EFFECTS OF PROBLEM-BASED LEARNING AND INTERACTIVE INVENTION INSTRUCTIONAL STRATEGIES ON NCE PRE-SERVICE TEACHERS' ACHIEVEMENT IN PHYSICS CONCEPTS AND ACQUISITION OF SCIENCE PROCESS SKILLS

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A THESIS IN THE DEPARTMENT OF TEACHER EDUCATION SUBMITTED TO THE FACULTY OF EDUCATION IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF THE UNIVERSITY OF IBADAN

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ABSTRACT

The traditional instructional strategies employed by most physics teachers in teaching the subject has consistently led to low student achievement. Hence there is need to employ new instructional strategies such as problem-based learning (PBL) and interactive invention (IIS) instructional strategies, particularly, among the NCE pre-service teachers in Nigeria. The two strategies have been proved in the literature to help in alleviating the problem of low student achievement in physics, but they have not been adopted in the teaching of physics in Nigerian Colleges of Education. This study, therefore, ascertained the effects of problem–based learning and interactive invention instructional strategies on NCE pre-service teachers' achievement in physics and acquisition of science process skills.

A pretest-posttest, control-group, quasi–experimental research design with a 3x3x2 factorial matrix was used. Three state and three federal colleges of education from South-western Nigeria were purposively selected. Ninety eight female and 94 male final year NCE physics students with high, medium and low self-efficacy constituted the sample. One state and one federal college of Education were used for each of the two experimental groups and the control group. The Instruments used were: Physics Achievement Test (r=0.875), Students' Physics Self–Efficacy Questionnaire (r=0.956), Science Proces Skills Worksheets (SPSW), Classroom Activities Rating Scale (r=0.820), Teachers' Instructional Guides for Problem-Based Learning Strategy (PBLS), Interactive Invention Strategy (IIS) and Conventional Lecture Method (CLM). Three research questions were answered and seven null hypotheses were tested at 0.05 level of significance. Data were analysed using Analysis of Covariance (ANCOVA), Multiple Clasification Analysis (MCA) and Scheffe post hoc analysis.

Treatment had a significant main effect on pre-service teachers' achievement in physics concepts ($F_{(2,174)}$ = 43.44, P <.05) and science process skills acquisition ($F_{(2,175)}$ = 183.80, P <.05). In achievement in physics concepts, students exposed to problem-based learning obtained a higher achievement score ($\bar{x}$=51.98) than those exposed to interactive invention instructional strategy ($\bar{x}$ =40.32) and the conventional lecture method ($\bar{x}$ =30.23). Those exposed to problem-based learning instructional strategy obtained higher science process skills scores ($\bar{x}$ =73.67) than those exposed to interactive invention instructional strategy ($\bar{x}$=60.21) and conventional lecture method ($\bar{x}$=26.73). There was no significant main effect of gender on pre-service teachers' achievement in physics ($F_{(1\ 174)}$ = .026 P > .05) and acquisition of science process skills ($F_{(1,175)}$ = .361, P >.05). The three-way interactions of treatment, self-efficacy and gender showed a significant interaction effect for achievement in physics ($F_{(3,174)}$ = 3.27, P<.05) and for science process skills acquisition ($F_{(3,175)}$ = 2.92, P <.05). There was no significant effect of self-efficacy and gender on achievement and science process skills acquisition; the two-way interactions showed no significant effect.

Problem–based learning and interactive invention instructional strategies improved student achievement in physics and science process skills acquisition. It is, therefore, recommended that teachers, curriculum developers and textbook writers should adopt these two instructional strategies for the improvement of students' learning outcomes in physics.

Key words: Problem-based Learning, Interactive invention, Achievement in physics concepts, Self–efficacy.

Word count: 483.

CERTIFICATION

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DEDICATION

This work is gladly dedicated to the Bishop of my soul The Almighty God.

And

My children, Nsikakabasi and Ubongabasi Ukoh whom together we did the work.

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To the King of kings, Lord of lords, Everlasting Father, the Source of Wisdom be glory, honour, adoration and praise forever and ever. Amen. I acknowledge with the highest regard and total humility, the favour of the Almighty God and His infinite love, protection, provision, grace and mercies over my life throughout the programme. Glory to His Name.

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Ukoh, E. E. (Mrs.)

Table of Content

Cover Page i

Abstract ii

Certification Page iii

Dedication iv

Acknowledgement v

Table of Content vi

List of Tables vii

List of Figures viii

CHAPTER ONE: INTRODUCTION

1.0 Background to the Study 1

1.1 Statement of the Problem 11

1.2 Research Questions 11

1.3 Hypotheses 11

1.4 Significance of the Study 12

1.5 Scope of the Study 13

1.6 Operational Definition of terms 13

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction 15

2.1 Theoretical Framework 15

2.2 Issues in Developing Quality Teacher Education 18

2.3 Problem-Based Learning and Achievement in Physics and Acquisition of Science Process Skills 23

2.4 Empirical Studies on Problem-Based Learning and Achievement In Physics Concepts and Acquisition of Science Process Skills 36

2.5 Interactive-Invention Strategy and Achievement in Physics

Concept and Acquisition of Science process skills 47
2.6 Empirical Studies on Interactive-Invention Strategy and Achievement in Physics Concepts 51
2.7 Self-Efficacy and Pre-service Teachers' Achievement in Physics 52
2.8 Gender Issues in Physics 58
2.9 Appraisal of Literature 61

CHAPTER THREE RESEARCH METHODOLOGY
3.0 Introduction 63
3.1 Research Design 63
3.2 Variables in the Study 64
3.3.1 Selection of Participants 64
3.3.2 Selection of Topics 65
3.4 Instrumentation 65
3.4.1 Physics Achievement Test (PAT) 66
3.4.2 Students' Physics Self Efficacy Questionnaire (SPSQ) 67
3.4.3 Science Process Skills Worksheets (SPSW) 68
3.4.4 Classroom Activities Rating Scale 68
3.4.5 Teachers' Instructional Guide on Problem-Based Learning Strategy (TIGPBLS) 68
3.4.6 Teachers Instructional Guide on Interactive Invention Strategy (TIGIIS) 69
3.4.7 Teachers Instructional Guide on Conventional Lecture Method (TIGCLM) 69
3.5 Procedure for Data Collection 69
3.6 Procedure for Data Analysis 73

CHAPTER FOUR: RESULT AND DISCUSSION
4.0 Introduction 74
4.1 Testing of Hypotheses 74
4.2 Discussion of findings 86
4.3 Summary of Findings 93

CHAPTER FIVE: SUMMARY OF FINDINGS, IMPLICATIONS AND RECOMMENDATIONS

5.0 Summary 94
5.1 Conclusion 95
5.2 Educational Implications 95
5.3 Contribution to the Body of Knowledge 96
5.4 Recommendations 96
5.5 Limitations of the Study 97
5.6 Suggestion for the Study 97
References 98
Appendices 121

LIST OF TABLES

Table 1.1	Students' Enrolment by Science Subjects and Sex in Colleges of Education in Nigeria Between 2005-2010	2
Table 1.2	Physics Results for Selected Colleges of Education 2005-2010	4
Table 2.1	Motivation Functions for the Inquiry Model	33
Table 2.2	Learning and Motivation Functions for the Phases to the Interactive Invention Instruction Model	50
Table 3.1	3x3x2 Factorial Matrix of the Design	63
Table 3.2	Table of Specification for PAT	66
Table 3.3	Work Schedule Template	69
Table 4.1	Summary of Analysis of Covariance of Physics Achievement Test (PAT) Scores by Treatment, Self Efficacy and Gender.	75
Table 4.2	Multiple Classification Analysis (MCA) of PAT Scores by Treatment Groups, Self-efficacy and Gender.	76
Table 4.3	Scheffe Multiple Range Comparison of Treatment Group Mean Scores for PAT.	77
Table 4.4	Summary of ANCOVA of Science Process Skills score by Treatment Groups, Self-Efficacy and Gender.	78
Table 4.5	MCA of Science Process Skills by Treatment Groups, Self –Efficacy and Gender.	79
Table 4.6	Scheffe Multiple Range Comparison of Treatment Group Mean Scores for Science Process Skills.	80

LIST OF FIGURES

Figure 3.1 Variables in the Study 64

Figure 4.1 Line Graph Showing the Significant Interactions Effects of Treatment, Self-Efficacy and Gender on Physics Achievement of Pre-service Teachers. 83

Figure 4.2 Line Graph Showing the Significant Interactions Effects of Treatment, Self-Efficacy and Gender on Acquisition of Science Process Skills of Pre-service Teachers. 85

LIST OF ABBREVIATIONS

National Commission for Colleges of Education	NCCE
Nigeria Certificate of Education	NCE
Problem-Based Learning	PBL
Interactive Invention Strategy	IIS
Education Sector Support in Nigeria	ESSPIN

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study.

In today's age of science and technology, scientific knowledge has grown exponentially, technological innovations have progressed at rapid pace and the effects of science and technology are clearly witnessed in all aspects of human life. It is obvious that science and technology education play a key role in the future of our societies. Because of its importance, all societies and particularly, developed countries have continuously sought to improve the quality of science and technology education (Aydȯgdu, 2006). Japan for instance, has become one of the world's acclaimed leaders in technology today through a well-planned and implemented science education programme (Olarewaju, 2002).

Nigeria in her quest for technological advancement has attempted to follow the good example of Japan. This could be seen in the National Policy on Education (Federal Republic of Nigeria, 2004). The policy stipulated measures for teaching science effectively at all levels. Science is taught in basic schools as basic science, in senior secondary schools as Biology, Chemistry and Physics and in tertiary level in diverse courses ranging from Physical Sciences to Biological Sciences, Medical Sciences to Engineering Sciences. Also, in the quest for development, the country has been changing from one system of education to another. However, the fact remains that no matter how good an educational system could be, for the aims to be achieved, the implementation stage of the programme is very important. In line with this, European Commission (2010) noted that the major determinant of any educational system is the quality of its teachers. This is because it is the teacher who will effect the necessary changes and facilitate the expected outcomes.

In an attempt to improve teacher quality, Nigeria established the National Commission for Colleges of Education (NCCE) with the responsibility of producing teachers with Nigeria Certificate in Education (NCE) to teach at basic education level. Also, for the future generation to have good foundation in science, Physics is included as part of the N.C.E programme. This is because the science curriculum for basic science contains many physics topics like motion, force, energy, machines, friction, electricity, magnetism and electromagnetism. The philosophy of the Nigeria Certificate in Education (NCE) in Physics is inspired by the desire to help students become intellectually informed in Physics and the need to produce competent teachers with good mastery of content, method, skills and knowledge of the development of the learner.

The objectives of N.C.E Physics Programme as contained in N.C.E. course outline are to produce students that will be able to: have basic knowledge of organizational concepts, techniques in practical Physics, laboratory management, plan and effectively execute Physics based lessons in basic schools, use science resources effectively, explain the nature of science, demonstrate the understanding of concepts of Physics, reflect upon them and revise them when necessary and correct students' misconception in Physics. Saddled with the great task of laying a solid scientific foundation for the future generation, the Physics programme in Nigeria Certificate in Education (N.C.E.) is faced with the problem of gross under-enrolment for the programme as can be seen in Table 1.

Table 1: Students' Enrolment by Science Subjects and Sex in Colleges of Education in Nigeria between 2005 -2010 Sessions.

	2005-2006			2006-2007			2007-2008			2008-2009			2009-2010		
Subject	**Female**	**male**	**Total**	**female**	**Male**	**Total**	**female**	**Male**	**Total**	**Female**	**male**	**Total**	**Fe-male**	**Male**	**Total**
Agric Edu. /Science	**8042**	**8695**	**16737**	**6511**	**7244**	13755	6681	8635	15316	5403	6317	11720	**3268**	**3711**	**6979**
Biology	**8261**	**7977**	**16238**	**7787**	**7598**	15385	9688	8995	18683	9944	9825	19769	**2881**	**3361**	**6242**
Chemistry	**8314**	**3686**	**7000**	**3234**	**3529**	6763	4102	5007	9109	4327	6330	10657	**1561**	**1312**	**2873**
Computer Science/ Edu	**7202**	**4153**	**11355**	**7103**	**4337**	11440	5981	4159	10140	7530	5003	12533	**2673**	**2639**	**5312**
Home - Econom-ics	**5474**	**179**	**5653**	**5072**	**325**	5397	4881	104	4985	4885	237	5122	**2526**	**80**	**2606**
Integrated - Science	**6037**	**5819**	**11856**	**4709**	**4944**	9653	4865	4547	9412	5154	4525	9679	**2824**	**1966**	**4790**
Mathemat-ics	**6890**	**8032**	**14922**	**6393**	**7211**	13604	5686	7406	13092	5079	7013	12092	**2279**	**2739**	**5018**
PHE	**2506**	**2917**	**5483**	**2455**	**2754**	5209	3149	4019	7168	2931	5283	8214	**712**	**781**	**1493**
Physics	**1591**	**2656**	**4247**	**1451**	**2347**	3798	1898	3346	5244	1841	3356	5197	**698**	**1156**	**1854**
Technical Education	**389**	**2405**	**2794**	**220**	**986**	1206	1030	2694	3724	492	2671	3163	**155**	**1397**	**1552**

Source: NCCE Statistical Digest, 2011

For 2005-2006 session, a total of 339,039 students enrolled into all the colleges of education in Nigeria but only 4,247 which is 1.25 percent registered for physics. For 2006-2007 session, 351,519 students enrolled into all the colleges of education in Nigeria but only 3,798 which is 1.08 percent registered for physics. 2007-2008 session, 330,561 students enrolled but 5,244 which is 1.59 percent registered for physics. 2008-2009 session, 351,288 students enrolled but only 5,197 which is 1.48 percent registered for physics. For 2009-2010 session, 365,223 students enrolled but 5,197 which is 1.49 percent registered for physics. A comparism of the enrolment rate of physics with other science courses shows that it is very low and inadequate to provide the number of physics teachers that are required for implementing the basic science programme. Moreso when the role physics plays is crucial for national development.

