquiry - based instructional strategies are both effective at improving achievement in and attitude of physics students' towards Physics than the conventional method.

Gender has a significant main effect on students' achievement in Physics with female students performing significantly better than male students but there was no significant main effect of gender on students' attitude towards Physics.

Numerical ability has a significant main effect on students' achievement in and attitude towards Physics. Students with numerical ability obtained the highest achievement score followed by students with medium numerical ability while students of the low numerical ability level obtained the least achievement score. Also, numerical ability of students' had a significant effect on their attitude towards physics across the treatment group and control.

The interaction effect of treatment and gender on students' achievement in and attitude towards Physics was not significant.

There was no significant interaction effect of treatment and numerical ability on students' achievement in and attitude towards Physics.

The interaction effect of gender and numerical ability on students' achievement in and attitude towards Physics was not significant.

The interaction effect of treatment, gender and numerical ability on students' achievement in and attitude towards Physics was not significant.

5.5 Recommendations

In view of the implications of the findings from the study, the following recommendations are made:

Physics teacher should make effective use of action learning strategy in the classroom in order to enhance the achievement of their students in the subject.

Publishers, federal and state ministries of education should sanitise on the use of action learning and thereafter organise conferences, seminars, and workshops for Physics teachers to acquit them with the use of action learning strategy in teaching various concepts in Physics. Physics teachers should also be encouraged to attend in-service training through government sponsorship in Nigeria.

The use of action learning strategy should not be limited to Physics as a subject, but should be incorporated in other science subjects.

Textbooks authors should emphasize action learning strategy as an instructional procedure that should be adopted by Physics teachers for effective teaching and learning of the subject.

Efforts should be geared towards the provision of science equipment necessary for enhancing the new strategy (action learning) by the government of Nigeria (state and federal), philanthropist, non-government organisations, private sectors and organisations.

There should be a monitoring team from state and federal ministries of education to check the on-going science education programmes for flaws or breakdowns, provision of information to regulate activities and undertake corrective actions. The inspection should focus on the effectiveness of the newly introduced strategies, maintenance of equipment for action learning and inquiry-based strategies improving students' achievement, attitude and quality of teaching.

Physics teachers should give relevant home work and assignment to students regularly.

Students should consult their teachers and fellow students whenever they have problems with a particular subject.

Parents and guardians should allocate specific time to their children for reading after school.

Parents, teachers, school counsellors and school administrators should concentrate much of their effort towards improving the achievement, mastery of the content matter and transfer of knowledge of students in physics and encouraging them to work collaboratively.

This research would suggest that order to encourage more women into pure science and science oriented courses, interventions need to be designed that focus not only on the academic achievement of girls but also, on how to make science-related occupations more interesting for young, high achieving girls. This type of intervention should start early in the academic careers for these young girls. Poor attitude to science subjects is one of the main reasons why many of these promising girls do not show interest in single science subjects at the secondary level and science-oriented courses at the nation's tertiary institutions respectively.

5.6 Limitations to the Study

- It was discovered that there are certain factors, which limited the generalizabilty of result of this study. These include the fact that the present study was conducted in only one Local Government Areas in Kwara State.
- The study was conducted only in public schools.
- Physics achievement score in this study was based on students' performance on selected abstract waves concepts only. No attempt was made to extend the coverage to other areas of Physics.
- Numerical ability of students was inferred from the equations and answers given by students during classroom interactions or in response to assignment. No attempt was made to make the students work individually rather the strategy adopted a whole class discussion method.
- Some instructional strategies used for this study have been applied by other experts and have produced valid results. However, a few additional ones used by the researchers were self generated and had no research backing for their usage. Therefore, they still need to be verified through other study before they could be adequately relied upon.
- Time limit was another constraint since the number of periods for the other subjects must not be disrupted.

5.7 Suggestion for further study

(1) Further research could also use the two strategies to teach other difficult concepts in Physics both at the secondary level and tertiary institutions most especially in private schools.

(2) Replication of the present study should be carried out on the extent to which the use of the two strategies can facilitate students' attitude towards Physics.

(3) More so, other moderator variables such as home background, locus of control cognitive style etc should be examined. This study can also be replicated in private schools.

(4) Further research should be carried out on the extent to which the use of action learning can facilitate achievement in other science subjects.

(5) There is need to replicate the study in other states of the federation.

REFERENCES

Abd-EL- Khalick, F. and Lederman, N. G 2000. Improving science teacher's conceptions of nature of science. A critical review of the literature. *International Journal of Science Education,* 22.7:665-701.

Abiakwo, D. E. 2002. Attitude to social implication of science, its measurement in Ogba, Ebema/Ndom L.G.A. of River State. *Proceedings of 43rd Annual Conference of STAN and Inaugural Conference* of CASTME Africa. 61-64.

Adar, L. 1969. *A theoretical framework for the study of motivation in education*. Jerusalem: The Hebrew University, School of Education.

Adedipe,V. O. 1986. Person logical correlates of academic achievement at secondary school level. *Nigerian Journal of Educational Psychology,* 1.1: 151-160.

Adeoye, F. A. 2000. Assessment procedure, cognitive style and gender as determinants of students' performance in hierarchical cognitive tasks in Physics. Unpublished Ph.D.Thesis. University of Ibadan, Ibadan.

Adepitan, J. O. 2003. Pattern of enrolment in physics and students' education of the contributory factor in Nigerian Colleges of Education. *African Journal Education Research* 9.1&2:33-35.

Adesina, A. D. and Akinbobola, A.O. 2005. The attitude of students towards part-time degree programme of the faculty of education, Obafemi Awolowo university, Ile-Ife. *Journal of Research in Education, 2.1:1-4.*

Adesoji, F. A. 2003. Modern strategies in the teaching of integrated science. *Teaching strategies for Nigeria secondary schools*. S.O. Ayodele (Eds). Ibadan: Power House Press Publishers 205-215

Adeyemi, K. and Akpotu, N. (2004). Gender analysis of student enrolment in Nigeria Universities. *Higher Education*. 48.3:361-378.

Afolabi, F. 2009. The effects of inquiry-based and competitive learning strategies on academic performance of senior secondary school students in physics. *International Journal of Social and Management Sciences*, 2. 2: 4 – 10.

Afolabi, F. and Akinbobola O. A. 2009. Constructivist problem based learning technique and the academic achievement of physics students with low ability level in Nigerian secondary schools. *Eurasian Journal Physics and Chemistry Education. 1.1: 45-51.*

Afuwape, M.O and Oludipe, D.I. 2008. Gender differences in integrated science achievement among preservice teachers in Nigeria. *Educational Research and Review* 3.7:242-245.

Ajelabi, P. A. 1998. The relative effectiveness of computer assisted and text assisted programmed instruction on students' learning outcomes in social studies. Unpublished PhD.Thesis. University of Ibadan, Ibadan.

Ajewole, G. A. 1991. Effects of discovery and expository instructional methods on attitude of students in Biology. *Journal of Research in Science Teaching.* 28.5:401-409.

Akinbobola, A. O. 2004. Effects of cooperative and competitive learning strategies on the performance of students in physics. *Journal of Research in Education* 1.1: 71-75.

___________. 2006. Effects of teaching methods and study habits on students' achievement in senior secondary school physics, using a pictorial organizer. Unpublished PhD. Dissertation. University of Uyo.

Akinbobola, A. O. and Ado, I. B. 2007. Hands-on and minds-on strategies for teaching of force: Guided discovery approach. In E.Udo, U. Uyoata, N.E.U. Inyang, H. Yero, & G. Bello (Eds.), *Hands-on and minds-on strategies in the teaching of force.* Proceeding of the Science Teachers Association of Nigeria

(STAN) primary science workshop. Uyo: Afahaide & Bros. Printing & Publishing co. 65-72.

Akinbobola, A. O. 2008. Facilitating Nigerian physics students' attitude towards the concept of heat energy. *Scientia Paedagogica Experimentalis* XLV.2: 353-366.

___________. 2009. Enhancing students' attitude towards Nigerian senior secondary school physics through the use of cooperative, competitive and individualistic learning strategies. *Australian Journal of Teacher Education*, 34.1: 1-9.

Akinbobola, O. A. and Afolabi, F. 2009. Constructivist practices through guided discovery approach: the effect on students' cognitive achievements in Nigerian senior secondary school physics. *Bulgarian Journal of Science and Educational Policy*. 3.2: 233-252.

Akinbote, O. 1999. Sex difference in the cognitive and affective outcomes in social studies of primary school pupils. *African Journal of Educational Research, 5*.1: 34-38.

Akinlaye, F. A. 1998. *Teacher-guided inquiry, guided-discussion and students' learning outcomes in some aspects of social studies.* Unpublished PhD Thesis. University of Ibadan, Ibadan.

Akpan, E. U. 1987. Wining students for science. A paper presented at the 28th annual conference of STAN, 17-22 August.

Alao, E. A. 1990. A scale for measuring secondary school students' attitude towards physics. *Journal of Science Teacher Association of Nigeria*. 26.2: 75-79.

Alant, B. 2004. Researching problem in introductory physics: Towards a new understanding of familiarity. *African Journal of Research in Mathematics, Science and Technology Education*, 8, 29-40.

Alexandria, K. and Larson, L. 2002. Teachers bridge to constructivism *The Clearing House,* 75.3:118 – 121.

Al-Methen, A. E and Willkinson, W. J. 1988. In support of a sociological explanation of sex differences in science and mathematics achievement: evidence for a Kuwuiti's study of secondary science certificate examinations. *Research in Science and Technological Education. 72. 1: 73-82.*

Ande, I. I. 1990. Effects of language of instruction on the learning conservation of weight and continuous quantity by primary two pupils. Unpublished Ph.D. thesis. University of Ibadan, Ibadan.

Anderson, L. W., and Krathwohl, D. R. 2001. A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives: Complete edition, New York: Longman.