This problem of low enrolment in Physics is also reported by researchers like Isenes (2003); Idris and Ayeni (2001); Ukpene (2001) and Kalijah (2000). Also the achievement of students in Physics at both secondary and tertiary levels is not very encouraging. This has been reported by many researchers (e.g Oludipe, 2003; Raimy & Adeoye, 2002; Ogunleye, 2001; Ivowi and Oludotun, 2001; Iroegbu, 1998; Ogunsola – Bamidele, 1996; Oyekan, 1993; Bangbelu, 1992; Farmer, 1990; Okeke, 1986; Egbugara, 1983).

Evidence from four selected colleges could be seen in table 2 which contains the final year results of physics students between 2005 and 2010. For the period of five years that is indicated in the table, a total of 916 students got to the final year and took the final examinations. Out of these, 689 passed the examinations and 227 failed. Only 28 students which is 3.06 percent graduated with distinction grade, 76 graduated with credit which is 8.29 percent, 197 which is 21.57 percent passed out with merit grade, 388 which is 42.35 percent graduated with pass grade. The highest number of students passed out with pass grade which is the lowest pass level obtainable. This is not good enough when one considers the fact that these students are going to be teachers of our coming generation. From the table, the number of students that failed is relatively high.

Table 2: PHYSICS RESULTS FOR SELECTED COLLEGES OF EDUCATION (2005-2010)

Year	**College**	**Dist.**	**Credit**	**Merit**	**Pass**	**Fail**	**Total Passed**	**Total No of students.**
2005-2006	School 1	4 (16.66)	2 (8.3)	3 (12.5)	2 (8.32)	13 (54.1)	11 (45.83)	24
	School 2	-	3 (12.5)	7 (29.16)	13 (54.17)	1 (4.17)	23 (95.83)	24
	School 3	2 (9.09)	5 (22.73)	2 (9.09)	10 (45.45)	3 (13.68)	19 (86.36)	22
	School 4	-	4 (13.79)	4 (13.74)	20 (68.96)	1 (3.45)	28 (96.55)	29
2006 – 2007	School 1	3 (6.81)	7 (15.9)	15 (34.1)	-	19 (43.20)	25 (56.82)	44
	School 2	-	5 (8.33)	27 (45)	15 (25)	13 (21.67)	47 (78.33)	60
	School 3	-	4 (17.05)	2 (9.52)	13 (61.90)	2 (9.52)	19 (90.48)	21
	School 4	6 (11.11)	5 (9.26)	11 (20.37)	28 (51.85)	4 (7.41)	50 (92.59)	54
2007 -2008	School 1	-	1 (5.88)	1 (5.88)	3 (17.65)	12 (70.59)	5 (29.41)	17
	School 2	-	5 (7.81)	29 (45.31)	9 (14.06)	21 (32.81)	43 (67.19)	64
	School 3	2 (5.56)	6 (16.67)	8 (22.22)	13 (36.11)	7 (19.44)	29 (80.66)	36
	School 4	2 (2.86)	6 (8.57)	8 (11.43)	39 (55.71)	15 (21.43)	55 (78.57)	70
2008-2009	School 1	4 (7.27)	6 (10.90)	7 (12.73)	9 (16.36)	29 (52.73)	26 (7.27)	55
	School 2	-	1 (1.75)	51 (89.47)	-	5 (8.77)	52 (91.23)	57
	School 3	-	3 (12.5)	1 (4.17	18 (75)	2 (8.33)	22 (91.67)	24
	School 4	-	5 (7.81)	7 (10.94)	47 (73.11)	5 (7.81)	59 (92.18)	64
2009 -2010	School 1	3 (7.14)	1 (2.38)	2 (4.76)	2 (4.76)	34 (80.95)	8 (19.05)	42
	School 2	-	-	5 (6.41)	54 (69.23)	19 (24.36)	59 (75.64)	78
	School 3	2 (3.45)	5 (8.62)	2 (3.45)	40 (68.66)	9 (15.52)	49 (84.48)	58
	School 4	-	2 (2.74)	5 (6.85)	53 (72.60)	13 (17.80)	60 (82.19)	73
Total		28 (3.06)	76 (8.29)	197 (21.50)	388 (42.35)	227 (24.78)	689 (75.21)	916

Source: The colleges of Education *** Percentages in Parenthesis.**

From tables 1 and 2, it is clear that very few students go in to study physics at the colleges of education and the achievement of these few enrollees at the end is not encouraging. This problem is not peculiar to Nigeria. In the Western countries, the same problem subsists as Wang, Spalding, Odell, Klecka and Lin (2010) reported that teacher education has been struggling with the central challenge of preparing and retaining sufficient number of high-quality teachers who can work effectively with students from diverse cultural and racial backgrounds. Murphy and White Legg (2005) equally reported that there has been more than a decade of declining enrolment of students in to Physics A-level courses leading to closure of a significant number of physics departments in higher education institutions in the United Kingdom.

In an attempt to tackle the problem of low enrolment and low achievement in Physics at all levels of education, the federal and state government of Nigeria on their parts have undertaken a list of reforms and initiatives at various times to promote Physics education (Ogunleye, 2001). These include establishment of agencies like the National Science and Technology Development Agency (NSTDA), Science Equipment Centers, admission policy provision of ratio 60: 40 in favor of science-related subjects in the Universities, establishment of Universities of Science and Technology, and development of new curriculum for Physics. However, the situation has not improved.

In 2008, Kwara State Government through the Ministry of Education, Science and Technology undertook an assessment of all the teachers in primary schools and reported that primary school teachers in Kwara State are seriously under-performing in all school subjects and even in the basic areas of literacy and numeracy (Education Sector Support Programe in Nigeria, 2008). Students' results from colleges show that pre-service teachers in schools are not doing well academically and teachers in the field are under performing. This situation calls for attention. This is what prompted the ongoing Educational reform in the Kwara State College of Education, Oro, to rescue the situation.

The problem of students' underachievement in physics has also engaged the attention of many scholars over the years (e.g. Adepitan, 2003; Ivowi & Oludotun, 2001; Ogunleye, 2001; Riess, 2000, Kalijah, 2000). Prominent among the factors which have been identified as contributing to the persistence of poor level of achievement in physics are: Inefficient teaching methods adopted by physics teachers in the field (Adepitan, 2003; Ivowi & Oludotun, 2001; Gbolagade, 2009), poor manipulation of science process skills (Aydogdu & Kesercioglu, 2005; Yesilyurt, Bayraktar & Erdemir, 2004; Saat, 2004), learner variables such as gender stereotype in physics and lack of confidence by physics students in their approach to tackling physics problems (Jimoh, 2004, Babosa, 2003; Riess 2000).

There seems to be a general consensus of opinion among science educators concerning the pivotal role played by the teaching method or instructional strategy adopted as classroom variables affecting students' achievement and attitude to science (Gbolagade, 2009) who also emphasized the importance of appropriate teaching method in the development of skills required for making science content relevant to the growth and development of both the individual, the society and to meet the teacher’s standards. He called for adequate training of teachers, which should include the introduction of appropriate methods of teaching the subject matter.

In search of solution to the problem of low achievement in Physics, physics educators over the years have developed different instructional strategies to arouse and sustain interest, build up self-efficacy and to positively change the attitude of learners to Physics. For instance, Onwioduokit (1989) developed problem solving models to enhance better acquisition of specific laboratory' skills and to improve students’ learning outcomes in Physics practical. Orji (1998) experimented on the use of problem solving and concept mapping strategies to improve achievement in and attitude to Physics. Iroegbu (1998) explored the use of problem-based learning for teaching physics in secondary schools. Adepitan (2003) explored the use of peer tutoring strategy to improve pre-service teachers’ achievement in science. Gbolagade (2009) tried out the constructivist model based instruction for pre-service teachers in science and Adedigba (2002) experimented with two collaborative group strategies for pre-service teachers.

In spite of these improved instructional strategies, students' achievement is still poor generally. It is important to note here that these laudable strategies do not get to the users who are the class teachers as some of them are not recommended in the curriculum. So, the investigator contends that if these strategies are emphasized and used in training pre-service teachers, they will get to know the different teaching strategies, their advantages over conventional teaching method, and they will use these improved strategies when they are on the field.

Various teaching strategies have been recommended in the NCE physics course outline these include: demonstration method, problem-solving method, practical method, project method, and discussion method, field work method, group discussion and lecture method which is the commonest of all. Akinsola (1994) found out that lecture method is still popular in Nigerian science classes, mostly at tertiary level inspite of its obvious and serious limitations. This could be as a result of the persistent and remarkable expansion in students enrolment at all levels of the education as well as shortage of classroom accommodation and other necessary facilities as pointed out by Oludipe (2003) and Ukpene (2001) because the lecture method is easier to use with large classes.

Ogunsola - Bamidele (1996) had earlier remarked that lecture method is the most abused of all the teaching methods and the least effective in many respects. May be this situation is what led to Erinosho's (1998) observation that the general approach to learning science is mainly of parroting and regurgitation of facts with virtually no link with the immediate environment of the learners. This has caused low participation and retention in science and technology among the youths. Tobias (1990) in her study titled 'they're not dumb, they're different: stalking second tier' observed that the introductory physics courses in colleges are responsible for driving off many students who had registered for physics without completing their programme. The negative features of the courses she cited include failure to motivate interest in physics by establishing its relevance to the students' lives and personal interest, relegation of students to almost complete passivity in the classroom, emphasis on competition for grades rather than cooperative learning and focus on algorithmic problem solving as opposed to conceptual understanding. These are typical of conventional lecture method.

The teacher standard according to ESSPIN (2008) is summarized as: Teacher exhibit professional knowledge and competency regarding how students learn and how to teach effectively, teachers have professional skills to plan and assess for effective learning, teachers provide and maintain conducive and enabling learning environments. These cannot be attained with conventional lecture method of instruction mostly in use in our classrooms; therefore, the need for more participatory method of instruction arises.

During the past twenty years, the role of the teacher has gradually changed from a traditional disseminator of information to that of a mentor or tutor. In this role, the teacher assists students with sources of information and provides them with guidance on analysis, interpretations and reporting of findings. The teacher becomes, rather a facilitator of learning than a sage-on-the-stage (possessor and communicator of ultimate scientific wisdom). However, the important role of the teacher in shaping the learning process should not be underestimated. Children usually need adult support to find the means and the confidence to produce and test their ideas (Popov, 2002).

Duyilemi (2005) advised that students should be given opportunity to be actively involved in the learning process. This has therefore, created room for further search for other instructional strategies that could possess enough cure and appeal to the learners and that would help to achieve the objectives of science education. All these call for constructivist-based teaching strategy in science.

Constructivism has emerged as one of the greatest influence on the practice of education in the last 25 years (Jones and Brader-Araje, 2009). This is because constructivist-based instruction firmly places educational priorities on students' learning. Also, Kinshuk (2003) reported that it has been found that students are able to learn and retain knowledge better by actively participating rather than learning passively. Therefore, the researcher adopted two constructivist strategies: problem-based learning strategy and interactive invention strategy which have not been given adequate attention in the NCE course outline. These perhaps, could be used to achieve the objectives of physics curriculum. More so, as pre-service teachers, they will use these strategies when they will be practicing as observed by Felder (1993) that teachers teach instinctively the way they were taught.

Problem–Based Learning (PBL) is an instructional strategy in which complex problems serve as the context and the stimulus for learning (Major and Palmer, 2001). In PBL classes, students work in teams to solve one or more complex and compelling ‘real world’ problems. They develop skills in collecting, evaluating, and synthesizing resources as they first define and then propose a solution to a multi-faceted problem. Students also summarize and present their solutions. The instructor in a PBL class facilitates the learning process by monitoring the progress of the learners and asking questions to move the students forward in the learning process, the instructor is not the sole resource for content or process information, but instead guides students as they search out appropriate resources (Major and Palmer, 2001).

Problem-based learning started in the 1960’s at McMaster Medical School as faculty developed PBL out of the perceived need to produce graduates who were prepared to deal with the information explosion, and who could think critically and solve complex problems. Soon after, medical schools around the world began to adopt the McMaster model. Also, educational and professional schools adopted the approach as well. For instance, Iroegbu (1998) used PBL to teach some physics concepts: work, energy, power, heat capacity and latent heat to 202 senior secondary II students. Based on the result obtained, he confirmed the potency of the PBL as an effective instructional procedure that could be used in reversing the current trend of under achievement in SSCE Physics examinations. He also found out that the use of PBL also promoted the acquisition of problem solving skills and line graphic skills.