Ani, R. O. 1993. Modification of people attitudes towards mathematics as an effective solution to science and mathematics education in Nigeria. In Obodo, G.C (ed) *Science and Mathematics Education- Nigeria: The Academic Forum.*

Amogu, N. K. 1993. *Sex and attitude as factors in mathmatics performance in the junior secondary schools*. Unpublished M.Sc (ED) thesis, University of Nigeria, Nsukka.

Angrist, S. S 1999. The study of sex roles. *Journal of Social Issues*.14.2: 19-20.

Applebee, A. N, Judith, A. L, Martin .N. and Adams, G. 2003. Discussion- Based approaches to developing understanding: classroom instruction and student performance in middle and high school English. *Educational Research Journal* 40.3:685-730.

Arigbabu, A. A and Mji, A. 2004. Is gender a factor in Mathematics performance among Nigerian pre -service teachers? *Sex Role* 51.11&12:749.

Ausubel, D. P. 1968. Educational psychology: a cognitive view. 2nd Ed. New York: Holt. Rinehart and Wiston.

Babikan, .Y. G. 1994. An empirical investigation to determine the relative effectiveness of discovery, laboratory and expository methods of teaching science concepts. *Journal of Research in Science Teaching.* 28.3:201-209.

Bainchini, J. A. and Solomon, E. M. 2003. Constructing views of science tied to issues of equity and diversity. A study of beginning science teachers. *Journal of Research in Science Education*, 22.7: 665-710.

Baird, D. 1997. Is physics classroom any place for girls? Unpublished MPhil thesis.University of Michigan.

Baker, D. R. and Piburn, M. D. 1997. Constructing science in middle and secondary school classroom, U.S.A: Allyn and Bacon.

Balogun, T. A. 1985. Interests in science and technical education in Nigeria. *Journal of Science Teachers' Association of Nigeria.* 23.1&2:92-99.

Bassock, M. 1990. Transfer of domain- specific problem solving producers. *Journal of Experimental Psychology: Learning Memory and Cognition, 16.3: 522-533.*

Basu, J. and Chakroboty, U. 1996. Effects of sex role identity on academic achievement of late adolescent in Indian. *Journal of Social Psychology*, 13.2: 257-259.

Bayer, B. K. 1971. Inquiry in the social studies classroom: a strategy for teaching. *Biology Teacher* 37.7: 411.

Benedict, N. 1990. Effects of two types media presentation on affective and psychomotor performances of fine arts students. *Journal Studies in Curriculum*, 1.1:1-9.

Biggs, J. 1995. Teaching for better learning. In J.Biggs and D Wattins (Eds), classroom learning: Educational Psychology for Asian teachers. 261-279. Singapore : Prentice Hall.

Bilesanmi-Awoderu, J. B. 2001. The relationship between Nigerian high school seniors' performance in theory and practice biology. *Ife Psychological* 9.1:134-140.

Birch Ann and Hayward Sheila 1994. Individual Difference: introductory psychology series. The Macmillian press ltd, Hong kong.

Bloom, B. S., Engelhart, M. D., Furst, E. J, Hill, W. H., Krathwohl, D. R. Eds. 1956. Taxonomy of Educational Objectives: Cognitive Domain. New York David Mackay Co.

Bloom, P., Benjamin S. and Krathwohl, D. R. 1956. Taxonomy of educational objectives: the classification of educational goals by a committee of college and university examiners. Handbook 1: Cognitive domain. New York, Longmans.

Bolaji, C. 2000. Gender difference and the use of two approaches in the teaching of algebra. *Kano Journal of Education* 3. 1:24-35.

Bolderg, J. F and Lewis, H. S 1996. Diagonistic study of gender difference in instructional materials utilization. Hongkong: *Science Teachers' Journal*. 2. 10: 29-32.

Brandon, P., Newton, B., and Hammond, O. 1987. Children's mathematics achievement in Hawaii: Sex differences favoring girls. *American Educational Research Journal*, *24*. 437–461.

Bruner, J. S. 1960. *The process of education*. E,Cambridge, Massachusetts: Harvard University Press.

Bruner, J. S. 1968. Toward a theory of instruction. New York: W. W. Norton & Company, Inc

Brooks, J. G. and Brooks, M. G. 1993. The case for constructivist classroom. Alexandria,va: association for supervision and curriculum development.

Bryne, E. 1978. Women and Education. London: Taristock

Cavallo, A. M. I. and Shafer, L. E. 1994. Relationships between students' meaningful learning orientation and their understanding in genetics topics. *Journal of Research in Science Teaching*, *31*:393-418.

Cavallo, A. M. 1996. Meaning learning, reasoning ability and students' understanding and problem solving of topics in genetics. *Journal of Research in Science Teaching*, 33.625-656.

Cavallo, A. M., Potter, W. H., and Rozman, M. 2004. Gender difference in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics.* 104. 288-300.

Chandavarkar, S. M., Doran, R. L. and Jacobson, W. J. 1991. Achievement of US high school physics students. *The Physics Teacher*, 29. 9:387-393 .

Changeiywo, J. A. 2001. Gender perspective in science and technology education in Kenya. *Journal of Education and Human Resources*, 1.1: 14-31.

Chambers, A. and Hale, R. 2007. Keep walking: Leadership learning in Action, RHA publication, UK.

Chipman, S. and Thomas, V. 1987. The participation of women and monitories in mathematics, scientifical and technical fields. In E. Rothkopf (Ed). Washinghton, D.C American educational research association. *Review of Research in Education*, 14.387-430.

Chiu, M. H. 2001. Algorithmic problem solving and conceptual understanding of chemistry by students at a local high school in Taiwan. Proc. National. Science Counsel. proc. National Science Counsel. Available from Worldwide Web: http:// herdsa.org.au/vic/cornerstones/pdf/chiu.PDF

Chartered institute of personnel and development 2007. Learning and Development Survey

Clabaugh, G.K (Ed.) 2009. New foundations, Jerome Brunner's educational theory. Retrieved Nov., 20,2010 from http:// www.new foundations.com/GALLERY/Bruner/html.

Clement, J. J. 1993. Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching* 30.10: 1241-1257.

Cobb, P., Yackel, E and Wood, T. 1992. A constructivist alternative to the representational view of mind in mathematics Education. *Journal of Research in Mathematics Education*. 23.1: 2-33.

Cobb, P. 1996. Where is the mind? A coordination of sociocultural and cognitive constructivist perspectives. In C. T. Foston (eds), *Constructivism: Theory, Perspectives and Practice*, 34-52. New York: Plenum.

Cognition and Technology group at Vanderbiit. 1996. Looking at technology in context: A framework for understanding technology and education research. In D.C Berliner and R.C. Calfee (Eds.,). *The handbook of educational psychology*. New York: Simon and Schuster-Macmillan 807-840.

Cohen, H. G. 1992. Two teaching strategies: Their effectiveness with students of varying cognitive abilities. *School Science and Mathematics, 92*.126-132.

Cohen, E. G. 1994. Restructuring the classroom: Condition for productive small groups. *Review of Educational Research* 64.1:1-35.

Colley, K. E. 1997. Does the acquisition of science process skills in a project based science curriculum differ by gender? An exploratory study of middle and high school students' experience. *Dissertation Abstracts International* 57.7:29-51.

Copley, J. 1992. The integration of teacher education and technology: A constructivist model. In technology and teacher education annual 1992. In D. Carey. R. Carey, D. Willis, and J. Wills, Charlottesville, Va: Association for the advancement of computing education.

Cohen, L., Manion, L. and Morrison, K. 2004. A guide to teaching practice, London, Routledge Falmer, Taylor and Francis Group.

Crawley, F. E., and Black, C. B. 1992. Causal modelling of secondary science students intentions to enroll in physics. *Journal of Research in Science Teaching*, *29*,.585-599.

Dagoli, A. J. 2000. The effects of teaching methods on students' achievement in geometry. *Journal of Education Studies* 4, 81-88.

Das, R. S. 1985. *Science teaching in School*. New Delhi: India.

David, K. D and Stanley, H. L. 2000. Effect of gender on computer-based chemistry problem solving. *Electronic Journal of Science Education* 4,4: 10-14.

Dean, R. H. (2000)- A wave is a wave-so where is the difficulty? *Physics Education*. 15, 373-375.

Dewey, J. 1910. *How we think*, New York: Dover Publications.

Diejomaoh, G. O. 1986. The relative effectiveness of three methods of teaching chemistry in secondary schools of Bendel State of Nigeria. Unpublished Ph.D. Thesis, University of Ibadan, Ibadan.

Dilworth, R. L. 1996. Action Learning: bridging academic and workplace domains. *The Journal of Workplace Learning*, 8.6: 48 – 56.

Dixon, N. 1998. Action learning: more than just a task force. *Performance Improvement Quarterly*, 11.1: 14.

Dogru, G, and Kalender. 2007. Applying the subject 'Cell" through constructivist approach during science lessons and the teacher's view. *Journal of Environmental and Science Education*. 2. 1:3-13.

Donnellan, C. 2003. Does sex make a difference? An equalities peak for young people on international women's day. *The Gender Issues*, 64. 14-17.

Ebenezer, J. V. and Zoller, U. Grade 10 students' perception of and attitude towards science teaching and school science. *Journal of Research in Science Teaching*, 30.2: 175-186.

Egbugara, U. O. 1986. Poor performance in physics: implications for national development in mass failure in public examinations causes and problem(ED) Proceedings of the national conference on mass failure in public examinations. April 21-25. 228-235.

Eggen, P and Kauchak, D. 1999. Educational psychology: windows on classrooms, upper saddle river, NJ: Merrill, Prentice Hall.

Ehindero, O. J. 1985. Correlates of physics achievement: The role of gender and non-induced student expectations. *Journal of Experimental Education*, 54. 1: 89-192.

Ehindero, S. 1986. *Curriculum foundations and development for Nigerian students.* Lagos: Concept Publishers.

Emovon, E. U. 1985. *Sciencing –Nigerian Experience*. Key note address delivered at the 26th STAN Annual conference. Conference proceedings: 7-10.