According to Major and Palmer (2001), the strategy provides students with the opportunity to gain content knowledge and skills, helps them develop advanced cognitive abilities such as critical thinking, problem solving and communication skills and improve their attitudes toward learning. Thus as a pedagogical strategy, problem-based learning promotes the kinds of active learning that many educators advocate (Barr and Tagg, 1995). Therefore, it is hoped that this strategy will help to improve the quality of pre-service teachers if it is used.

The interactive invention strategy (IIS) is another strategy that is widely applied and can be used to teach both concepts and skills (Gbolagade, 2009). It uses teacher's explanation and modeling combined with students' practice, invention and feed-back to teach concepts and procedural skills. In an interactive invention instruction lesson, students are active in responding to teachers' questions, analyzing examples and practicing skills to the point where they can be used with little or no mental effort. Rosenshine (1995) reported that interactive invention strategy usually produces better scores on standardized tests of basic skills than other strategies. According to Maccini and Gugnon (2002), interactive invention includes: continuous modeling by teachers, followed by more limited teacher involvement and fading teacher involvement as students begin to master the material.

These two active learning strategies have been reported to be good in facilitating cognitive and science process skills development (Yilmaz; 2005 and Millar; 2004). Aydogdu (2006) observed that science process skills form the basis of the ability to conduct scientific research and a means whereby learners construct knowledge on their own and acquire problem solving skills. Also, these skills constitute a general definition of the logical and rational thought that an individual uses throughout his life-time. Duran and Ozdemir (2010) reported that science process skills facilitate learning in science, make students active, improve students' sense of taking responsibility for their own learning, making learning lasting and equip students with ways and methods of inquiry. Salin and Pekmez (2001) has shown that the acquisition of science process skills by pre-service teachers is important as a teacher not properly equipped with these skills will experience difficulties to deliver these skills to his students and will avoid performing experimental activities, thus, physics concepts will be taught theoretically.

Problem-based learning and interactive invention instructional strategies have what Iroegbu (1998) described as helpful instructional design which assures that individual learner becomes committed to the study as well as engages in regular practice of skills to be acquired. This is because the study is built on the principle that learning by doing is more effective than learning by being told and promoting individual participation. The principle involves active development of knowledge through concrete exploration, experimentation and elaboration in the domain of interest (Iroegbu, 1998). The principle also implies that learners will be more able to exhibit higher level of cognitive outputs since they are given opportunity in the strategies to interact with materials, ask questions, discuss answers teach peers and criticize submissions and are also able to put their learning to use thereby, rehearsing the learning and making it easier to remember.

Iroegbu (1998) identified monologue–oriented interaction pattern in Nigerian physics classes and noted that this is inappropriate and ineffective for achieving the high level objectives of the new physics curriculum. He observed that where monologue is predominant, rote learning is encouraged which in turn imposes heavy burden on the learners memory. Such learners according to Iroegbu (1998) find it difficult to recall information when the need arises there by creating fear and lack of confidence in learners. Learners that doubt their capability shy away from difficult task, have low aspirations and weak commitment to the goals they choose to pursue (Pajares, 2006). With the problem-based learning and interactive invention strategies, there is provision for hands-on activities and experiment and students build and verify their knowledge. These strategies therefore could be used to improve students' self-efficacy which had been reported to be related to achievement and retention in most academic areas including the sciences.

Self-efficacy is a person's self-judgment of personal capabilities to initiate and successfully perform specified tasks at designated levels and to expend greater effort, and persevere in the face of adversity (Bandura, 1994). Fend and Scheed (2005) in their study of the effects of self–efficacy on achievement submitted that self-efficacy influence academic achievement in physics.

The actual state of gender inequality and probable ways of restoring gender balance in various fields of human endeavors has been the concern of many research studies. The quantitative aspect of physics has always been reported to be the cause of gender imbalance in participation in the subject. Babosa (2003) observed that women are generally greatly underrepresented in physics than all the sciences. Barbosa explains further that many women who take physics end up running away from it and that statistics show that a higher proportion of women than men leave physics at each stage of their career. This could probably be because the learning needs of the female students are not met in the teaching strategies used. However, Problem–based learning and interactive invention strategies could provide opportunities for students to work in small interactive mixed gender groups where the group members help one another and every member of the group is carried along thereby enforcing cooperative learning. This may improve the participation and achievement of both males and females. Herein lies the need for this study.

From the forgoing, the researcher hopes to examine the effects of problem-based learning and interactive invention instructional strategies in mixed self-efficacy and gender groups on pre-service teachers' achievement in physics as well as their acquisition of science process skills.

1.2 Statement of the problem

The persistent low achievement of students in physics has been a major concern to physics educators and researchers. Several factors have been adduced to be responsible for this trend, mainly the instructional strategy used in teaching physics such as the use of lecture method, inadequate science process skills, gender stereotype and lack of confidence in tackling physics problems. This study therefore ascertained the effects of problem-based learning instructional strategy and interactive invention strategy on pre-service NCE students' achievement and acquisition of science process skills in physics.

1.3 Research Questions

Based on the problem stated above, this study addressed the following research questions:

1. How and to what extent will NCE students' performance depend on instructional strategy employed?
2. How will acquisition of science process skills be affected by mode of instruction?
3. To what extent will pre-service physics teachers' self-efficacy and gender influence their performance?

1.4 Hypotheses

This study is designed to provide answers to the following hypotheses at $p<.05$ level of significance.

HO_I: There is no significant main effect of treatment on pre-service teachers':

(a). achievement in physics concepts

(b). acquisition of science process skills.

HO_2: There is no significant main effect of self- efficacy on pre-service teachers’:

(a). achievement in physics concepts

(b). acquisition of science process skills

HO_3: There is no significant main effect of gender on pre-service teachers':

(a). achievement in physics concepts

(b). acquisition of science process skills

HO_4 There is no significant interaction effect of treatment and self-efficacy on pre-service teachers':

(a). achievement in physics concepts

(b). acquisition of science process skills

HO5: There is no significant interaction effect of treatment and gender on pre-service teachers':

(a). achievement in physics concepts

(b). acquisition of science process skills

HO_6: There is no significant interaction effect of self efficacy and gender on pre-service teachers':

(a). achievement in physics concepts

(b). acquisition of science process skills

HO_7: There is no significant interaction effect of treatment, self efficacy and gender on pre-service teachers':

(a). achievement in physics concepts

(b). acquisition of science process skills

1.5 Significance of the study

This study is considered significant because the findings would provide relevant information on the joint and independent effects of these two instructional strategies used. This would provide an opportunity for the pre-service teachers to have interesting hand–on instructional strategies which they would learn from and most likely use to implement what they have learnt. The experiment would provide for would be teachers practical and interesting alternative strategies they would use during their career so that they can do something different from what other teachers had been doing.These strategies would most likely improve achievement of the learners in physics. This study would expose to some level the influence that self-efficacy has on achievement and acquisition of science process skills.This study will hopefully provide some data on some aspects of gender inbalance in physics. This study would guide the curriculum planners on the instructional strategies to recommend that will improve learners' achievement in physics. This study may also provide a basis for further researcher.

1.5 Scope of the study

This study covered three states and three federal colleges of education in the South Western Nigeria. All the available NCE III physics students from these colleges were allowed to take part in the study. Some aspects of Electromagnetism III with course code PHY 321 as contained in the NCCE course outline was taught. A total of one hundred and ninety two (192) students of which ninety four (94) were males and ninety eight (98) females took part in the exercise. Scores on forty-item Physics Achievement Test were used to determine the achievement of students in physics. Scores obtained from the science process skills worksheets were used to determine acquisition of science process skills. Self-efficacy was limited to the scores obtained from the four point Likert scale of the self-efficacy questionnaire.

1.6 Operational definition of terms.

The following terms which were used in the course of this study were operationally defined as follows:

Conventional Lecture method: This is the general way majority of Nigerian teachers teach science. It is characterized by preparation of lesson note, verbal presentations of physics content of the note, theoretical examples, note taking and assignments. This method is used by majority of science teachers in the classrooms.

Gender: In this study, gender refers to the attribute of being a male or female.

Interactive Invention Strategy: This is an instructional strategy that emphasizes meaningful high students-teacher interactions. The teacher starts with

-assessing the background knowledge of the learners by distributing worksheets to them and asking them to answer questions based on previous lessons.

- introduction and explanation of the concepts and skills to be learnt for the day
- guided practice
- individual practice that will lead to students' discovery of scientific knowledge

- assessment of acquired knowledge and skills.

Physics Achievement: This is the students' scores in physics achievement test.

Pre-service Teachers: These are College of education students offering Physics as major/minor subject.

Problem-Based Learning: Problem-based learning is an instructional strategy that involves phase by phase instructional procedures:

- problem presentation
- information search
- presentation of findings
- summary and conclusion.

Students in small mixed gender interactive groups of five work, on given real life problem to learn scientific processes and acquire knowledge of basic science.

Science process skills: In this study, science process skills are observation, classification, measurement, stating of hypotheses, testing of hypotheses, analysis, drawing up of inference and generalizations.

Self-efficacy: In this study, self-efficacy is judged by the achievement of the participants on the self-efficacy scale measured with a four points Likert scale with 40 as the highest point obtainable and 10 as the lowest point obtainable. Scores of 30-40 is high, 21-29 is medium and 10-20 is low.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The review of related literature is arranged in the following order:

2.1 Theoretical Framework

2.2 Issues in Developing Quality Teacher Education

2.3 Problem-Based Learning and Achievement in Physics Concepts and Acquisition of Science Process Skills

2.4 Empirical Studies on Problem-Based Learning and Achievement in Physics Concepts and Acquisition of Science Process Skills

2.5 Interactive-Invention Strategy and Achievement in Physics Concepts and Acquisition of Science Process Skills

2.6 Empirical Studies on Interactive-Invention Strategy and Achievement in Physics Concepts

2.7 Self-Efficacy and Pre-service Teachers' Achievement in Physics

2.8 Gender Issues in Physics Achievement

2.9 Appraisal of Literature

2.1 Theoretical Framework

The theoretical framework on which this study is situated is **constructivist theory** to teaching and learning. In the past twenty five years, constructivism has emerged as one of the greatest influence on the practice of education. (Jones & Brader–Araye, 2009). This is because constructivist based instruction firmly places educational priorities on students' learning and by this constructivism is defined as a theory which focuses on learners' ability to mentally construct meaning out of their own environment and to create their own learning.

Constructivists believe that all human beings have the ability to construct knowledge in their own minds through a process of discovery and problem solving. The constructivist argues that as far as instruction is concerned, the instructor should encourage learners to discover principles by themselves. This involves collaborative learning where group of students interact and help each other to learn.

Central to the tenet of constructivism is that learning is an active process. Information may be imposed but understanding cannot be for it must come from within. According to Jenkins (2000), the idea is that students actively construct their own knowledge. The minds of the students mediate input from the outside world to determine what the students will learn. Learning is active mental work, not passive reception of teaching.

During the process of learning, learners may conceive of the external reality somewhat differently, based on their unique set of experiences with the world and their beliefs about them. However, learners may discuss their understandings with others and thus develop shared understandings. While different learners may arrive at different answers, it is not a matter of 'anything goes' but learners must be able to justify their positions and establish their validity (Gbadagade, 2009).

Constructivism offers teachers instructional approaches that are congruent with current research on learning by viewing learning as an active process, taking students prior knowledge into consideration, building on preconceptions, and eliciting cognitive conflict, teachers can design instruction that goes beyond rote learning to meaningful learning that is more likely to lead to deeper and longer lasting understandings (Jenkins, 2000).

Jenkins explained that learning and teaching framework based on constructivism consists of five phases namely: engagement, exploration, explanation, elaboration and evaluation. To him, engagement phase is a problem identification stage, exploration is the experimenting and problem solving stage, explanation is the classification stage, elaboration is the generalization stage and evaluation is the signal feed back stage.

Some of the theorists associated with constructivism are John Dewey, Jerome Brunner, Jean Piaget and Lev Vygotsky but for the purpose of this study, the work of Jean Piaget was used. **Jean Piaget** (1896-1980), a Swiss philosopher tended to focus primarily on the development of the individual while ignoring the greater socio-cultural context, but the roots of constructivism are clearly present in Piaget's focus on the active role of the individual in learning (Jones & Brader-Araje, 2009).

According to Piaget (1967a), "all knowledge is tied to action, and knowing an object or an event is to use it by assimilating it to an action scheme". For Piaget, knowledge construction takes place when new knowledge is actively assimilated and accommodated into existing knowledge. He believed that our understanding of reality is constantly being revised and re-constructed through time and with respect to exposure to new experiences (Jones & Brader- Araye, 2009).

Constructivist theory of Piaget (1967b) is an approach where learner is seen as an active participant who in the course of learning is structuring his experience and knowledge. In a constructivist learning environment, the teacher is seen to take up the responsibility of creating and making a collaborative problem-solving environment where students are allowed to construct their own knowledge and the teacher acts as a facilitator and guide (Kimmitt & Sledge, 2002).

Piaget believes that the cognitive development of students toward formal thought could be facilitated through the three cognitive processes: assimilation, accommodation and reorganization. Piaget ideas are used in problem-based learning and interactive invention strategies as these two strategies emphases experimentation. This is a very important stage in both strategies where learners are given opportunities to verify their findings in the case of problem-based learning and measure what they have learnt in the case of interactive invention strategy. This provides the pre-service teachers opportunities to interact with materials which facilitate permanent learning and enables them to come out with lasting mastery of contents and skills.

Problem–based learning instructional strategy is based on constructivist theory of learning where the learner is the central focus of the learning process, particularly the work of Piaget who emphasized that knowledge is tied to action. In problem-based learning instructional strategy learners are given adequate opportunity for them to take control of their learning process by participating fully in the problem solving process.

When problem is presented to the groups, students brain storm on the problem to identify issues involved, draw up learning objectives and schedule duties to group members, who will embark on investigation (information search) for the solution of the given problem. Collation of findings and verification by experiment is done all by the students with the instructor only acting as a guide. At the end, result is presented to the class.

During these rigorous exercises, new experiences are gained, new knowledge is acquired and their critical thinking skills are improved. These improve the overall performance of the students. As the knowledge in science is dynamic, would-be teachers will be well equipped with how to search and verify information, search for new discoveries in the area so that they will not teach obsolete ideas and have all it takes to make the teaching of physics practical-based.

Interactive invention strategy is also a strategy that is based on constructivist theory of learning particularly, Piaget believes on learning. Here students are allowed to interact with peers, instructor and materials bringing about meaningful learning that is more likely to lead to deeper, longer lasting understandings.

Here students experiment on what they are taught and with constant practice with apparatus they master the use of these instruments and become proficient in verification of their knowledge and skills that are learnt. During this interaction process, the students undergo the assimilation stage and accommodation stage when the skills assimilated become useful in solving problems as Piaget proposed, where they construct new knowledge from their experiences and incorporate into an already existing knowledge.

2.2 Issues in Developing Quality Teacher Education

Although learning can take place independently of a teacher yet it is inconceivable for there to be a school without a teacher according to Anikweze (1995), who also pointed out that it is the competence of the teachers that gives life and substance to education, be it at the smallest mushroom kindergarten school or at the loftiest of the universities. Jusuf (2005) in the same line opined that teachers are the single most important factor in student learning in school and that students who have access to highly qualified teachers achieve at a higher rate regardless of other factors.

Ukeje (1991) further substantiates this glowing encomium on teachers by stating that if the child is the centre of the educational system, the teacher is the pivot of the educational process and that teaching is the most vital and strategic profession for national development. Without teachers, there can be no good doctors, engineers, lawyers; hence teaching cannot be compared to other professions. The mistakes of the education programme have more devastating effects on the nation than the mistakes of other professions. The National Policy on Education (FRG, 2004) states that teacher education is designed to produce highly motivated, sensitive, conscientious and successful classroom teachers who will handle students effectively and professionally for better educational achievement.

Teacher education refers to the policies and procedures designed to equip prospective teachers with the knowledge, attitude, behaviours and skills they require to perform their tasks effectively in the classroom, school and wider community (Wikipedia, 2011). Teacher education is often divided into three stages: initial teacher training/ education where pre-service courses are taken before entering the classroom as a fully responsible teacher; induction, the process of providing training and support during the first few years of teaching and teacher development or continuing professional development for practicing teachers.

Teacher education could be organized according to two basic models; consecutive model where a teacher first obtains a qualification, in one or more subjects and then studies for a further period to gain an additional qualification in teaching and concurrent model where a student simultaneously study both one or more academic subjects and the ways of teaching that subject leading to qualification as a teacher of that subject (Wikipedia, 2011).

The question of what knowledge, attitude, behaviours and skills teachers should posses is the subject of much debate in many countries. However foundational knowledge and skills, content area and methods knowledge and practice at classroom teaching or at some other form of educational practice seems to be generally accepted as the content of the curriculum for teacher education. Because the world that teacher are preparing young people to enter is changing so rapidly and because the teaching skills required are evolving likewise, no initial course of teacher education can be sufficient to prepare a teacher for a career of 30-40 years (Jusuf, 2005).

However the quality of teacher education is of utmost importance to any country of the world because the quality of a teacher determines to a great extent the quality or level of national development. Okebukola (1995) in discussing the mission for the preparation of future teachers for Nigeria suggested that training activities geared specially to prepare teachers need to contemplate not only instruction on the curriculum and specific teaching procedures but more importantly on the development of the ability to reason pedagogically on the part of student teachers in order to convert substantive knowledge into teachable knowledge and experiment with how this can be done.

Kolawole (1999) further asserted that if the quality of our teachers is not improved through an effective teacher preparation programme nationwide, education will be doomed in the country, while our aim of developing technologically and scientifically will remain a mirage. According to Farant (1991), quality teachers and excellent teaching are functions of clearly conceived, designed, implemented and faithfully operated teacher education.

In USA according to Liston, Borko and Whitecomb (2010) for instance, teacher quality is seen as a key policy lever to narrow achievement gap that exist along racial and economic lines. Ensuring the quality profile of the teacher workforce is crucial to extend the democratic mission of public schooling to an unprecedented number of students who are more diverse than at any point in US history.

Defining teacher quality has been both problematic and elusive according to Liston, Borko and Whitecomb (2010). They identified three terms usually used in discussing teacher quality: qualified teacher, effective teacher and good teacher and pointed out that these terms focus on teacher characteristics or qualification, teaching outcomes and teaching practices respectively and none adequately captures the complexity of a system that supports teacher quality.

In line with this view, Goe and Stickler (2008) reported that many studies attest that some teachers contribute more to their students' academic growth then other teachers, but research has not been very successful at identifying the specific teacher qualifications, characteristics and classroom practice that are most likely to improve students' learning.

This lack of definitiveness does not necessarily mean that research studies on teacher quality have been poorly conducted. Findings in an area as broadly defined as teacher quality are often difficult to interpret, given the many ways of identifying and measuring the qualifications, characteristics and practices that contribute to the concept of what makes a good teacher. Differences in definition, combined with difference in ways of measuring teacher effectiveness, can even produce contradictory findings about educational efficacy (Levine, 2001). While careful research is the appropriate tool for determining more precisely what it means to be an effective teacher, these inherent complexities make it difficult for stakeholders to draw useful conclusions from the diverse findings (Levine, 2001).

In an attempt to understand teacher quality better, some teacher quality variables will be examined. Starting with highly qualified teacher, in U.S.A. legislatively, the federal law No Child Left Behind (2001) defines highly qualified teacher as having the following qualifications: a bachelor's degree, a state teaching certification or a passing score on the state teacher licensing examination, and subject matter knowledge (Hess and Petrilli, 2006). This is equivalent to having a degree in education in a particular subject area and having the teacher registration certificate in Nigeria.

Critiques of this definition emphasize the overly narrow focus on content preparation, the imprecision of measures for each qualification, and the variability across states to define when a teacher has met criteria. For example, given the wide variation in state's licensure requirements and pathways to certification, holding a state teaching license, though relatively easy to measure from state data bases, does not say much about a teacher's knowledge or practice. Overall, the federal definition of highly qualified teacher sets a minimum base for teacher knowledge and focuses on input measures.

The term effective teacher generally refers to teacher's ability to foster students' achievement. There is a long tradition of research on teacher-effectiveness, dating back to the 1960s and 70s (Shulman, 1986) who reported that much of this research examined specific teaching practices (e.g., teacher's questioning strategies) and correlated them with student learning gains. More recent and sophisticated extensions of this line of research include work done by Marzano and colleagues at the Mid-continent Research for Education and Learning (Marzano, Pickering and Pollock, 2001).

Teacher effectiveness research is grounded in classrooms and often uses classroom-based assessments. However, the recent Aspen Institute report, *Beyond NCLB* written to guide the reauthorization of NCLB, defines "effective" in terms of teacher's ability to improve students achievement as measured on standardized tests. The Commission draws upon studies using value-added methodologies to argue that in the NCLB reauthorization, emphasis should be placed on developing data systems that allow states and districts to identify those effective teachers who contribute to children's achievement growth each year.

This is a shift from a focus on qualifications to describe teacher quality to a focus on achievement outcomes. Critiques have focused on the narrowness and limitations of most state's standardized tests (Nichols and Berliner, 2007), the flaws in current value-added models (Braun, 2003), and the potential to abuse a teacher identifier system in making hiring or retention decisions.

> Good teacher is perhaps the most common and least precise of all terms. Shulman, President of the Carnegie Foundation for the Advancement of Teaching, describes a good teacher in the following way: in the classroom of a good teacher, students are visible, engaged, attentive and participating…In good teaching, students are responsible for their learning; they are accountable for their understanding….Good teaching is passionate, and it induces an emotional response in students….Good teaching starts with inducing habits of mind, but does not stop there. Good teaching engages practical thinking and problem-solving skills that can be applied in a variety

> of settings. And good teaching affects students' values, commitments, and identities. (Loeb, Rouse, and Shorris, 2007, p.7)

Shulman's definition focuses on teaching practices. Grounded in the moral dimensions of teaching, his description reminds us that a good teacher connects learners with significant ideas, with themselves, and with their world. Good teachers do more than boost achievement, they shape lives. His definition will most likely resonate with teacher educators for it reflects a more complex and holistic understanding of a teacher's interactions with and impact on students.

Critiques emphasize the measurement problems associated with this definition. For instance, which aspects of teaching practice does one focus upon, or how does one assess teacher's ability to shape student's identities? Also, the definition of a teacher's impact is too expansive; efforts to enhance teacher quality should focus teaching on academic achievement as this is the unique purview of schools and already a sufficiently large goal.

Researchers locate teacher quality problem in different places. Where one locates the problem, in turn, shapes the policy and practice recommendations and initiatives pursued (Levine, 2006). Each location reflects a "theory of action" for improving teacher quality as well as values and understandings regarding the teacher's role(s) in schools. Some see the problem as a supply/demand issue: The profession is not attracting the "right" individuals into teaching (Liston et al, 2010). Though the empirical research that undergirds teacher attributes is far from conclusive (Rice, 2003), criteria often considered in teacher quality discussions include overall academic ability strong academic preparation or knowledge in particular content areas and commitment to serve.

Some view the quality problem as a concern about *preparation.* From this point, teachers who complete university-based or college of education programs do not leave with the appropriate knowledge and practices to be effective in contemporary classrooms. Critics tend to outline the following weaknesses: low admission standards, curricular fragmentation, excessive requirements, disconnection with classroom worlds, and inadequate quality control mechanisms (Levine, 2006). Teacher educator's attention to candidate's beliefs, attitudes, and knowledge often translates into teachers having a principled understanding of what they want to do without sufficient practical tools to enact that commitment (McDonald, 2005).

Others construct the problem as a retention matter. The profession is failing to identify and/or keep those teachers with greatest potential to improve teaching and learning. Ingersoll (2001) describes the "revolving door" that many new teachers go through. Within the first five years, a significant number of teachers leave the profession altogether despite the role that experience appears to play in teacher's ability to foster student learning (Greenwald, Hedges, and Laine, 1996). This phenomenon contributes to what has been dubbed the "teacher quality gap," a situation where poor and minority students are most likely to have least experienced teachers (Peske and Haycock, 2006).

Many factors are in play including teacher age, teacher salaries, and teacher working conditions. Of these, teacher working conditions appear to be critical (Johnson, 2006). Conditions include appropriateness of a first-year teacher's teaching assignment, quality of induction and mentoring, curriculum alignment within the school, quality of continued professional development and the professional learning culture among teachers, adequacy of facilities and resources, and the quality of the building-level leadership.

In addition to the problem of a disproportionately high number of new teachers leaving the profession in the first five years, others argue that evaluation systems are not well honed to identify those who are able to impact students' learning. As a result, weak teachers are retained rather than let go. This situation argues for policies to strengthen evaluation systems, particularly those used in teacher's initial teaching years.

The researcher contends that it is best to see the challenges associated with teacher quality as a complex, overlapping *systems* problem. To enhance teacher quality policy ideas and proposals need to address, in concert, concerns associated with supply/demand, preparation, and retention. Policies and initiatives directed toward one facet of the teacher quality problem tend to yield fragile results because weaknesses in other parts of the system overwhelm progress made in one area.

One barrier to systemic thinking is that policy is made by different stakeholders who have different points of leverage within the system. Another is the lack of alignment regarding teaching standards about what constitutes high quality practice; in many states, teaching standards and performance expectations in teacher preparation differ from district evaluation standards for novice or veteran teachers. Another possible barrier is the lack of longitudinal data systems that allow stakeholders to ease out relationships among teacher qualifications, teacher preparation, and student learning. But perhaps the greatest barrier is the will to act in bold and visionary ways.

2.3 Problem-Based Learning and Achievement in Physics Concepts and Acquisition of Science Process Skills

Problem - Based Learning (PBL) is student' centered instructional strategy in which students collaboratively solve problems and reflect on their experiences. Finkle and Torp (1995) states that problem - based learning is a curriculum development and instructional system that simultaneously develops both, problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem solvers confronted with an ill-structured problem that mirrors real-world problems.