Entwistle, N. 1993. Styles of learning and teaching. London. David Fulton Publishers.

Erickson, F. 1986. Quality methods in research on teaching. In M.C. Wittrock (eds.), *Handbook of Research on Teaching. 119-161*. NewYork:Macmillian.

Eryılmaz, A. 1992. Students' Preconceptions in Introductory Mechanics. Unpublished Mastery Thesis, Middle East Technical University, Ankara, Turkey

Erinosho, S. U. 1994. Perspective on women in science and technology in Nigeria. FME blue print on women education in Nigeria, Lagos: NERDC press.

Erinosho, Y. E. 2005. Women and science. 36th inaugural lecture, Olabisi Onabanjo university, Ago-Iwoye 1. 37.

Federal Republic of Nigeria 2004. *National policy on education*, Lagos: NERDC.

Fennema , A. and Sherman, J. A. 1996. Mathematics attitude and scale. *Journal of Research in Mathematics Education.* 6. 7:101.

Field, J., 2003, A two-week guided inquiry project for an undergraduate geomorphology course, *Journal of Geoscience Education*, 51. 255-261.

Finkelstein, N. 2003. Coordinating physics and education instruction. *Journal of College Science Teaching*, 33.1: 37-42.

Furner, J. M and Duffy, M. L. 2002. Equity for all students in the new millennium: Disabling math anxiety. *Intervention in School and Clinic 38*. 2: 67-74.

Free, A.B. 2002. Constructing constructivism: the voyage of elementary science teachers. http://www.lib.umi.com/dissertation s/preview_all/9907900. Retrieved on 13 October, 2011.

Gaigher, E. 2004. Effects of a structured problem solving strategy on and conceptual understanding of physics: A study in disadvantaged South African schools. PhD thesis, University of Pretoria. http://upetd.up.ac.za/thesis/available/etd-02022006-160908. Retrieved on January, 10, 2008.

Gardner, P. L. 1975. Measuring attitudes to science. *Research in Science Education, 25.3:283*-2995.

Gagne, R. M. 1980. The conditions of learning. New York Holt, Rinehart and Winston.

Glasersfield, V. E. 1995. Radical constructivism: *A way of knowing and learning*. London: Falmer Press.

Graffit, B. 2004. Effects of values clarification and action learning on students' environmental problem- solving skills and attitudes. *Journal of Environmental Values Education.* 91. 23: 23-29.

Guetzekey, C. J. 1998. Pupils' preference for science subjects. *British Journal of Educational Psychology*. 7.8:101-189.

Guthrie, E. E. 2004. Increasing reading comprehension and engagement through concept-oriented reading instruction: *Journal of Educational Psychology, 96*. 3: 403–423

Gupta, R., Ashley, A. and Rosenstein, A. 2005. "Implementing Action Learning in Marketing Research Courses." Proceedings of Northeast Decision Sciences Institute.

Hacker, J. 1992. Sex differences in science achievement. *Journal of Educational Psychology, 524-552*.

Haggarty, S. M. 1995.Gender and teacher development: issues of power and culture. *International Journal of Science Education*, 17.1:1-15.

Hakes, R. R. 1998. Interactive-engagement versus traditional method: A six thousand student survey of mechanics test data for introductory physics courses. *America Journal of Physics*, 66.1: 64-74.

Hales, L. and Hartman, T. 1978. Personality, sex and work values. *Journal of Experimental Education*.46. 16-21.

Halpern, D. F., Hanson, C. and Riefer, D. 1990. Analogies as an aid to understanding and memory. *Journal of Educational Psychology* 82: 298-305.

Hand, B. and Treagust, F. D. 1991. Student achievement and science curriculum development using a constructive framework. *School Science and Mathematics, 91:* 172-176.

Hanna, G. 1989. Mathematics achievement of girls and boys in grade eight: Results from twenty countries. *Educational Studies in Mathematics, 2.* 225–232.

Harvey, T. V. 1980. The relative importance of physics of school and university for male and female. *School Science Review*. 16. 217:774-778.

Haury, D. L. 1992. Recommended curriculum guides. In science curriculum resources handbook. Millwood, NY: Kraus International publications.

Havard , N.1996. Students' attitudes to studying A-Level. *Public Understanding of Science*, 5. 4:321-330.

Hermann, G. 1969. Learning by discovery: A critical review of studies. *Journal of Experimental Education, 38*: 59-72.

Hersh, R. H., and Merrow, J., 2005. Declining by degrees: Higher education at risk, New York, Palgrave Macmillan, 256.

Hazari, . Z. & Potvin, G. 2005. Views on female under-representation in physics: retraining women or reinventing physics? *Electronic Journal of Science Education*,10.1:101-122.Retrieved June 20,2009 from http://wolfweb.unr.edu/homepage/crowther/elbe/potvin.pdf.

Hestenes, D. 1987. Towards a modeling theory of physics instructions. *American Journal of Physics 60.7:440-454.*

Hmelo-Silver. A, Duncan. D, and Chinn.C. 2007. Scaffolding and achievement in problem-based and inquiry learning. *Educational Psychologist 42*.2: 99–107.

Hodson, D. 1990. A critical look at practical work in school science. *School Science Review,* 71. 33-40.

Hodson D. and Hodson, J. 1998. From constructivism to social constructivism: a vygotskian perspective on teaching and learning science. *School Science Review*, 79.2: 33-41.

Humrich, E. 1988. Sex differences in the second IEA study-US results in an international context. *ERIC Document Reproduction Service,* 292-649.

Ibeagha, E. J. 1986. Instructional strategies of University trained physics teachers as correlates of learning outcomes in secondary school physics. Unpublished Ph.D Thesis, University of Ibadan, Ibadan.

Ibitoye, S. J. 1998. Gender difference and achievement in secondary school agricultural science in Kwara State. *Nigerian Journal of Technical Education*. 6.1:148-153.

Iroegbu, T. O. 1998. Problem based learning, numerical ability and gender as determinants of achievements problems solving line graphing skills in senior secondary physics in Ibadan. PhD. Thesis. University of Ibadan, Ibadan.

_________. 2004. *Enwisdomization and African philosophy*. Owerri: International press Ltd.

Ikitde, G. A. 2008. Comparative effect of riverine and upland schools' location on Biology students' achievement. *Sciential Pedagogical Experimentalis* XLV. 2267-280.

Ikwa, E. O. 2002. Competency of Physics students in maths and their performance in Physics in difficult concepts. Unpublished M.Sc (Ed) thesis, University of Uyo, Uyo.

Imobekhai, S. Y. 1988. The influence of self- concept, school environment and gender on students' psychological adjustment and study behaviour. *Nigerian Journal of Counselling and Development,* 2. 1:1-7.

Ivowi, U. M. O. 1985. Students' misconceptions about motion. *Journal of Research in Curriculum,* 3.2: 57-64.

Ivowi, U.M.O. 1997. Redesigning school curricula in Nigeria, WCCI region 2 seminar, NERDC conference centre, Lagos. 2-21.

Johnson, D. W., Johnson, R. T. and Holubec, E. J. 1991. Cooperative in the classroom Interaction Book Co., Edina.

Jonassen, D. H. 1991. Objectivism versus constructivism: Do we need a new philosophy paradigm? *Educational Technology Research and Development 39: 5-14.*

_________. 1994. Thinking technology: Towards a constructivist design model. *Educational,* 34.3: 34-37.

Jonassen, D. H., Peck, K. L and Wilson, B. G. 1999. Learning with technology: A constructivist perspective, New Jersey:Prentice Hall.

Jonassen, D. H. 2000. *Computer as mind tools for schools:* Engaging critical thinking (2nd Ed.), New Jersey: Prentice Hall.

Jones, J. 1990. Outcomes of girls, schooling: unravelling some social differences. *Australian Journal of Education*. 3.2:153-167.

Jones, E. P. 2001. Gender and mathematics attitude of students in Arkansas. Ph.D Dissertation, University of Memphis. Retrieved from www.lib.umi.com/dissertation/results. Chicago: Scientific Software International Inc.

Kahle, J. B, Meece, J and Scantlebury, K. 2000. Urban African-America middle school science students: Does standards-based teaching make a difference? *Journal of Research in Science Teaching*, 37, 9:1019-1041.

Kahn, M. 2004. For whom the school bell tolls: Disparities in performance in senior certificate mathematics and physical science. *Perspectives in Education*, 22. 149-156.

Kaptan, F. and Korkmaz, H. 2002. Probleme Dayalı Öğrenme Yaklaşımının Hizme Öncesi Fen Öğretmenlerinin Problem Çözme Becerileri ve Öz Yeterlik İnanç Düzeylerine Etkisi. *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Bildiri Kitabı*, II, Ankara.

Karplus, R. 1977. *Journal of Research in Science Teaching*, *14*, 169.

Keeves, J. P. 1991. Sex differences in ability and achievement in Hasten,T. and Postlethwaite.

Kempa, R. F. and Diaz, M. M. 1990a. Motivational traits and preferences for different instructional modes in science. Part 1. *International Journal of Science Education*, *12*: 194-203.

_______________ 1990b. Motivational traits and preferences for different instructional modes in science. Part 2. *International Journal of Science Education*, *12*: 205-216.

Kelly, P. T. 1994. Science and elementary education. *Teachers College Record*.12:182.

Keller, C. K., Allen-King, R. M., and O'Brien, R., 2000, A framework for integrating quantitative geologic problem solving into courses across the undergraduate geology curriculum, *Journal of Geoscience Education*, 48. 459-463.

Kenya National Examinations Council, 2005. *Kenya National Examinations Council Regulation and syllabus (2006-2007).* Nairobi: Self.

Kim, T. 2005. The effects of a constructivist teaching approach on students' academic achievement, self- concept and learning strategies. *Asia Pacific Education Review*. 6. 1: 7-19.

Kirschner, A, Sweller, C. and Clark, O. 2006. Reading, Stephen Downes, Nov., 12.

Kletzy, N. E. 1980. The effect of two methods of teaching abstract topics in high school chemistry. Unpublished M.A. dissertation: Sam Houston State University.

Kleeves, J. P. and Ai-Kenhead, G. 1995. *Science curriculum in a changing world.* Ed. Fraser.

Kober, N. 1993. What we know about science teaching and learning. Washington, DC: Council for Educational Development and Research.

Kramer, R. 2007. How might action learning be used to develop the emotional intelligence and leadership capacity of public administrators? *Journal of Public Affairs Education* 13.2: 205-230.

Labudde, P. W., Herzog, W. Pneueschwander, M, Violi, E and Garber, C. 2000. Girls and Physics: teaching and learning strategies tested by classroom interventions in grade 11. *International Journal of Science Education.* 22.2: 143-157.

Lebow, D. 1995. Constructivists' values for instructional systems design: five principles towards a new mind set. *Educational Technology Research and Development.* 41.3: 4-16.

Laura, A. R. 2006. Why are there so few female physicists? *The Physics Teacher,* 44. 177-180

Lawson, A. E. 1975. Developing formal thought through biology teaching. *American Biology Teacher,* 37.7:411.

___________. 1978. Development and validation of the classroom test of formal reasoning. *Journal of Research in Science Teaching, 15*, 11-24.

Lawson, A. E. and Bealer, J. M. 2000. What kinds of scientific concepts exist? Concept construction and intellectual development in college biology. *Journal of Research in Science Teaching*. 37. 996-1018.

Lawson, J, Beaty. L, Bourner, T, & O'H ara, S. 1997. Action learning Comes of age part 4; where and when? *Education and training* 39.6: 66-70.

Leiuhardt, G, Seewald, A and Engelra, B. 1997. Learning, what is taught: sex difference in instructions. *Journal of Educational Psychology*. 60.24: 90.

Linn, M. 1985. Fostering equitable consequences from computer learning environments. *Sex Roles,13,* 229–240.

Linn, M. and Hyde, J. 1989. Gender, mathematics and science. *Educational Research, 18. 17-27.*

Lovell, K and White, G. E. 1995. Some influences affecting choices of subjects in schools and training colleges. *British Journal of Education*. 16.7:25-27.

Marlowe, B. A. and Page, M. L. 1998. Creating and sustaining the constructivist classroom, U.S.A: Corwin press.

Marsick, V. 1998. Learning in the workplace. London: Croom Helm.

Marquardt, M. J. 1999. Action learning in action. Middle and high school students IV Palo Alto, CA:Davies-Black.

____________. 2004. Harnessing the power of action learning. *TD,* 58.6: 26–32.

McCarty, T. L, Regina, H. L, Stephen, W. and AaCita, B 1991. Classroom inquiry and Navajo learning styles: A call for reassessment. *Anthropology and Education Quarterly,* 22.1:42-59.

Mclnnis, C., James, R. and Hartley, R. 2000. Trend in the first year experience: in Australian Universities. Melbourne. Dept., of education, training and youth affairs.

Meyer, R. E and Font, J. T. 1992. A cluster analysis of high school science classroom environments and attitude towards science. Journal of Research in Science Teaching. 9: 929-937.

Meyer, R. E. 1999. Multimedia learning: are we asking the right questions? *Education Psychologist* 32: 1-19.

Meltzer, O. 2002. The relationship between mathematics preparation and conception learning gains in physics: A possible “hidden variable” in diagnostic pretest scores. *American Journal of Physics.* 70. 12:1259-1268.

Merrill, M. D. 2007. A task-centred instrutional strategy. *Journal of Research on Technology in Education*, 40.1: 33 – 50.

Mills, H. R. 1991. *Teaching and training:* A handbook for instructors (3rd ed). London: Macmillan Publishers.

Milton, L. P. 1995. Sex role and technical achievement in adolescents. *American Journal of Educational Research*. 43. 3:229.

Moreira, M. A. 1978. Experimental college physics course based on Ausubel's learning theory. *Science Education*. 62: 529-545.

Mohanty, S. 2003. *Teaching science in secondary schools*, New Delhi: Deep & Deep Publications PVT Ltd.

Mumford, A. 1996. Authors and authorities in action learning. England:MCB University Press Ltd.

National Research Council 1996. *National science education standards*.Washington, DC: National Science Press.

______________. 2000. *National science education standards*.Washington, DC: National Science Press.

______________. 2006. *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

Nakhleh, M. B. 1993. Are our students' conceptual thinkers or algorithmic problem and problem solving of topics in genetics? *Journal of Research in Science Teaching* 33: 625 – 656.

NERDC.1994; 2008. Nigerian Educational Research and Development Council. Lagos: NERDC.

Nurrenbern, S. C. and Pickering, M. 1987. Concept learning versus problem solving: Is there a difference? *Journal of Chemical Education*. 64 .6: 508-510.

Nguyen, F, Clark, R and Sweller, J. 2006. Efficiency in learning: evidence-based guidelines to manage cognitive load. San Francisco: Pfeiffer. ISBN 0-7879-7728-4.

Nwagbo, C. 2001. The relative efficacy of guided inquiry and expository methods on the achievement in biology of students of different levels of scientific literacy. *Journal of Science Teachers Association of Nigeria*,36.1&2:43-51.

Nwagwu, H. O. 1981. Sex difference in the manifestation of behavioural problems in Nigeria schools children. *African Journal of Education Research*, 4.2:1-8.

Nwasofor, C. C. 2001. Cultural impedements on women in science technology and mathematics education. STAN conference proceedings 20-25 August.

Oakes, J. 1990. Opportunities, achievement, and choice: Women and minority students in science and mathematics. In C. B. Cazden (Ed.), *Review of Research in Education, 16*.153–222. Washington, DC: American Educational Research Association

Odubunmi, E. O. and Balogun, T. A. 1995. The attitude of some Nigerian students towards integrated science. *Journal of Research in Curriculum*1.3:123-125.

Oduro-Mensah, E. O. 1987. Effects of science related attitude and teaching strategy on achievement in high school Biology. Unpublished Ph.D thesis, University of Ibadan, Ibadan.

Ogunleye, W. 1993. Strategies for teaching physics for learning gain in the senior secondary school: a guide to teachers. *Journal of Science Teachers' Association of Nigeria,* 28.1 &2: 151-156.

_____________. 1996. Level of acquisition of process skills among some physics students and implications for science education. *Journal of Science Teachers Association of Nigeria.* 31.1&2:39-46.

Ogunleye, A. O. 1999. Science education of Nigeria: Historical development, curriculum futures and research, Ibadan: town Publishers.

Okebukola, P. A. O. 1992. Can good concept mappers be good problem solvers?" *Education Psychology*, 12. 2: 113 – 129.

Okeke, E. A. C 1999. Sex differences in the understanding of important biological concepts. *Nigerian Journal of Education,* 12.1:124-132.

Okoronka, A. U. 2004. Model based instructional strategies as determinants of students' learning outcomes in secondary Physics in Lagos State. Unpublished Ph.D Thesis University of Ibadan, Ibadan.

Okpala, P. N. 1995. Science and technology education for all in UNESCO/ BREDA. *Reports on the state of education in Africa 95-99.*

Okpala, N. P. 1998. Students' factors as correlates of achievement in physics. *A Journal of British Institute of Physics,* 23.6:361-365.

Okpala, N. P and Onocha, C. O 1998. The effect of systematic procedures on students' achievement in mathematics and science subjects. *UNESCO-AFRICA. (A six month Journal of Darkar UNESCO, Regional office in Africa) 10. 55-61.*

Oludipe, D. I. 2012. Gender difference in Nigerian junior secondary students' academic achievement in basic science. *Journal of Educational and Social Research* 2.1:93-99.

Omrod, J. 1995. Educational psychology: principles and applications. Englewood Cliff, N.J: Prentice-Hall.

Onyehalu, A. S. 1996. Sex differences in the acquisition of conservation among Ibo speaking children of Nigeria. *Journal of Education in Africa*. 2.1:119-128.

Onyejiaku, F. O. 1987. Technique of effective study. A manual for students in schools, colleges and universities. Calabar: Wasen Press Ltd.

O'Hara, S., Webber, T and Murphy, W. 2001. The joy of set: people management, 8th February.

O'Hara, S., Bourner, T. and Webber, T. 2004. Practice of self managed action learning. *Action Learning: Research and Practice*, 1.1: 29-42.

Orji, A. B. 1998. Effects of problem solving and concept mapping instructional strategies on students' learning outcome in physics. Unpublished PhD Thesis, University of Ibadan, Ibadan.

Orende, W. and Chesos, R. 2005. Radical changes made. *The Daily Nation Nairobi, Kenya:* Nation Media Group Ltd.

Osokoya, M. M. 1998. Mathematical knowledge and skills required by Nigerian secondary school students in learning school science. *Journal of the Science Teachers Association of Nigeria, 18.1: 69-75.*

.

Omwirhiren, E. M. 2002. The effect of guided discovery and traditional methods on the achievement of SSCE students in chemical energetics. *Africa Journal of Research in Education*, 2.1&2:21-24.

Onadeko, A. A. 2009. Effects of numerical and graphing supplementary instructions on senior secondary students' learning outcomes in Physics. Unpublished Ph.D Thesis, University of Ibadan, Ibadan.

O'Neil, J. and Marsick, V. J. 2007. Understanding Action Learning. NY: AMACOM Publishing.

Onibokun, O. N. 1999. Evaluation of social studies. In Obemata J.O. etal.(eds.). Evaluation in African in honour of E.A Yoloye. 40- 59.

Onwuegbu, O. C. 1998. Effects of cognitive style, study habit and instructional strategies on students' learning outcomes in senior secondary school Physics in Delta state. Unpublished Ph.D. Thesis, University of Ibadan, Ibadan

.

Ownioduokit, F. A. 1996. Difficult concepts in physics as experienced by senior secondary students in Akwa Ibom State Nigeria. *Journal of Research Information in Education*.1.1:19-28.