Duch (2008) defines problem-based learning as an instructional method that challenges students to "learn to learn," working co-operatively in groups to seek solutions to real world problems which prepare students to think critically and creatively, and to find and use appropriate learning resources. Barrows and Kelson as cited by Levine (2001) defines PBL as both a curriculum and a process. The curriculum consisting of carefully selected and designed problems that demands from the learner, acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies, and team participation skills.

The fore-going definitions of PBL shows the diverse ways different scholars perceive PBL. However, there appear to be a central idea that cuts across all the definitions. The idea is that the problem is encountered first in the learning situation, and it serves as a focus and stimulus for the application of problem solving as well as its search and study of facts and information needed for understanding and resolving the problem (Albaness and Mitchell, 1993; Iroegbu, 1998).

In recent decades research in cognitive science has revealed a lot about the nature of learning. Students construct knowledge; they do not take it in as it is disseminated, but rather they build on knowledge they have gained previously (Cross, 1998). They benefit from working together, and they may learn best from teaching each other (Annis, 1983; McKeachie, Pintrich, Lin & Smith 1986). Research also suggests that students learn best in the context of a compelling problem (Ewell, 1997); they learn through experience (Cross, 1999).

Students learn through making cognitive connections, social connections, and experiential connections (Cross, 1999). Because they make these connections differently, students do not learn in the same way. This relatively new information suggests that teaching is a complex activity, and it necessitates the emergence and development of approaches to instruction that are consistent with what is known about the way that learning happens (Ewell, 1997).

This new understanding has given rise to a paradigm shift in higher education, one from a focus on teaching to a focus on learning (Barr and Tagg 1995). New pedagogy emphasizing learning, such as Problem-Based Learning (PBL) intimate that alternative pedagogy is gaining prominence and may ultimately become the dominant classroom paradigm.

PBL is an educational approach in which complex problems serve as the context and the stimulus for learning. In PBL classes, students work in teams to solve one or more complex and compelling "real world" problems. They develop skills in collecting, evaluating, and synthesizing resources as they first define and then propose a solution to a multi-faceted problem. In most PBL classes, students also summarize and present their solutions in a culminating experience.

The instructor in a PBL class facilitates the learning process by monitoring the progress of the learners and asking questions to move students forward in the problem-solving process (Major and Palmer, 2001). Unlike traditional classrooms, the instructor is not the sole resource for content or process information, but instead guides students as they search out appropriate resources.

Problem is part of life and man is always facing the challenge of solving one problem or the other everyday. An effective education should be one that equips man with adequate techniques of solving whatever problem he may face in life. Maybe this is why Lave (2001) defined PBL as a total approach to education and that the process of PBL replicates the commonly used systematic approaches to resolving problems or meeting challenges that are encountered in life and career.

Iroegbu (1998) pointed out that there is a strong view among problem based learning experts that problem based learning is a basic human learning process. West (1992) observed that whenever a person is confronted with a problem, some learning occurs during the solving process. These scholars have argued that information learnt from problems are retained and recalled more successfully than information, which are written or given orally.

The knowledge of science is dynamic. Maybe it was this nature of science that prompted West (1992) to say that it is wasteful and impossible to teach students the knowledge they require to be effective citizens, because such knowledge could become obsolete in the nearest future. By the time the learner leaves school, the society will demand from him to understand and supply knowledge which has not been discovered yet, and to solve problems which have not been yet identified. According to West (1992), what is required is to evolve some authentic way of handling the demands of new knowledge and new problems, which is what is involved in problem based learning.

According to Gallagher, Sher, Stepien andWorkman (1995), PBL is a curricular and instructional approach which successfully resolves the seemingly contradictory demands of science education reform in a way that is true to the discipline of science, its process, and the larger goals of educating an independent reasoning citizenry. To Gallagher, the best way for students to learn science is to experience problems that challenge science, and the thought, habits of mind and actions associated with trying to solve them. This implies opportunities for authentic, inquiry-based learning.

Problem-based learning (PBL) is a powerful vehicle for this, in which a real-world problem becomes a context for students to investigate, in depth, what they need to know and want to know (Checkly, 1997). It is a robust, constructivist process, shaped and directed primarily by the student, with the instructor as a meta-cognitive coach. PBL is not just another iteration of what many science educators already use in their classrooms. To be truly "problem-based", Gallagher et al (1995) emphasizes, all three of these key features must be present: initiating learning with a problem, exclusive use of ill-defined problems and teacher as meta-cognitive coach.

The theme of science education reform is to understand science as ways of thinking and doing as well as bodies of knowledge. Emphases are thinking and problem solving and habits of mind that promote exploration and discovery such as curiosity, questioning, openness to ideas, learning from errors and persistence. Learning needs to occur in the context of real investigation through inquiry and reasoning, which means teaching for understanding not memorization of facts (AAAS). Learning process specialists, Wiggins and McTighe (1998) advised that learning is best, much more takes place, when the learner is the one who looks deeper to create meaning and develop understanding.

Perkins and Blythe (1994) explain understanding to mean deep learning that goes well beyond simply "knowing", such as being able to do thought-demanding things with a topic like finding evidence and interpreting information in new ways. Wiggins and McTighe (1998) stress that students need to "uncover" content for meaning, to question and verify ideas if they are to be understood and Caine and Caine (1997) emphasized that the mind needs to be understood as purposive, self-reflective, creative, and requiring freedom to create meaning. For these reasons, Wiggins and McTighe (1998) advised that a priority in teaching for understanding is shaping content in ways that engage students in making sense out of it through inquiry and application.

In PBL there is a shift in roles for students and teachers. The student, not the teacher, takes primary responsibility for what is learned and how. The teacher is "guide on the side" or meta-cognitive coach in contrast to "sage on the stage", raising questions that challenge students' thinking and help shape self-directed learning so that the search for meaning becomes a personal construction of the learner. Understanding occurs through collaborative self-directed, authentic learning, characterized by problem-finding, problem solving, reiteration and self-evaluation. This, according to Barrows (1997), is what distinguishes true PBL from "same-name" methods that use a problem of any sort somewhere in the teaching/learning sequence.

In PBL, Gallagher et al (1995) explains, students encounter a problem as it occurs in the real world, outside the classroom. There is insufficient information to develop a solution, no single right answer or strategy, and a need to redefine the problem as new information is gathered. Ultimately, students cannot be sure of their solutions because information will still be missing. This also characterizes science as he describes it as "a process of thinking about problems then designing means of approaching them... not necessarily to solve the problem you outlined, but to make an inroad or a start, asking what further approaches can I use to get a handle on this problem?" (pg 139)

Some Assumptions in Problem-Based Learning

A primary assumption of PBL is that when one “solves the many problems one faces every day, learning occurs” (Barrows and Tamblyn, 1980). This assumption is countered by the public assumption that learning occurs only in formal education settings, so once one leaves school one ceases to learn. Proponents of PBL believe, as did Popper (1994), that “Alles lebenist Problemlösen [all life is problem solving].” If all life is problem solving, then all life is replete with learning opportunities. The most consistent finding from PBL research is the superiority of PBL-trained learners in life-long learning.

In addition to the importance of life-long learning, PBL proponents assume the primacy of problems in learning; that is, learning is initiated by an authentic, ill-structured problem. In PBL classes, students encounter the problem before learning, which is countered by centuries of formal education practice, where students are expected to master content before they ever encounter a problem and attempt to apply the content. Learning in PBL is bounded by problems.

Problem-based learning is based on constructivist assumptions about learning, such as: Knowledge is individually constructed and socially co-constructed from interactions with the environment; knowledge cannot be transmitted, there are necessarily multiple perspectives related to every phenomenon, learning and thinking are distributed among the culture and community in which we exist and the tools that we use, knowledge is anchored in and indexed by relevant contexts. PBL is underpinned by theories of situated learning, which assume that learning is most effective when it is embedded in authentic tasks that are anchored in everyday contexts.

In everyday and professional lives, people continuously solve ill-structured problems, those that have multiple or unknown goals, solution methods, and criteria for solving the problems. Because meaning is derived by learners from interactions with the contexts in which they are working or learning. Knowledge that is anchored in specific contexts is more meaningful, more integrated, better retained, and more transferable.

One reason for this phenomenon is the ontology that students use to represent their understanding (Jonassen, 2006). Knowledge constructed for solving problems results in epistemological (task-related procedural knowledge) and phenomenological (the world as we consciously experience it) knowledge types. These are richer, more meaningful and memorable representations.

In addition to supporting more meaning by anchoring learning in authentic problems, problems provide a purpose for learning. Without an intention to learn, which is provided by problems, meaningful learning seldom occurs. When studying course content, students who are unable to articulate a clear purpose or intention for learning seldom learn meaningfully. When knowledge is evaluated based on its similarity to an authority, students' epistemological development is retarded. They fail to understand or accommodate multiple perspectives and make no effort to construct their own culturally relevant understanding (Jonassen, 2006).

Traditional academic approaches -- those that employ narrow tasks to emphasize rote memorization or the application of simple procedures – will not develop learners who are critical thinkers or effective scholars (Duyilemi, 2005). Duyilemi went further to say that students need to take part in complex, meaningful learning programme that require sustained engagement and collaboration. A growing body of research demonstrates that students learn more deeply if they are engaged in activities that require applying classroom-gathered knowledge to real-world problems. Like the old adage states, "Tell me and I forget, show me and I remember, involve me and I understand."

Problem-Based Learning as Instructional Methodology

Problem-based learning is an instructional methodology, that is, it is an instructional solution to learning problems according to (Greenwald, 1996). He went further to explain that the primary goal of PBL is to enhance learning by requiring learners to solve problems and that it is a methodology with the following characteristics: It is problem focused, such that learners begin learning by addressing simulations of an authentic, ill-structured problem. The content and skills to be learned are organized around problems, rather than as a hierarchical list of topics, so a reciprocal relationship exists between knowledge and the problem. Knowledge building is stimulated by the problem and applied back to the problem.

It is student centered, because instructor cannot dictate learning. It is self-directed, such that students individually and collaboratively assume responsibility for generating learning issues and processes through self-assessment and peer Problem-Based Learning assessment and access their own learning materials. Required assignments are rarely made. It is self-reflective, such that learners monitor their understanding and learn to adjust strategies for learning. Tutors are facilitators (not knowledge disseminators) who support and model reasoning processes, facilitate group processes and interpersonal dynamics, probe students' knowledge deeply, and never interject content or provide direct answers to questions.

The PBL learning process normally involves the following steps: Students in groups of five to eight encounter and reason through the problem. They attempt to define and bound the problem and set learning goals by identifying what they know already, what hypotheses or conjectures they can think of, what they need to learn to better understand the dimensions of the problem, and what learning activities are required and who will perform them.

During self-directed study, individual students complete their learning assignments. They collect and study resources and prepare reports to the group. Students share their learning with the group and revisit the problem, generating additional hypotheses and rejecting others based on their learning. At the end of the learning period (usually one week), students summarize and integrate their learning.

Brief History and Forms of Problem-Based Learning

The PBL approach had its start in the 1960s at McMaster Medical School as faculty developed PBL out of the perceived need to produce graduates who were prepared to deal with the information explosion, and who could think critically and solve complex problems (Major and Palmer, 2001). This institution developed its entire curriculum around problem-based learning.

Soon after, medical schools around the world began to adopt the McMaster model. In these cases, PBL is an approach to structuring the curriculum that involves confronting students with problems from practice which provide a stimulus for learning (Boud and Feletti, 1991). However, there are many possible forms that a curriculum and process for teaching and learning might take and still be compatible with this definition (Boud and Feletti, 1991). For example, educational and professional schools also began to feel many of the same needs as medical schools, so they began to adopt the approach as well, although in different forms, such as hybrid PBL and traditional curricula and course-by-course models; again the approach spread to institutions around the world.

Also educators and employers alike began to call for change in undergraduate programmes (Jones, 1997). They also wanted students who could think critically, solve problems, and work in teams. The 1998 Boyer Report, "Reinventing Undergraduate Education: A blueprint for America's research universities", for example, articulates these charges and recommends inquiry-based learning as a vehicle for improvement (The Boyer Commission, 1998). And many undergraduate institutions began to develop PBL programs and curricula. Aalborg has one of the most comprehensive undergraduate PBL curriculums, and Maastricht also has a developed PBL program of study. More recently, in the U.S., the University of Delaware has turned attention toward PBL, as has Samford University in Birmingham, Alabama. In addition to these more comprehensive efforts, individual faculty members at more than 300 institutions are using PBL at the undergraduate level (The Boyer Commission 1998).

PBL has been applied globally in a variety of professional schools (Boud and Feletti, 1991; Gijselaers, Tempelaar, Keizer, Blommaert, Bernard andKasper 1995; Wilkerson and Gijselaers, 1996), such as architecture (Donaldson, 1989; Maitland, 1998), business administration (Merchand, 1995), chemical engineering (Woods, 1996), engineering studies (Cawley, 1989), law schools (Boud and Feletti, 1991; Kurtz et al., 1990; Pletinckx and Segers, 2001), leadership education (Bridges and Hallinger, 1996; Cunningham and Cordeiro, 2003), nursing (Barnard et al., 2005; Higgins, 1994). Also PBL has been applied in social work (Bolzan and Heycox, 1998), and teacher education (Oberlander and Talbert-Johnson, 2004).