_______________2000. Knowledge of mathematics as a predictor of students' performance in Physics. *Nigerian Journal of School Science Education,* 6.1:9-15.

Ownioduokit, F. A. and Ikwa, E. O. 2000. Enriching physics education in Nigeria to cope with the challenges of the present millennium. 41st Annual conference proceeding of Science Teachers' Association of Nigeria.

Pedler, M, Brook, C and Burgoyne, J. 2003. Flexible working people management 17th April, 2003.

Piaget, J. 1954. Constructivist of reality in the child. New York : Basic Books.

____________1964. Development and learning. *Journal of Research in Science Teaching, 2:* 176-186.

___________ 1965. The origin of intelligence in children. Translated by Cook, Margret. New York: International University Press.

Putman, H. and Hansen A. 1978. Sex differences in self –concept. Variables and variables and vocational attitude, maturity of adolescents. *Journal of Experimental Education*, 46: 23-27.

Poepping, .N. and Mella, I. 2001. Ueben Im Chemieuntencht.Der mathematische *un Naturue, ssenschattliche unterncht,* 54:417-419.

Quaiser-Pohl,C. and Lehman, W 2002. Girls' spatial abilities: charting the contributions of experiences and attitudes in different academic groups. *British Journal of Educational Psychology* 72.2:245-260.

Raghurbir, K. P. 1979. The effects of prior learning outcomes in student achievement and retention in science instruction. *Journal of Research in Science Teaching, 16*: 301-304.

Raimi, S. M. and Adeoye, F. A. 2002. Gender difference among college students as determinants of performance in integrated science. *African Journal of Science Education*, 20. 9: 1043-1059.

Ramsden, J. 1998. Mission impossible: Can anything be done about attitudes to science? *International Journal of Science Education*, *20*. 125-137.

Reddish, E. F. 1994. Implications of cognitive studies for teaching physics. *American Journal of Physics, 62. 796-803.*

Reddish, E. F, Saul, J. M and Steinberg, R. N. 1998. *American Journal of Physics,* 66. 212-224.

Resnick, L. B. 1986. *Learning to Think.* Washington, D.C.: National Academy Press.

Reid, N. 2003. Gender and Physics. *International Journal of Science Education,* 25.4:509-536.

Revans, R. W. 1998. *ABC of action learning*. London: Lemos and Crane.

Robertson, H. J. 1988. The idea book: A resources for improving the participation and success of female students in maths, science and technology. Ottawa: Canadian Teachers' Federation.

Robinson, M. 2001. It works but is it action learning? *Education and Training*.43. 2:64-71.

Robinson, W. R. and Niaz, M. 1991. Performance based on instruction by lecture or by interaction and its relationship to cognitive variables. *International Journal of Science Education,* 13. 203-215.

ROC(D). 11. 1: 20-38. [Online]. [Accessed Jun 10, 2003]. Available 2011.

Rowell, J. A., Simon, J., and Wiseman, R. 1962. Verbal reception, guided discovery and the learning of schemata. *British Journal of Educational Psychology, 39*: 235-244.

Sadker, M, Sadker, D and Klein 1991. The issue of gender in elementary and secondary education. In G. Grant (Ed.), review of research in education Washington D.C. *American Educational Research Association*, 17. 269-234.

Samuel, W. W and John, G. M. 2004. Effects of cooperative class experiment teaching method on secondary school students' chemistry achievement in Kenya's Nakuru district. *International Education Journal* 5.1:26-35.

Sawchuk, P. H. 2003. Adult learning and technology in working class life. NewYork: Cambridge.

Schneider, L. S. and Renner, J. W. 1980. Concrete and formal teaching. *Journal of Research in Science Teaching, 17*: 503-517.

Schibeci, R.A. 1984. Attitudes in science: An update. *Students Science Education. 11:26-59.*

Schunk, D.H and Hanson, A.R. 1985. Peer models: Influence on children's self-efficacy and achievement. *Journal of Education Psychology*. 77:33-322.

Schunk, D. H. 2008. Learning theories (5th ed.,) upper saddle river, N.J pearson education, Inc

Scott, A. N. 2004. How does cooperative group work versus independent practice on the learning of some problem solving strategies? *School Science and Mathematics*, 1.2:25-30.

Scruggs, T. E and Mastropieri, M. A. 1993. Reading versus doing: the relative effects of textbook based and inquiry-oriented approaches to science learning in special education classrooms. *Journal of Special Education*, 27.1: 1-15.

Shayer, M. and Adey, P. S. 1993. Accelerating the development of formal thinking in middle and high school students IV: three years after a two year intervention. *Journal of Research in Science Teaching*. 30: 351-366.

Shrigley, R. L., and Koballa, T. R., Jr. 1987. *Applying a theoretical framework: A decade of attitude research in science education.* University Park: The Pennsylvania State University, Department of Curriculum and Instruction.

Simon, S. 2000. Students' attitude towards science. In M. Monk and J. Osborne (Eds). Good Practice in Science Teaching (What Research has to say). 104-119. Open University Press Buckingham.

Simpson, R. D. and Troost, K. M. 1982. Influences of commitment and learning of science among adolescent students. *Science Education*, 66.5: 763-781.

Simpson, R.D. and Oliver, J.S. 1990. A summary of the major influences on attitude towards and achievement in science among adolescent students. *Science Education*, 74.1:1-8.

Skaalvick, E. M. 1990. Gender differences in general academic self esteem and success expectations on defined academic problem. *Journal of Education Psychology*, 42. 3: 593-598.

Smith, B. D. 1998. Psychology. (6th ed.), McGraw-Hill Companies Inc., U.S.A. p.30.

Smith, P. A .C and O'Neil, J. 2003. A review of action learning literature 1994-200 Part 1 – bibliography and comments. *Journal of Workplace Learning* 15.2: 63-69

Smith, B. L and MacGregor, J. T. 1992. What is collaborative learning? Collaborative learning: A sourcebook for Higher Education: 9-22.

Solomon, J. 1989. The social construction of pupils' science. In Millard, R (Ed.) Doing science: images of science and science Education. Lewes, Falmer Press.

Soyemi, M. O. 1985. Cognitive and affective outcomes of three instructional strategies in secondary school mathematics. Unpublished Ph.D thesis, University of Ibadan,Ibadan.

Sophia, A and Merza, A. 2006. The effects of inquiry-based computer simulation with cooperative learning of scientific thinking and conceptual understanding. *Malaysia Online Journal of Instructional Technology, 3.2: 1-16*.

Statistics Canada 1989. Education in Canada. A statistical review for 1988-1989 (cataloque 81-229). Ottawa: ministry of supply and services.

Stephen, J. 1991. *Impacts of an integrated learning system on third-, foruth-, and fifth- grade mathematics achievement*. Doctorial dissertation, Baylor University. Dissertation abstract international, ix+52 pp UMI Number: AAG 9132228).

Stephen, M. and Sandra, M. 2006. Gender and students achievement in English schools. London. Centre of economics education, London school of economies. Sterling Publishers.

Sunberg, M. D and Dini, M. L. 1994. Decreasing course content improves student comprehension of science and attitudes toward science in fresh biology. *Journal of Research in Science Teaching.* 31. 6:679-693.

Sweller, J. 2003. Evolution of human architecture. In B.Ross(Ed.), the psychology of learning and motivation. San Diego: Academic press. ISBN 0125433433.

Sweller, J. and Clark R.E (2006). Scaffolding achievement in problem-based and inquiry learning. *Educational Psychology* 93.3:403-423.

Talton, E. L. and Simpson, R. D. 1986. Relationships of attitude toward self, family and school with attitude towards science among adolescent. *Science Education,* 70.4: 365-374.

Tobias, S. 1990. They're not dumb, they're different: stalking the second tier, Research cooperation, 192.

Trembath, R. J and White, R. T 1979. Mastery achievement of intellectual skills. *Journal of Experimental Education.*45: 172-192.

Trice, A. G. and Dey, E. L. 1997. Trends in faculty, teaching goals: A longitudinal study of change. *Journal of College Student Development*. 38:527-534.

Tamir, P. 1988. Gender differences in high school science in Israel. *British Educational Research Journal*, *14.* 127–140.

Thomas, K. 1990. *Gender and subject in higher education.* Milton Keynes: Open University Press.

Turner, J. 1997. Psychology for classroom. London: Oxford University Press.

Twomey-Fosnot, C. 1989. *Enquiring teachers, enquiring learners: a constructivist approach for teaching.* New York: Teachers College Press.

Udoukpong, B. E. 1993. Effects of the instructional techniques on students' attitude to social studies education. *Journal of Education*. 2.1: 234-236.

Ugbokwe U. O. 1987. Are colleges of education comparable? A study into some sectors of comparison between institutions. *The Beacon*.1. 1: 49 -59.

Ugwuanyi, J.U. 1998. Effects of guided discovery and expository teaching methods on students' achievement in physics in selected secondary schools in Nsukka, Enugu State, Nigeria. *Nigerian Journal of Technical Education, 15*. 167-171.

Ukwungwu, J. O. and Nworgu, B. G. 1999. Affective and cognitive correlates of achievement in Pre-NCE physics course. *Journal of the Science Teachers Association of Nigeria*.34.1&2:55-59.

Ukwungwu, J. O. and Ezike R. O. 2000. Gender and physics achievement disparity in Nigeria. A meta-analysis of findings. *African Journal of Research in Education*.1.1:134-138.

Ukwungwu, J. O. and Olarinoye, R. O. 2000. The effects of teaching methods and levels of entry characteristics on students retention in physics. *Journal of the Curriculum Organisation of Nigeria.* 7. 1&2:112-116.

Ukwungwu, J. O. 2002. Gender difference study of performance in integrated science. A summary of studies conducted in Nigeria. *Journal of the Science Teachers Association of Nigeria.* 37.1&2:55-59.

Viann, E. 2004. Gender difference and the effects of cooperative learning in college level mathematics. Unpublished PhD thesis, Curtin University of Technology.

VonGlasserfield, E. 1995. A constructivist approach to teaching. In L.P. Steffe and J.Gale constructivism in education. Hillsdale, N.J Erbaum.

______________1989. Cognition, construction of knowledge, and teaching, *Syntheses*, 80. 121-140.

Vygotsky, L.S. 1978. Mind and society: The development of higher mental processes. Cambridge, MA: Harvard University Press.

________________1986. Languages and thought. Cambridge , Mass: institute of technology press.

Walding, R, Faghani, C, Over, R. and Bain, N. D. 1994. Gender differences in response to questions on Australia national chemistry quiz. *Journal of Research in Science Teacher,* 31. 8: 833-846.

Weinburgh, M. 1995. Gender differences in student attitudes towards science. A meta analysis of the literature from 1970-1991. *Journal of Research in Science Teaching.* 32.4:387-398.

Weinstein, K. 1995. *Action learning: A journey in discovery and development*. London: Harper Collins Publishers.

West African Examination Council, 1999. Chief examiner's annual reports, Abuja: WAEC.

_______________ 2000. Chief examiner's annual reports, Abuja: WAEC.

______________ .2001. Chief examiner's annual reports, Abuja: WAEC.

______________. 2002. Chief examiner's annual reports, Abuja: WAEC

_______________. 2003. Chief examiner's annual reports, Abuja: WAEC.

_______________. 2004. Chief examiner's annual reports, Abuja: WAEC.

______________. 2005. Chief examiner's annual reports, Abuja: WAEC.

______________ . 2006. Chief examiner's annual reports, Abuja: WAEC.

______________. 2007. Chief examiner's annual reports, Abuja: WAEC.

______________. 2008. Chief examiner's annual reports, Abuja: WAEC.

Westbook, S. L. and Renner, J. W. 1980. Concrete and formal teaching. *Journal of Research in Science Teaching*. 31:65-76.

Westbrook, S. L. and Rogers, L. N. 1996. Doing is believing: Do laboratory experiences promote conceptual change? *School Science and Mathematics, 96*: 263-271.

White, B, Todd, A .S. and John, R. F. 1999. Enabling students to construct theories of collaborative inquiry and reflective learning: computer support for metacognitive development. *International Journal of Artificial Intelligence in Education*, 10.151-182.

Wilen, W, Ishler, M, Hutchison, J and Kindsvatter, V. R. 2000. Dynamic of effective teaching, United States, Longman.

Willis, J. W., Stephens, E. C. and Mathew, K. I. 1996. Technology, reading and language arts. Needham Heights. Mass:Allyn & Bacon.

Woodhouse, H. and Ndongko, T. M. 1993. Women and scientific education in Cameroon: some critical reflections. *Interchange. 24: 131-158.*

Yager, R. E. 1991. The constructivist learning model. *Science Teacher*. 58.6: 52-57.

Yara, P. O. 2009. Students' attitude towards mathematics and academic achievement in some selected secondary schools in south western Nigeria. *European Journal of Scientific Research*, 36.3:336-341.

Yildirim, U. and Eryilmaz, A. 1999. Effects of gender, cognitive development and socioeconomic status on physics achievement. *Hacettepe UniversitesiEgitiim Fakultesi Derisi* 15: 121- 126.

Young, P. 1992. Reader-friendly science. *Science Scope*, 16 .1: 22-24.

Young, D. J. 1997. A multilevel analysis of science and mathematics achievement. Paper presented to the annual meeting of the American Educational Research Association.

Young, D. J. and Fraser, B. J. 1993. Socio-economic and gender effects on science achievement: An Australian perspective. *School Effectiveness and School Improvement*, 4. 4: 265-289.

_____________. 1993. *Sex differences in science achievement: A multilevel analysis*. Paper presented at the annual meeting of the American Educational Research Association, SanFrancisco.

Zarotiadou, E., Georgiadou, A, and Tsaparlis, G. 1995. A comparative study of logical and rote methods of solving stoichiometry problems in lower high school. Proceedings of the 3: 314-317. Lublin- Kazimierz, Poland: Maria Curie-Sklodowska University.

Zarotiadou, E. and Tsaparlis, G. 2000. Teaching lower-secondary chemistry with a Piagetian constructivist and an Ausbelian meaningful receptive method: a longitudinal comparison. *Chemistry Education: Research and Practice in Europe* 1,1: 37-50.

Zoller, U. 2000. Teaching tomorrow college science courses- are we getting it right? *Journal of College Science Teaching*. 29.6: 409-414.

APPENDIX I

DEPARTMENT OF TEACHER EDUCATION

UNIVERSITY OF IBADAN

ACHIEVEMENT TEST IN PHYSICS (ATP) TIME: 40mins

Please give the following background about yourself

Name of School: ____

Age: _________________________ Sex: _____________________________

Class: ________________________

INSTRUCTION: Read each question carefully and unite your answer (the letter a, b, c, d) corresponding to the option you have chosen as your best answer. Please do not waste your time on any one question. Attempt all questions. All questions carry equal marks.

ACHIEVEMENT TEST IN PHYSICS

1. A periodic pulse travels a distance of 20.0m in 1.00s. If its frequency is $2.0 \times 10^3 H_2$, calculate the wavelength.
   a) 1.0×10^{-3}m b) 1.0×10^{-2}m c) 2.0×10^{-2}m d) 1.0×10^{2}m

2. Light is considered as a transverse wave because it travels

   a) Through materials without causing disturbance of the medium

   b) Through the space with constant speed

   c) In a direction parallel to the plane containing the electric and magnetic fields

   d) In a direction perpendicular to the plane containing the electric and magnetic field.

3. Which of the following equations represents the distance, X, and travelled by a body moving on a straight road with a constant speed? (The other symbols have their usual meanings).

a) $x = ut + ½at^2$ b) $x = ut$ c) $x = V^2–U^2/2a$ d) $ut = ½at^2$

4. A body dropped from a certain height above the ground level, falls with uniform

a) retardation b) speed c) acceleration d) velocity

5. A wave travelling from water to glass suffers a change in its speed at the common boundary which of the following properties explains the observation?

a) Dispersion b) refraction c) interference d) diffraction

6. The amplitude of a particle exerting simple harmonic motion is Jam while its angular frequency is 10rads-1. Calculate the magnitude of the maximum acceleration of the particle. a) 0.25ms-2 b) 0.50ms-2 c) 2.00ms-2 d) 5.00ms-2

7. A moving object is said to have uniform acceleration of its

a) displacement decreases at a constant rate

b) speed is directly proportional to time

c) velocity increases by equal amount in equal time intervals

d) the quantity of a note depends on its overtones

8. Which of the following statements about a progressive mechanical wave is correct?

a) It can be plane polarized
b) Its energy is localized at specific parts of its profile
c) It does not require a material medium for its propagation.
d) Its frequency remains constant as it travels between different media

9. The amplitude of a wave is the

a) Distance travelled by the wave in a complete cycle of its motion

b) Make displacement of the wave particle from the equilibrium position

c) separation of two adjacent particles vibrating in a phrase

d) Distance between two successive troughs y the wave

10. The S. I. unit of frequency, period and amplitude of a wave are respectively

a) hertz, seconds and centimetre

b) seconds, metre, and hertz

c) metre, hertz and second

d) hertz, second and metre

11. A note of frequency 200Hz has a velocity of 400ms$^{-1.}$ Calculate the wavelength of the note.

a) 5.0m b) 2.0m c) 0.5m d) 0.2m

12. Which of the following waves is electromagnetic?

a) X-rays b) sound waves c) water waves d) tidal waves

13. In a wave equation y=EoSin (200t-Πx), Eo represents the

a) amplitude b) frequency c) period d) wavelength

14. In which of the following media would sound wave travel fastest?

a) Wind b) water c) iron d) mercury

15. Which of the following electromagnetic waves can be detected by its heating effects?

a)Ultraviolet radiation b) X-rays c) Gamma rays d) Infrared radiation

16. A 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) interference

17. A wave of wave length 0.30m travels 900m in 30s. Calculate its frequency.

a) 1000Hz b) 2200Hz c) 270Hz d) 7500Hz

18. In a wave, the maximum displacement of particles from their equilibrium positions is called

a) Frequency b) amplitude c) period d) wavelength

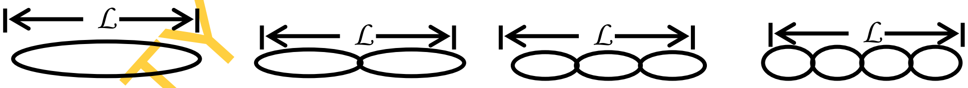
19. Which of the following is a stringed instrument?

a) flute b) trumpet c) piano d) drum

20. When the direction of vibration of the particles of a medium is perpendicular to the directions of travel of a wave, the wave transmitted is known as

a) Sound wave b) transverse wave c) Longitudinal wave d) stationary wave

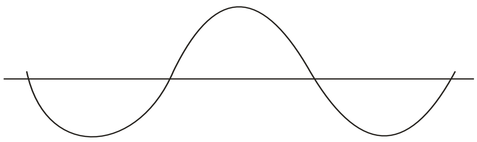
21. Which of the following modes of vibration of a stretched string is the first overtone?



a) b) c) d)

22. How far from a cliff should a boy stand in under to hear the echo of his day 0.93 later? Speed of sound in air = 330ms^{-1}).

a) 36.67m b) 74.25m c) 148.50m d) 297.00m

23. 

The diagram above shows a wave from in which energy is transferred from A to B in a time of

a) 2.5×10^{3}Hz b) $1/0 \times 10^{3}$Hz c) 4.0×10^{-2}Hz d) 1.0×10^{-3}Hz

24. A slinky spring fixed at one end is placed horizontally on a table. The free end is placed parallel to the table and then released. The resulting wave form is

a) Transverse b) Longitudinal c) Stationary d) Electromagnetic

25. Radio wave has a wavelength of 150m if the velocity of radio wave in free space is $3 \times 10^{3}m^{s-1}$. Calculate the frequency of the radio wave

a) 4.5×10^{10}Hz b) 5.0×10^{9}Hz c) 4.5×10^{7}Hz d) 4.5×10^{10}Hz

APPENDIX II

PHYSICS ATTITUDE QUESTIONAIRE (PAQ)

Section A Instructions: **5MINS**

1. Please give the following background information about yourself.

Age:……………………………………………………………

Class:…………………………………………………………

Sex:……………………………………………………………

2. Below is a set of statements made in connections with physics. Tick (√) any one of options. Strongly agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD), which best expresses your opinion. Example: My mother is the best mother in the world.