Moreover, Moust, van Berkel and Schmidt (2005) reported that PBL is also frequently integrated into a wider range of disciplines, such as biology (Szeberenyi, 2005), biochemistry (Osgood et al., 2005), calculus (Seltzer et al., 1996), chemistry (Barak and Dori, 2005), economics (Garland, 1995), geology (Smith and Hoersch, 1995), psychology (Reynolds, 1997), science courses (Allen, Duch & Groh 1996), physics, art history, educational psychology, leadership education, criminal justice, nutrition and dietetics, and other domains of post-secondary education (Edens, 2000; Savin-Baden, 2000; Savin- Baden and Wilkie, 2004). In introducing PBL into K–12 education, Barrows and Kelson (1993) systematically developed PBL curricula and teacher-training programs for all high-school core subjects (Illinois Math and Science Academy, http://www.imsa.edu). Since then, PBL has been promoted by a number of scholars and practitioners for use in basic education (Arends, 1997; Glasgow, 1997; Jones et al., 1997; Kain, 2003; Krynock and Robb, 1999; Savoie and Hughes, 1994; Stepien et al., 2000; Torp and Sage, 2002; Wiggins and McTighe, 1998).

Various results of implementations of PBL in K–12 settings have been widely reported. First, PBL has been shown to be effective in conveying a variety of content areas—for example, mathematics (Cognition and Technology Group at Vanderbilt, 1993), science (Kolodner et al., 2003; Linn, Shear, Bell & Slotta 1999), literature (Jacobsen and Spiro, 1994), history (Wieseman and Cadwell, 2005), and microeconomics (Maxwell, Mergendoller & Bellisimo 2005). Secondly, PBL has been implemented effectively in schools in urban, suburban, and rural communities (Delisle, 1997; Fogarty, 1997). Thirdly, PBL has been used effectively in a wide variety of student populations—for example, gifted elementary, middle and high-school students (Dods, 1997; Gallagher, 1997; Gallagher et al., 1995 and Stepien et al., 1993), as well as low-income students (Stepien et al 1993).

Interest in PBL is increasing in higher education and K–12 education as evidenced by the widespread publication of books about PBL (such as Barrows, 2000; Duch et al., 2001; Evenson and Hmelo, 2000; Kain, 2003; Torp and Sage, 2002). As Internet concerned with PBL (http://interact.bton.ac. uk/pbl/) reveal, many teachers around the world are using PBL, and the numbers are expected to grow. An increasing number of PBL literature reviews (Albanese and Mitchell, 1993; Dochy et al., 2003; Gijbels et al., 2005; Hmelo-Silver, 2004; Newman, 2003; Smits et al., 2002; Van den Bossche et al., 2000; Vernon and Blake, 1993) and PBL conferences also reflect the popularity of PBL.

As mentioned earlier, curriculum wide application of problem based learning was made popular by its application to courses at Mc Master University in the late 1960s (Albanese and Mitchell, 1993). What is described is a real world program that combines science content skills to create useful experiences for learners by drawing connections between students' lives in the society and what goes on in the classroom. Problem based learning has successfully been employed in medical education and engineering education both of which depend heavily on knowledge and application of the principles of physics (Iroegbu, 1998).

Kinimitt and Sledge (2002) reported that Howard Barrows, a physician and neurophysiologist, is most frequently attributed with the invention and implementation of problem based learning to medical school. The problems as highlighted by Kinimitt and Sledge (2002) that prompted Barrow to think of a change were:

* Students experience difficulty in applying their basic science knowledge in the field
* Emphasis on delivery of content
* Regulating evaluation and management of real life medical to "vocational" skills
* Linear, sequential delivery thought process as opposed to circular overlapping webs.

He therefore incorporated the teaching of clinical reasoning skills into the curricula which brought about the development of problem based learning.

The problems Barrow experienced seem to be similar to what teacher education is facing in Nigeria presently (Esspin, 2008). In order to overcome these problems Iroegbu (1998), West (1992) and Bickly (1990) recommended the adoption of problem based learning which they found to be effective in promoting the acquisition of problem solving skill.

Levine (2001) reported that PBL students do as well as their counterparts from traditional classroom on national examination but they are better practitioners of their professions. Also, Kreger (2004) summarized the benefits of PBL to include engagement in learning due to cognitive dissonance, relevance to real-world scenerios, opportunities for critical thinking, meta-cognitive growth and real-world authenticity that promote transfer and recall.

Inquiry Based Problem-Based Learning

Eggen and Kanchak (2006) classify PBL in to two.

i. Problem solving model

ii. Inquiry model. The investigator used the inquiry model. The inquiry model is similar to the problem solving model because they are both types of PBL but inquiry differs in its approach. Instead of focusing on the solution to a specific problem, it asks a question and then gathers information in an attempt to answer it (Eggen and Kanchak, 2006). These authors explained further that the processes of inquiry model are very much part of our everyday life and this will help remove the notion that physics is an abstract course. Also, involving students in inquiry is an effective way of helping them learn to think critically, develop as self-directed learners and acquire a deep understanding of specific topics.

The inquiry model is designed to give students practice with critical thinking while focusing on questions about how the world operates and systematically answering questions based on facts and observations. Inquiry is central to scientific thinking and can play a powerful role in our everyday lives. When using this model, students are provided with opportunities and Gardner (2002) noted these opportunities as helping learners learn how to systematically design investigation, examine and try out what they know, discover what they need to learn, improve their communication skills, state and defend positions with evidences and sound argument, become more flexible in processing information and meeting obligations, practice skills that they will need after their education.

In this strategy, learning is organized around the learners' area of interest. Since the introduction of ICT to education, most students have developed much interest in ICT. They spend hours doing one thing or the other in the internet. Since they enjoy doing this, the researcher believes that organizing instruction around this area will motivate them to learn.

Models of Inquiry Problem-Based Learning.

Several models of inquiry problem based learning have been presented by different authors. The idea seems to be the same but the presentation differs slightly.

Eggen and Kenshak (2006) present a five (5) phase- model. Phase I: identifies a question Phase II: generates hypotheses, Phase III: gathers data Phase IV: assesses hypotheses Phase V: generalizes.

This model gives a general and simplified form of the idea of inquiry model and these authors gave motivation functions for the inquiry model and it is as shown below:

Table 2.1

Motivation Functions for the Inquiry Model

Phase	Learning motivation function
Phase 1	
Identify question: a question or problem is Identified that provides the focal point for students' investigation	* Attracts attention

	* Capitalize on the motivating effect of curiosity and challenge.
Phase 2	
Generates hypotheses	
Students generate hypotheses that attempt to answer the questions	*Activates background knowledge * Begins schema production.
Phase 3	
Gather Data: Students gather data related to the hypotheses.	* Develops meta-cognition * Promotes involvement.
Phase 4	
Assess hypotheses	
Students assess the validity of the hypotheses based on the data gathered	* Promotes perception of competence * Achieve equilibrium.
Phase 5	
Generalize	
Students generalize based on their assessment of hypotheses.	* Facilitates transfer * Advances schema production.

Gardner (2002) produced a nine steps model and pointed out that the steps could be repeated and recycled. Step two to five may be repeated and reviewed as new information becomes available and redefines the problem. Step six may occur more than once especially when teachers place emphasis on going beyond what he called "first draft".

Step 1: Explore the issues. Here "ill-structured" problem is presented to the group. Discussion of the problem statement is made and its significant parts listed.

Step 2: List "what do we know".

It includes both what you actually know and what strength and capabilities each team member has.

Step 3:

Develop and write out the problem statement in your own words. This should come from your group’s analysis of what you know, and what you will need to know to solve the problem.

Step 4:

List possible solutions: List them all and order them from the strongest to the weakest. Choose the best that are most likely to succeed.

Step 5: List actions to be taken with a timeline:

What do we have to know and do to solve the problem. How do we rank these possibilities?

How do these relate to our list of solutions?

Step 6: List "what? do we need to know". Research the knowledge and data that will support your solution. Discuss possible resource (Expert, books, web site) Assign and schedule research tasks.

* If your research support your solution and if there is general agreement go to (7) if not, go to (4).

Step 7:

Write up your solution with its supporting documentation, and submit it: There may be presentation of findings.

Step 8:

Review your performance and take pride in what you have done well and learn from what you have not done well:

Step 9: Celebrate your work.

Stepien, Gallagher and Workman (1993) presented and tested a six-step model which had been adopted by many researchers. It is interactive model. Step two to five may be conducted concurrently as new information becomes available and redefines the problem. Stepien et al model (1993) includes the following activities:

1. Defining and detailing issues
2. Creating hypotheses
3. Searching for and then scanning data
4. Defining hypotheses with the help of data collection
5. Conducting empirical experiments or other researches.
6. Developing solutions that fit the conditions of the problem
7. Justifying the solution to the problem.

It has been observed by Iroegbu (1998), that these models should be used as a guide in solving physics problems because what really determine the method and technique to be used in real life depends on the problem, its structure, subject and its content. Stepien et al (1993) have also observed that professional problem solvers do not follow the "lock-stepped prescription of a particular problem solving programme".

They therefore discouraged the teaching of prescription of a particular problem solving programme since they believe that problem-based learning is apprenticeship to real life problem solving.

From the above discussion it is clear that in using this instructional strategy the process of science is adequately followed and science process skills are learnt and improved. Science process skills are the underlying skills and premises which govern the scientific method (Hills, 2012). Hills enumerated these to include the following six actions, in no particular order: observation, communication, classification, measurement, inference, and prediction. These basic skills are used in the experiments of scientists and students, as well as in the everyday life of average person, to a degree. And he explains that they allow everyone to conduct objective investigation and to reach conclusions based on the results. The first of the science process skills, observation, involves noting the attributes of objects and situations through the use of the senses. Classification goes one step further by grouping together objects or situations based on shared attributes. Measurement involves expressing physical characteristics in quantitative ways. Communication brings the first three skills together to report to others what has been found by experimentation.

Inference and prediction are the more sophisticated of the science process skills. Beyond simply seeing and reporting results, scientists must extract meaning from them. These skills can involve finding patterns in the results of a series of experiments, and using experience to form new hypotheses. It is also essential for a scientist to be able to distinguish his objective observations from his inferences and predictions. This is because scientific inquiry and study depend on objectivity and an avoidance of hasty assumptions in experimentation (Hills, 2012). All of the science process skills contribute to a larger purpose, namely problem solving. Problem solving is the reason for scientific inquiry, and forms the essence of it. A typical experiment wherein a scientist uses process skills and scientific method will start with certain questions being asked. Based on prior knowledge and experience, the scientist will make an educated guess as to the answer or outcome. This hypothesis will guide the design and execution of an experiment. All these skills are what PBL emphasizes.

2.4 Empirical Studies on Problem-Based Learning and Achievement in Physics Concepts and Acquisition of Science Process Skills

Research findings that support the use of PBL instruction abound in the area of medicine; few of such exist in secondary schools but are scarce in colleges of education. Some of these are reviewed here. Barrow (1992) observed that medical students experienced difficulty in applying their basic science knowledge in order to make diagnosis based upon patient symptoms. Barrow was concerned that medical school emphasized the delivery of content and thereby relegated the evaluation and management of the patient's medical problem to "vocational skills". He determined to redesign the curriculum of medical school with the objective of addressing the perceived problem. He investigated the clinical reasoning of practicing physicians by videotaping them and interacting with patients.

Barrow observed that seasoned diagnosticians immediately generated a number of diagnoses based on very little hard information and then used the remainder of the patient's interview to substantiate, eliminate, or generate alternative diagnoses. He discovered that the thought processes of these diagnosticians were circular, overlapping of information which contrasted sharply with the linear, sequential delivery of information in the medical school classroom. Barrows determined that this type of reasoning, or cognitive process was the integral skill that medical school curriculum failed to convey. This then became his objective; to find a way to incorporate the teaching of clinical reasoning skills into the curricula. This objective led to the development of problem-based learning. After the implementation, Barrows found out that the new method showed clear positive effect on physicians' competence, which was strong for social and cognitive competences such as coping with uncertainty and communication skills.

After Barrow's experiment, several other medical schools have incorporated PBL into their curricula, using patient cases to teach students how to think like a Clinician. Koh, Wong and Koh (2008) reported that more than 80% of medical schools in the United States now have some form of PBL in their programs. These authors carried out a systematic review of research of 10 years of data from the university of Missouri medical school PBL curriculum and found that the method is effective; they therefore support the use of PBL in medical schools. Bickley, Domar, Ubuker and Tift (1990) carried out a study, which they called pathology education in problem-based medical curriculum. The subjects were 88 Pathology undergraduates in part I NBME examination. The results obtained showed that the PBL students were significantly higher achievers than their conventional counterparts.