SA	A	D	SD
√			

The above example shows that I strongly agree with the above opinion.

2. Please use pencil so that you can easily make a change if you wish to do so at any point.

Physics Attitude Questionnaire (PAQ)

SECTION B

S/N		SA	A	D	SD
1	I have good feelings towards physics				
2	I really like physics				
3	Physics is important to everyday life				
4	It is useful for me to solve problems when learning physics				
5	Knowledge in physics consists of many disconnected topics				
6	To learn physics, I only need to memorize solutions to sample problems				
7	When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values.				
8	I feel nervous in physics class				
9	I cannot learn physics if the teacher does not explain things well in the class				
10	I study physics to learn knowledge that will be useful in my life outside of school.				
11	If I get stucked on a physics problem on my first try, I usually try to figure out a different way that works				
12	Understanding physics basically means being able to recall something you've read or been shown				
13	There could be two different correct values to a physics problem if I use two different approaches				
14	To understand physics I discuss it with friends and other students.				
15	I enjoy solving physics problems				
16	In physics, it is important for me to make sense out of				

	formulas before I can use them correctly				
17	Reasoning skills used to understand physics can be helpful to me in my everyday life				
18	Spending a lot of time understanding where formulas come from is a waste of time				
19	I can usually figure out a way to solve physics problems				
20	The subject of physics has little relation to what I experience in the real world				
21	There are times I solve a physics problem more than one way to help my understanding				
22	It is possible to explain physics ideas without mathematical formulas				
23	When I solve a physics problem, I explicitly think about which physics ideas apply to the problem				
24	It is possible for physicists to carefully perform the same experiment and get two very different results that are both correct				
25	When studying physics, I relate the important information to what I already know rather than just memorizing it the way it is presented				

APPENDIX III

DEPARTMENT OF TEACHER EDUCATION

UNIVERSITY OF IBADAN

NUMERICAL ABILITY TEST (NAT) TIME: 30mins

Please give the following background about yourself

Name of School: ____

Age: ______________________ Sex: __________________________

Class: _____________________

INSTRUCTION

The following set of questions is meant to test your simple mathematical ability and reasoning. Read each question carefully and unite your answer (the letter a, b, c, d) corresponding to the option you have chosen as your best answer. Please do not waste your time on any one question. Attempt all questions. All questions carry equal marks.

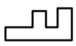
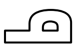
NUMERICAL ABILITY TEST (NAT)

1. Find the product of 0.0409 and 0.0021 leaving your answer in the standard form.

   a. 8.6×10^{-6} b. $8.6\text{x}10^{-5}$ c. $8.6\text{x}10^{4}$ d. $8.6\text{x}10^{5}$ e. $8.6\text{x}10^{-4}$

2. Evaluate $(101.5)^2 - (100.5)^2$

   a.1 b. 2.02 c. 20.02 d. 202 e. 2020

3.  is to  as  is to ____ a.  b.  c. 

   d.  e. 

4. Simplify $36^{1/2} \times 6^{-1/2} \times 5^{0}$

a. 0 b.$^{1/24}$ c. $^{2/3}$ d.$1^{1/2}$ e. $7^{1/2}$

5. Evaluate 0.009 ÷ 0.012, leaving your answer correct to two significant figures.

a. 7.5×10^{2} b. 7.5×10^{1} c. 7.5×10^{-1} d. 7.5×10^{-2} e. 7.5×10^{3}

6. Express 0.00562 in standard form.

a. 5.62×10^{-2} b. 5.62×10^{2} c. 5.62×10^{-3}

d. 5.62×10^{4} e. 5.62×10^{3}

7. Divide 3.6721 by 4

a. 0.9180 b. 1.4180 c. 1.1680 d. 1.1680 e. 1.9180.

8. Find the average of the first four prime numbers greater than 10.

a. 20 b. 19 c. 17 d. 15 e. 16

9. Arrange in ascending order of magnitude: 26_8, 36_7 and 25_9.

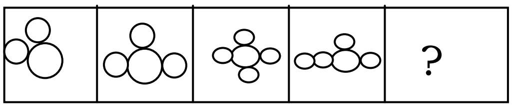
a. 25_9,26_8,36_7 b. 26_8,25_9, 36_7 c. 36_7, 26_8,25_9

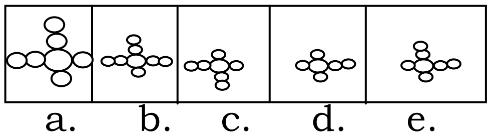
d. 36_7,25_9,26_8 e. 27_7,25_9,36_8

10. What fraction must be subtracted from the sum of $2^{1/6}$ and $2^{1/2}$ to give $3^{1/}4$?

a. $^{1/3}$ b. $^{1/2}$ c. $1^{1/6}$ d. $1^{1/2}$ e. $^{1/6}$

11. The drawing in the first part of the row goes together to form a series. In the last part of the row, find the drawing that belongs where you see the question mark (?) in the series.





12. Express the square root of 0.000144 in the standard form.

a. 1.2×10^{-4} b. 1.2×10^{-3} c. 1.2×10^{-2} d. 1.2×10^{-1} e. 1.2×10^{-5}

13. Find the correct to two decimal places, the mean of 9, 13, 16, 17, 19, 23, 24

a. 23.00 b. 17.29 c. 16.50 d. 16.3 e. 15.33

14. The difference between $4^{5/7}$ and $2^{1/4}$ greater than the sum of $^{1/14}$ and $1^{1/2}$ by

a. 23/28 b. 24/28 c. 50/36 d. 27/28 e. 25/28

15. Express the true bearing of 250^0 as a compass bearing

a. $N20^0E$ b. $S20^0E$ c. $N20^0W$ d. $S70^0W$ e. $S70^0E$

16. Find the mean deviation of these numbers 10, 12, 14, 15, 17, 19.

a. 2.5 b. 2.6 c. 2.7 d. 2.8 e. 2.9

17. Which of the following is equal to $\frac{72}{125}$?

a. $\frac{2^3 x 3^2}{5^3}$ b. $\frac{2^4 x 3}{5^3}$ c. $\frac{2^3 x 3^2}{5^5}$ d. $\frac{2^4 x 3}{5^5}$

e. $\frac{2^2 x 3^2 x 4^2}{5^2}$

18. Arrange the following numbers in ascending order of magnitude

a. 6/7<0.865<13/15 b. 6/7<13/15<0.865

c.13/15<6/7<0.865 d.13/15<0.865<6/7

e. 0.865<6/7<13/15

19. Find the median set of the following numbers
110,116,113,119,118,127,118,117,113.

a. 117.5 b. 118 c. 117 d.116 e.113

20. Which of the following is in descending order?

a. $\frac{9}{10}, \frac{4}{5}, \frac{3}{4}, \frac{17}{10}$ b. $\frac{4}{5}, \frac{9}{10}, \frac{3}{4}, \frac{17}{20}$

c. $\frac{9}{10}, \frac{17}{10}, \frac{4}{5}, \frac{3}{4}$ d. $\frac{4}{5}, \frac{9}{10}, \frac{17}{10}, \frac{3}{4}$

e. $\frac{17}{10}, \frac{4}{5}, \frac{3}{4}, \frac{9}{10}$

21. Simplify the expression in standard form

$$\frac{0.00275\text{x } 0.0064}{0.025\text{x } 0.08}$$

a. $8.8\text{x}10^{-1}$ b. $8.8\text{x}10^{-2}$ c. $8.8\text{x}10^{-3}$ 10 d. $8.8\text{x}10^{3}$ e. $8.8\text{x}10^{2}$

22. Calculate $3310_5 - 1442_5$

a. 1313_5 b. 2131_5 c. 4320_5 d. 1103_5 e. 1102_5

23. Convert 3.1415926 to 5 decimal places

a. 3.14160 b. 3.14159 c. 0.31415 d. 3.14200 e. 3.14269

24. Find the L.C.M OF $2^3\text{X}3\text{X}5^2$, $2\text{X}3^2\text{X}5$ and $2^2\text{x}3^3\text{x}5$

a. $2^2\text{x}3^3\text{x}5^2$ b. $2^3\text{x}3^3\text{x}5$ c. $2^2\text{x}3^2\text{x}5^2$ d. $2^3\text{x}3^3\text{x}5^2$ e. $2^3\text{x}5^3\text{x}3$

25. A string is 4.8m. A boy measured it to be 4.95m. Find the percentage error?

a. $\frac{5}{16}$ % b. $1^{5/16}$ % c. $3\frac{1}{33}$% d. $3\frac{1}{8}$% e. 15%

APPENDIX IV

SCORING KEY FOR NUMERICAL ABILITY TEST (NAT)

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

APPENDIX V

SCORING KEY FOR ACHIEVEMENT TEST IN PHYSICS (ATP)

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

APPENDIX VI

Cronbach Alpha Coefficient (r)

Summary of the Mean(X), Standard Deviation (Si) and Variance (Si^2) of Trial Testing Distribution for Physics Attitude Questionnaire (PAQ).