Albanese and Mitchell (1993) examined problem-based learning literature for a period of twenty years (1972-1992) and conducted a meta-analysis of the findings. Effect size was computed for finding. The study defined effect size as the difference in means of the problem-based learning and the conventional group divided by a composite standard deviation. The results of the study showed that

1. PBL is more nurturing and enjoyable.
2. PBL graduates perform as well, sometimes better than their conventional counterparts.
3. Lecturers enjoy using PBL as a teaching method.
4. In a few instances PBL students scores lower in the basic sciences than their conventional counterparts.

The authors however noted that two apparent disadvantages of PBL in the medical school curriculum are:

1. The students view themselves as less well prepared in basic science courses as their conventional counterparts.
2. PBL graduates tend to engage in backward reasoning.

The authors also examined the results of ten institutions operating PBL and conventional curricular, they found that in six of the cases the overall basic science scores for students in the conventional programme were higher than those in PBL curriculum. However, only in three of the cases were the differences in mean scores significant at .05 levels. The PBL students also outperformed their conventional peers in three instances. These were in situations where the PBL versions were more directive or have greater teacher intervention.

In secondary schools in Nigeria, Iroegbu (1998), used PBL to teach some physics concepts: work, energy, power, heat capacity and latent heat to 202 senior secondary II students. The result showed a significant main effect of PBL on physics achievement. The obtained F-ratio was $F_{(3,\ 20,)}$ = 10. 248 P<.05. With alpha level of 0.05, the critical F. ratio required for the rejection of the null hypothesis for the degree of freedom was 2.65. On using the multiple classification analysis (MCA), the result showed that the treatment main effect accounted for 12% $(.34 \times 100\%)^2$ of the observed variance in the data. Based on the result obtained, he confirmed the potency of the PBL as an effective instructional procedure that could be used in reversing the current trend of under achievement in SSCE Physics examinations. He also found out that the use of PBL also promoted the acquisition of problem solving skill and line graphic skill.

Recently, Gbolagade (2009) conducted an investigation on the impact of PBL and interaction model on pre-service teachers' knowledge, attitude, classroom practice and students' teaching outcome in JSS Mathematics. He trained 36 pre-service teachers on these approaches and observed them during their teaching practice and discovered that PBL is more effective in promoting knowledge, attitude and classroom practice of pre-service teachers in the colleges of Education in content, and methodologies of teaching. He therefore concluded that;

* PBL could be used to bridge the gap in terms of teachers' Knowledge, attitude and classroom practice of low, medium and high academic ability.
* PBL could be used to effectively improve Mathematics problem solving skills of students.
* PBL could be used to reduce the general effect of "mathophobia" in secondary schools.

Hmelo-silver, Durcan and Chinn (2007) described a project called Genscope, an inquiry-based science software application and submitted that the students using the software showed significant gains over the control groups, with the largest gains shown in students from basic science courses. These authors also cited the study of 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. Also, the study also found that inquiry based PBL teaching method greatly reduced the achievement gap for African-American students.

Other research findings in some major areas are discussed below:

Learning Outcomes in Basic Domain Knowledge: Acquisition and Applications

Problem-based learning is often criticized for its emphasis on facilitating higher order thinking and problem-solving skills at the expense of lower level knowledge acquisition. This concern has been expressed not only by teachers (Angeli, 2002) but also by students (Dods, 1997; Lieux, 2001; Schultz-Ross and Kline, 1999). In some cases, the students believed that content was inadequately covered, even though they understood the content more thoroughly (Dods, 1997) and performed comparably to traditional students on assessments (Lieux, 2001). Polanco et al. (2004) investigated the effect of PBL on engineering students' academic achievement. They found that, when compared to their counterparts, PBL curriculum significantly enhanced engineering students' performance on the Mechanics Baseline Test, in which the focus of the test was on understanding and application of the concepts rather than recall of factual knowledge.

Also, to evaluate the validity of the criticism that PBL students tend to underperform on knowledge acquisition when being measured with standardized tests, Gallagher and Stepien (1996) embarked upon an investigation in which they devised a 65-item multiple-choice test intentionally imitating typical final exams on the topic of American studies. The results showed that no significant difference existed in the content acquisition between students who were in the PBL course and students who were in the non-PBL course; in fact, the PBL students' average gain was higher than the other three traditional classes.

Zumbach et al. (2004) also studied PBL effects on fourth graders in a German elementary school. They found no significant difference on domain knowledge acquisition between students who studied using PBL and traditional formats. Similar results were also found in student learning in a Quantity Food Production and Service course (Lieux, 2001) and diabetes-related learning among adolescents with diabetes (Schlundt, Flannery, Davis, Kinzer & Pichert, 1999). Yet, a significantly lower gain score in economic knowledge was found in PBL classes than in lecture- and discussion-based classes in high-school economics classes (Mergendoller et al., 2000).

Research from medical education, on the other hand, provides a rich body of empirical evidence for evaluating the effectiveness of PBL. Blake, Hosokawa and Riley (2000) reported a very successful implementation of PBL curriculum at the University of Missouri–Columbia. They compared the performance of six classes of medical students from 1995 to 2000 on the U.S. Medical Licensing Examination (USMLE, formerly NBME). They found that the PBL classes performed substantially better on both basic science and clinical science than did the classes under a traditional curriculum. More encouragingly, the mean scores of the PBL classes (1998 and 1999) were significantly higher than their respective national mean scores, and the mean scores of the traditional classes were lower than national mean scores. Especially, the 1996 class (traditional curriculum) scored significantly lower than the national mean score.

Also, as measured by Key Feature Problems (KFPs), Doucet et al. (1998) found that PBL students performed significantly better on applying knowledge in clinical reasoning than did the traditional students in a headache diagnosis and management course. Similarly, PBL students performed significantly better than their counterparts in their clerkships (Distlehorst et al., 2005) and in podiatric medicine (Finch, 1999). Schwartz et al. (1997) compared PBL and traditional medical students at the University of Kentucky and found that PBL students performed equally well or better on factual knowledge tests and significantly better on the application of the knowledge in an essay exam and a standardized patient exam than did lecture based students. Also, Shelton and Smith (1998) reported a better pass rate for the PBL biomedical students than their counterparts in both year 1 and year 2 in an undergraduate analytic science theory class.

To summarize existing empirical studies being conducted on PBL, a number of meta-analyses have been conducted. Albanese and Mitchell (1993) examined research from 1972 to 1992, and Vernon and Blake (1993) examined research from 1970 to 1992. Both meta-analyses concluded that, in general, the PBL research findings were mixed. The two meta-analyses agreed that traditional curriculum students perform better on basic science knowledge acquisition, but PBL students perform better on clinical knowledge acquisition and reasoning.

Moreover, their finding that PBL students' knowledge acquisition was not robust was confirmed by another meta-analysis of 43 PBL studies conducted 10 years later by Dochy et al. (2003). However, when comparing students' performance on progress tests under PBL and traditional curriculum, Verhoeven et al. (1998) findings only partially agreed with the findings of Albanese and Mitchell (1993) and Vernon and Blake (1993). They found that the traditional students obtained better scores on basic science, while PBL students performed better on social science; yet, to their surprise, the PBL students did not outperform traditional students on clinical science.

Two other PBL literature reviews conducted by Berkson (1993) and Colliver (2000) did not agree with the two seminal meta-analyses and found no convincing evidence to support the superiority of PBL in the acquisition of either basic or clinical knowledge. Nevertheless, they concluded that PBL resulted in similar achievement as did traditional methods, which implied that PBL would not undermine students' acquisition of domain knowledge. Even though there is consensus that PBL curricula result in better knowledge application and clinical reasoning skills but perform less well in basic or factual knowledge acquisition than traditional curriculum.

McParland et al. (2004) demonstrated that undergraduate PBL psychiatry students significantly outperformed their counterparts in examinations, which consisted of multiple-choice questions. Equivalent performance on basic science knowledge acquisition (or USMLE step 1) and knowledge application and clinical reasoning (or USMLE step 2) between students learning under PBL curriculum and traditional curricula was reported in several studies (Alleyne et al., 2002; Antepohl and Herzig, 1999; Blue et al., 1998; Distlehorst et al., 2005; Prince et al., 2003; Tomczak, 1991; Verhoeven et al., 1998).

Retention of Content

With respect to students' retention of content, PBL research revealed an interesting tendency. In terms of short-term retention, either no difference was found between PBL and traditional students (Gallagher and Stepien, 1996) or PBL students recalled slightly less (Dochy et al., 2003); yet, PBL students consistently outperformed traditional students on long-term retention assessments (Dochy et al., 2003; Mårtenson et al., 1985; Tans et al., 1986, as cited in Norman and Schmidt, 1992).

Tans and associates found that PBL students' recall was up to five times greater on the concepts studied than traditional students 6 months after the course was completed. The study by Mårtenson et al. (1985) showed that no difference was found in the short-term retention of the content between PBL students and traditional students. However, the PBL students' long-term retention rate was 60% higher than that of traditional students. Also, the PBL students tended to remember more about principles, whereas the traditional students retained more rote-memorization types of knowledge.

Similarly, Eisensteadt et al. (1990) discovered that PBL students retained less than traditional students in the immediate recall test. Nonetheless, their retention rate remained rather consistent 2 years later, while the traditional students' retention had declined significantly. Norman and Schmidt (1992), in their study on PBL concluded that PBL might not improve students' initial acquisition of knowledge; however, the deeper processing of information in PBL classes appears to foster better retention of knowledge over a longer period of time.

Problem-Solving Skills

Improving problem-solving skills is one of the essential promises of PBL. The results of PBL research by and large support this assumption. Gallagher et al. (1992) conducted an experiment using an interdisciplinary PBL course called Science, Society and Future (SSF) on gifted high-school students with a comparison group of high-school students. They found that PBL students showed a significant increase in the use of the problem-finding step from pretest to post-test, which was a critical problem-solving technique. In contrast, in the post-test, the comparison group tended to skip the problem-finding step and move directly from the fact-finding step to the implementation step. The result suggested that PBL is effective in fostering students' development of appropriate problem-solving processes and skills.

Moreover, PBL has shown a positive impact on students' abilities to apply basic science knowledge and transfer problem-solving skills in real-world professional or personal situations. Lohman and Finkelstein (1999) found that the first-year dental education students in a 10-month PBL program improved significantly in their near transfer of problem-solving skills by an average of 31.3%, and their far transfer of problem- solving skills increased by an average of 23.1%. Based on their data, they suggested that repeated exposure to PBL was the key for facilitating the development of problem-solving skills.

Several other studies have shown that PBL has very positive effects on students' transfer of problem-solving skills to workplaces. For example, Woods (1996) reported that employers praised McMaster University's PBL chemical engineering graduates' outstanding problem-solving skills and job performance. Compared to other new employees who typically required 1 to 11/2 years of on-the-job training to be able to solve problems independently, "the PBL graduates think for themselves and solve problems upon graduation" (Woods, 1996).

Kuhn's (1998) study also illustrated the rapid development of expertise of first-year PBL residents in the emergency room. A superior ability to synthesize basic knowledge and clinical experience (Patel et al., 1991), in addition to applying and transferring the knowledge and skills into the workplace, may explain why PBL students outperformed traditional students in NBME/USMLE Part 2 while PBL students seemingly possessed slightly less basic science knowledge than traditional students as shown in their performance in NBME/USMLE Part 1. Clinical reasoning and solving problems on the job require more than mere memorization of factual knowledge.

Norman and Schmidt (1992) pointed out that no evidence exists to confirm PBL advantages in general problem-solving skills that are content free, which, again, supports the effectiveness of authentic, contextualized learning in PBL.

Higher Order Thinking

Higher order thinking is an important cognitive skill required for developing sophisticated problem-solving skills and executing complex ill-structured problem-solving processes. To be an effective problem solver, students need to possess analytical, critical thinking, and metacognitive skills. Articulating problem spaces requires analytical skills (Newell and Simon, 1972), evaluating information involves critical thinking skills, and reflecting on one's own problem-solving process requires meta-cognitive skills.

Shepherd (1998) reported that fourth- and fifth-grade students gained a significantly greater increase in critical thinking skills measured by the Cornell Critical Thinking Test (CCTT) than did the comparison group after participating in a 9-week PBL course (the Probe Method). Schlundt et al. (1999) also observed an improvement of self-efficacy in insulin administration management, problem-solving skills, and flexibilities in choosing coping strategies to overcome the difficulty of dietary adherence among adolescent diabetic patients who received a 2-week PBL summer program. They concluded that, instead of just teaching the facts, the PBL course helped the patients rationalize the self-care guidelines and consider more alternatives to seek better solutions and strategies to cope with the difficult lifestyle.

Furthermore, in a longitudinal study of the problem-solving performance of medical students using PBL and traditional methods, Hmelo (1998) observed that students' problem-solving skills and processes changed qualitatively over time. This change was certainly influenced by the type of curriculum. The students in the PBL curriculum, she noted, generated more accurate hypotheses and coherent explanations for their hypotheses, used hypothesis-driven reasoning, and also were more likely to explain their hypotheses and findings with science concepts as compared to traditional students.