ITEMS	Ẍ	Si	Si^2	TOTAL SCORE
1	2.42	0.84	0.71	121
2	2.64	0.74	0.52	132
3	2.48	0.89	0.79	134
4	2.32	0.84	0.71	176
5	2.48	0.84	0.71	124
6	2.38	0.81	0.66	119
7	2.48	1.04	1.08	124
8	2.50	0.87	0.76	125
9	2.40	0.90	0.81	120
10	2.40	0.78	0.61	120
11	2.38	0.88	0.77	119
12	2.46	0.91	0.83	123
13	2.46	0.81	0.66	123
14	2.36	0.78	0.61	118
15	2.38	0.86	0.74	119
16	2.46	0.76	0.58	89
17	2.48	0.93	0.87	124
18	2.38	0.88	0.77	119
19	2.60	0.86	0.74	130
20	2.50	0.86	0.74	125
21	2.54	0.65	0.42	127
22	2.44	0.71	0.50	122
23	2.58	0.84	0.71	129

24	2.54	0.79	0.62	127
25	2.58	0.88	0.77	129

$\sum Si^2$=17.69 **3118**

$\sum$**Si**^{2}=17.69

Si^2=181.98

Total score=3118

K=25

Calculation of Cronbach Alpha Coefficient (r)

Using the formula

$$r = \frac{K}{K-1}\left[1 - \frac{\sum Si^2}{SX^2}\right]$$

Where

K= Number of items

Si^2= Variance of scores for each item

$\sum Si^2$=Sum of items variances (for the 25 item).

SX^2=Variance of total scores in the test.

N	K	$\sum Si^2$	SX^2	r
50	25	17.69	181.98	0.94

APPENDIX VII

NUMERICAL ABILITY TEST: Reliability

S/N	Score
1	22
2	20
3	02
4	20
5	14
6	12
7	24
8	18
9	20
10	20
11	18
12	18
13	20
14	18
15	20
16	24
17	22
18	22
19	20
20	18
21	20
22	20
23	18
24	20
25	18
26	16
27	10

28	16
29	18
30	20
31	14
32	16
33	22
34	20
35	20
36	18
37	16
38	22
39	20
40	18
41	18
42	16
43	22
44	18
45	20
46	22
47	16
48	20
49	22
50	18

n= 50

$\overline{X}$ = 18.52

S = 3.68

S^2 = 13.52

Calculation of Kuder – Richardson (k-20)

Using formula

$$r = \frac{N}{N-1}\left[1-\frac{\bar{X}(N-\bar{X})}{NS^2}\right]$$

Where r = reliability coefficient

N = Number of test items

$\bar{X}$ = Mean performance

S^2 = Variance estimate

$$1.042\left[1-\frac{18.52\,(25-18.52)}{25\times18.52}\right] = 1.042\left[1-\frac{18.52\,(6.48)}{463}\right]$$

$$1.042\left[1-\frac{120.01}{463}\right] = 1.042\left[1-0.259\right]$$

$$1.042 \times 0.741 = 0.77$$

N	$\bar{X}$	S	S^2	R
25	18.52	3.68	13.52	0.77

APPENDIX VIII

ACHIEVEMENT TEST IN PHYSICS (Reliability)

S/N	Score
1	24
2	18
3	14
4	12
5	04
6	20
7	22
8	18
9	18
10	16
11	14
12	02
13	14
14	16
15	18
16	20
17	20
18	20
19	18
20	18
21	16
22	18
23	16
24	18
25	18
26	20
27	18

28	18
29	20
30	08
31	14
32	14
33	08
34	12
35	20
36	14
37	22
38	20
39	24
40	16
41	18
42	22
43	20
44	22
45	20
46	18
47	18
48	16
49	22
50	20

n = 50

$\overline{X} = 17.12$

S = 4.52

$S^2 = 20.43$

$\sum x = 856$

2

$\sum x = 15656$

Calculation of Kuder – Richardson (K – 20)

Using Formula

$$r = \frac{N}{N-1}\left[1 - \frac{\bar{X}(N - \bar{X})}{NS^2}\right]$$

Where r = reliability coefficient

N = Number of test items

$\bar{X}$ = Mean performance

S^2 = Variance estimate

$$1.042\left[1 - \frac{17.3\,(25-17.13)}{25 \times 20.43}\right] = \left[1.042\ 1 - \frac{17.12\,(7.86)}{510.75}\right]$$

$$1.042\left[1 - \frac{134.88}{510.75}\right] = 1.04\left[1 - 0.27\right]$$

$$1.042 \times 0.73 = 0.76$$

N	$\bar{X}$	S	S^2	R
25	17.13	4.52	20.43	0.76

APPENDIX IX

Difficulty and Discrimination Indices of Achievement test in physics Items

Item no	Difficulty (D)	Discrimination index (d)
1	45.0	0.58
2	42.0	0.54
3	54.0	0.45
4	56.0	0.54
5	48.0	0.52
6	44.0	0.50
7	55.0	0.52
8	56.0	0.56
9	58.0	0.54
10	54.0	0.46
11	52.0	0.56
12	55.0	0.58
13	57.0	0.48
14	45.0	0.52
15	54.0	0.50
16	55.0	0.52
17	53.0	0.54
18	54.0	0.55
19	56.0	0.50
20	52.0	0.56
21	51.0	0.54
22	52.0	0.49
23	54.0	0.46
24	46.0	0.51
25	55.0	0.54

Average difficulty index = 52.12 Average discrimination index = 0.52

APPENDIX X

Difficulty and Discrimination Indices of Numerical Ability test Items

Item no	Difficulty (D)	Discrimination index (d)
1	46.0	0.52
2	49.0	0.54
3	55.0	0.50
4	58.0	0.46
5	56.0	0.55
6	55.0	0.52
7	58.0	0.54
8	52.0	0.52
9	54.0	0.54
10	58.0	0.56
11	51.0	0.54
12	50.0	0.56
13	53.0	0.54
14	54.0	0.52
15	56.0	0.50
16	58.0	0.48
17	54.0	0.55
18	52.0	0.52
19	55.0	0.54
20	56.0	0.56
21	57.0	0.50
22	56.0	0.55
23	50.0	0.51
24	52.0	0.50
25	54.0	0.52

Average difficulty index = 53.9 Average discrimination index = 0.53

APPENDIX XI

LESSON BY LESSON/ WEEKLY BREAKDOWN OF TOPICS

Week	Topic/Main concept	Further Breakdown/Sub-concepts	Objectives to be performed by students
1.	Production and propagation of wave(LESSON 1)	-Concept and meaning of waves motion -pulsating /vibrating systems as source of waves -Waves as mode of energy transfer -Role of medium and factors affecting it -Distinction between particle and wave motion -Classification/ types of waves into longitudinal and transverse, plane and spherical, stationary and progressive with examples. -Groups of waves – mechanical and electro-magnetic with examples. -Use of ripple tank and stroboscope for production and observation of waves.	-Define wave/ wave motion -Differentiate between wave motion and particle motion -Explain relationship between energy and role of medium in propagation o wave - Give two groupings of waves as mechanical and electromagnetic with examples - Differentiate between mechanical and e-m wave, progressive and standin -Describe two types of waves i.e. transverse and longitudinal and give examples of each. -Explain compression and rarefaction. -Explain where/how a given waves derives its energy. - Recall other ways of energy transfer other than waves
2.	Representation of a wave (Lesson 2)	-Terms and definition of terms associated with wave motion-crest, trough, node, antinode, amplitude, frequency, angular speed, period, wavelength, speed/velocity, wave front, wave constant, etc. -Graphical representation of progressive and standing wave. -Mathematical representation of progressive wave. Y=A sin (wt±) -Mathematical relationship between period, frequency, wavelength and velocity, i.e y=f^ and f=1/T -Sinusoidal and Cosinenusoidal wave form	-Representation wave graphically in Sine of Cosine form (progressive and standing). -Write a simple mathematical representation of wave. -Define and label the following on a wave profile: crest, trough, node, antinodes, amplitude, frequency, period, wavelength, speed/velocity and w front. -Derive mathematical relationship between frequency, wavelength, period velocity of a wave (V=f^) -Solve problems involving the above terms. -Define wave front, compression, rarefaction, cycle, vibration, periodic, et
3.	Further Description of mathematical Representation of wave (LESSON3)	-Difference between Sinusoidal and Cosinenusidal wave graphically illustrated and mathematically expressed. -Relationship between and motion circular motion and simple harmonic as periodic motion and simple harmonic as periodic motion. -Other forms of mathematical representation of wave and the meaning of terms and symbols. -Concepts of phase and meaning –phase difference, phase angle, phase lead, phase log, in phase, phasor diagrams. -Problems involving the mathematical representation of wave to calculate frequency, period, velocity, angular speed, phase difference, amplitude.	-Write various forms of mathematical representation of progressive wave a explain symbols. -Calculate wavelength, velocity, angular speed, frequency, period, amplitu and phase difference using the mathematical representation of a wave. -Explain the meaning of the terms phase, phase lead, phase lag, in phase, o of phase as well as describe particles in these states of vibrating in phase a out of phase and calculate their phase difference.
4.	Properties of waves1 (LESSON 4)	The following properties are listed and fully discussed –reflection, refraction, superposition, diffraction, interference and polarization. -Reflection –Definition, laws of reflection, types of reflection, bodies and reflection. -Refraction – definition, laws of refraction, refractive index and snell's law, critical Angle and total internal reflection.	-List the properties of wave giving example of each behavior -Define reflection and refraction -State law of reflection and refraction -Draw/ sketch ray diagrams to show reflection and refraction different med -Define refractive index and state snell's laws of refraction -Give examples of reflection of sound and light waves -Solve problems.

5.	Properties of Waves (2) (LESSON 5)	-Diffraction of waves-definition, effect of size of aperture and wavelength of wave. -Sketch various diffraction patterns. -Diffraction of sound and light wave and effect aperture size. -Interference- definition, types of interference, conditions for interference of waves, coherent wave, constructive and destructive interference explained with sketches -Polarization-meaning, type of medium required, plane polarization, condition for polarization of wave Polaroid, uses and application of polarized light.	-Define/ explain diffraction, interference and polarization -Explain effect of aperture on diffraction -Differentiate between diffraction of sound and light -Give application of diffraction and polarization -Differential between constructive and destructive interference -Explain sound wave but light wave can be polarized -Give uses of Polaroid /polarized light