Self-Directed Learning and Life-Long Learning

The ultimate goal of PBL is to educate students to be self-directed, independent, life-long learners. Through actively executing problem-solving processes and observing tutors' modeling of problem-solving, reasoning, and meta-cognitive processes, PBL students learn how to think and learn independently. Though their data did not support the superiority of PBL on knowledge or general problem-solving skills acquisition, Norman and Schmidt (1992) concluded that PBL appeared to enhance self-directed learning. This conclusion was supported by Woods (1996) assessment of chemical engineering students' comfort level toward self directed learning. Ryan (1993) also reported a significant increase in PBL students' perceptions of their abilities as self-directed learners at the end of the semester in a health-science-related course.

Moreover, Blumberg and Michael (1992) used students' self-reports and library circulation statistics as measures of students' self-directed learning behaviors between a PBL class (partially teacher-directed) and a lecture-based class. They concurred that PBL promoted self-directed learning behaviors in students. Similar evidence was also found in a number of studies, such as those by Coulson and Osborne (1984), Dwyer (1993), Dolmans and Schmidt (1994), and van den Hurk, Wolfhagen, Dolmans and Van der Vleuten (1999). The long-term effects of PBL on helping students develop self-directed/life-long learning skills and professional preparation was even more evident in other research results.

Two other studies revealed that PBL graduates rated themselves better prepared professionally than their counterparts in terms of interpersonal skills, cooperation skills, problem-solving skills, self directed learning, information gathering, professional skills and the ability to work and plan efficiently and independently (Schmidt and van der Molen, 2001; Schmidt et al., 2006).

Moreover, in Woods (1996) study mentioned before, the PBL alumni and the employers who hired the PBL graduates gave highly positive comments regarding their self-directedness and independence in solving work related problems and improving professional development. These studies provided strong evidence for the positive long-term effects of PBL on students' self directed and life-long learning skills and attitudes.

The reflective inquiry process used in the study by Chrispeels and Martin (1998) provided the students in an administrative credential program with a metacognitive framework. This reflective process helped the students become effective problem solvers by exercising higher order thinking skills to identify personal and organizational factors that constituted the administrative problems they faced in work settings.

Self-Perception and Confidence

Students consider PBL to be effective in promoting their learning in dealing with complex problems (Martin et al., 1998), enhancing their confidence in judging alternatives for solving problems (Dean, 1999), acquiring social studies content (Shepherd, 1998), enriching their learning of basic science information (Caplow et al., 1997), developing thinking and problem-solving skills (Lieux, 2001), improving interpersonal and professional skills (Schmidt and van der Molen, 2001; Schmidt et al., 2006), and advancing self-directed learning, higher level thinking, and enhancement of information management skills (Kaufman and Mann, 1996).

In summary, PBL research results overall have clearly demonstrated advantages of PBL for preparing students for real-world challenges. The emphasis of PBL curricula on application of domain knowledge, problem solving, higher order thinking, and self directed learning skills equips students with professional and life-long learning habits of mind, which are indispensable qualities of successful professionals. Although PBL students' performance in basic domain knowledge acquisition has been slightly inferior to traditional students, the format of the tests and the time-delay effects may justify this result.

This speculation may suggest further research issues and merit empirical evidence to shed deeper insight on these aspects of PBL. Also, Iroegbu (1998) pointed out that PBL requires students to think, reason, learn and solve problems, which shows a high level of intellectual demand. Birch (1996), suggested that operating at the level of intellectual problem solving, theory and practice can no longer be separated. Other researchers like Rossman (1993), Stepien and Gallagher (1993) recommend the use of PBL in schools because they found the strategy to be profitable and effective. Based on the above mentioned benefits and PBL being a structured method of inquiry suitable for developing students -capacity to be actively engaged, the researcher has decided to test PBL potency in physics in colleges of Education in Nigeria.

Several other studies focus on the change in knowledge and skill levels that occur with PBL instruction. A few studies show slight decreases in knowledge of basic sciences (Albanese and Mitchell, 1993). Other studies show that on tests of medical knowledge, students in traditional programs scored higher than students in the PBL curriculum (Schmidt, Dauphinee and Patel, 1987; de Vries, Schmidt and de

Graaff, 1989). Overall, most studies show no significant difference between the knowledge that PBL students and non-PBL students acquire about sciences (Albanese and Mitchell, 1993).

However, students who acquired knowledge in the context of solving problems have been shown to be more likely to use it spontaneously to solve new problems than individuals who acquire the same information under more traditional methods of learning facts and concepts through lectures (Bransford, Franks, Vye and Sherwood, 1989). In addition, students in the problem-based learning environment have developed stronger clinical competencies although the differences were small and not significant (de Vries, Schmidt and de Graaff, 1989). A study conducted in nutrition and dietetics course found that PBL students perceived that they developed stronger thinking and problem-solving skills, effective communication skills, and sense of personal responsibility than did students who received lectures (Lieux, 1996).

Much of the medical school research shows that student attitudes toward learning do change. Students in PBL courses often report greater satisfaction with their experiences than non-PBL students. For example, PBL medical students at Harvard reported their studies to be more engaging, difficult, and useful than did non-PBL students (Albanese and Mitchell, 1993). Additional research studies document that students who experience PBL have substantially more positive attitude towards the instructional environment than do students in more traditional programs. PBL students tend to give high ratings for their training whereas students in traditional programs are more likely to describe their training as boring and irrelevant (de Vries, Schmidt and de Graaff, 1989; Schmidt, Dauphinee and Patel, 1987).

These changes in attitudes are marked by an impact on student retention. In countries with high dropout rates among medical school students, such as in Holland, students in the PBL medical program were much more likely to graduate and do so in less time than students in the more traditional curriculum (de Vries, Schmidt and de Graaff, 1989). In addition, attendance was significantly higher in the PBL class than in the lecture version (Lieux, 1996).

Research also shows changes in student study behavior. Coles (1985) and Newble and Clark (1986) report that students were more likely to use versatile and meaningful approaches in studying than non-PBL students, who were likely to use reproduction. Nolte, et al., (1988) found that use of reserve material went up. Blumberg and Michael (1992) found that PBL students were more likely to use textbooks and other books and informal discussion with peers than did non-PBL students, who were more likely to rely on lecture notes.

Research on PBL in medical schools, as seen in the reviews by Albanese and Mitchell (1993) and Vernon and Blake (1993), and others mentioned above has focused primarily on comparing the outcomes of PBL methods to more traditional pedagogical methods. Research on PBL as a method for preparing professionals has followed in this tradition. These studies do provide insight as to how PBL compares to traditional methods.

However, PBL presents some unique challenges for assessment. Because the focus of this pedagogy is primarily on learning to learn and less on mastery of a particular body of knowledge, traditional methods of course assessment such as examinations may not be very effective (Major, 1999). If traditional assessment is a good measure of traditional pedagogy, it stands to reason that an alternative assessment may be necessarily a better measure for an alternative pedagogy, such as PBL. Using alternative assessment in the case of PBL can help bridge the gap between instruction and assessment. Authentic assessment uses tasks developed from realistic activities in the professional world (Nightingale, Te Wiata, Toohey, Ryan, Hughes and Magin 1996). Nightingale et al. (1996) define authentic assessment tasks as "complex simulations, case studies, or multi-faceted projects . . . assessing a range of knowledge, skills and attitudes in the one assessment task."

Some signs of a movement in this direction exist. Recently studies have begun to investigate PBL outcomes, such as teamwork or presentation skills, that may not be associated with traditional lecture methods. Cockrell, Caplow and Donaldson (2000), for example, recently conducted a study examining students' perspectives on their learning as members of collaborative groups. The researchers, using interpretive methods, found that the collaborative groups fostered students' sense of ownership of the knowledge that was created over the semester. The researchers also suggested that within the groups, leadership moved from student to student as situations arose and resolved. From the forgoing instances cited, there seems to be clear evidence that PBL could be used to rescue the present state of teacher standard in the colleges of education in the nation.

2.5 Interactive-invention Strategy and Achievement in Physics Concepts and Acquisition of Science Process Skills

The interactive invention strategy is another method that is widely applicable and can be used to teach both concepts and skills (Gbolagade, 2009). It uses teacher's explanation and modeling combined with students' practice, invention and feed-back to teach concepts and procedural skills. In an interactive instruction lesson, students are active in responding to teachers' questions, analyzing examples and prac-ticing skills to the point where they can be used with little or no mental effort.

Rosenshine (1995) reported that interactive invention approach usually pro-duces better scores on standardized tests of basic skills than do other approaches. Models based on this approach are based on a combination of operant and information processing learning. According to Maccini and Gugnon (2002), interactive invention includes continuous modeling by teachers, followed by more limited teacher in-volvement and fading teacher involvement as student begin to master the material.

This is in line with social constructivist idea. Learning, according to Vygotsky is best understood in light of others within an individual's world. This continual inter-play, between the individual and others is described by Vygotsky as the zone of prox-imal development (ZDP) (Vygotsky, 1978). He defined the zone of proximal devel-opment as the intellectual potential of an individual when provided with assistance from a knowledgeable adult (the teacher). The individual, by means of this assistance is able to move through a series of steps that eventually lead to "self regulation" and intellectual growth. This is important because it allows for the measurement of the intellectual potential of an individual rather than on what the individual has achieved.

Interactive learning describes a method of acquiring information through hands on, interactive means. The opposite of interactive learning is passive learning, which is merely observing a learning process or just listening to information. Interac-tive learning model is based on theory and research indicating that social interaction is an essential component of classroom learning.. They are strategies that involve stu-dents working collaboratively to reach common goals. These are to increase learners' involvement in classroom activities, develop their social interaction skills, provide students with leadership and decision making experiences and give them the chance to interact with peers from different cultural and socioeconomic backgrounds. John-son and Johnson (1994) gave five essential elements under gird-all-effective group interaction strategies

* Face-to-Face interaction
* Group goals

* Individual accountability
* Group processing
* Collaborative skills

Face to face interaction between students has 3 benefits as listed by Johnson and Johnson (1994):

1. It encourages students to put their sometimes-fuzzy thoughts into words. This is a cognitive demanding task (as anyone who tries to write something will attest to it that it promotes clear thinking and learning).
2. It allows for the sharing of alternative perspectives helping students' view and ideas in different ways.
3. It allows students to co-construct knowledge, building on the ideas of others (Eggen and Kanchank, 2006).

Group goals refer to incentives within a learning environment that help create a team spirit and encourage students to help each other. A group goal focuses students' energy an agreed on and shared learning task, and individuals' efforts contribute to others' goal attainment (Slavin, 1995). Group goals reward co-operation. In support of this view, researchers found that successful groups had extensive interactions, focusing on counting, and group goals encourage students to explain content to their teammates (Cohen, 1994). Group goals also encourage students to ask for and give help. Teacher can promote group goals by setting up grading systems that reward students for the whole group's performance, such as free time, certificates of achiever bonus points for grades.

According to Eggen and Kanchank (2006), there is individual accountability which mean that all students are responsible for meeting learning objectives as measured by quizzes, tests or individual assignments. Without individual accountability, the most able students in the group may do all the work, with teammates being ignored or given a free ride. Collaborate skills are interactive abilities that students learn and utilize in groups. They include turn-taking, listening, learning disagreeing constructively, giving feedback, reaching consensus, and involving every member in the group. They are some of the most important skills students learning in-group activities, and they often have to be taught and developed (Mc Devitt and Ormrod, 2002). Group processing encourages members to reflect on the effectiveness of' their group. This makes the group more effective, and it helps individuals understand how their actions contribute to the working of the group.

Table 2.2

Learning and Motivation Functions for the Phases to the Interactive Invention Instruction Model

Phase	Learning and motivation
Phase 1: introduction and review	Attracts Attention
Students are drawn into the lesson	Activates background knowledge
Phase 2: Presentation	Begins scheme production
New content is presented and explained	Promotes involvement
Phase 3: grounded practicing	Develops perceptions or competence
Student practice	
The concept on skill under the teacher's guidance.	Ensure success
Phase 4:. Independent practice.	Advances Scheme production
Students practice using the concept or skill on their own.	Develops automatically

This transactional model as it is also called begins with review of previous knowledge. This is important according to Gardner (2002) because making connections between what is already known and what is to be learned is a critical success factor for learning. The objectives of the lesson is stated clearly and written on the board with what they are to gain at the end of the lesson. This attracts attention and activates curiosity of the students, making them to be ready to learn.

This stage is followed by presentations. Here, the teacher attempts to begin the process of schema production by explaining and modeling the skill being taught in a way that will make sense to the learners. The teacher also allows students to be involved through questioning. This increases motivation and helps the teacher assess the learning progress (Eggen and Kauchak, 2006).

Guided practice is a very important part of this approach. During this stage, the students try out the new content as the teacher carefully monitors their progress and provides support and feedback. Teacher and students roles change during this phase. The teacher moves from information provider and model to coach and students move from receiving information to inventing their understanding with examples and problems.

Research indicates that this method provides teacher with access to students thinking, allowing them to understand and "debug" students' error and misconceptions during the lesson (Eggen and Kanchak, 2006). Independent practice stage provides students' opportunity to tryout the new skills and concept on their own, developing automaticity and the ability to transfer their understanding to a new context (Gersten, Taylor & Graves, 1999). This eventually improves their science process skills. According to Hills (2012), the skills necessary to be successful in accomplishing any science process include the ability to be objective, observant, and consistent in action. Intellectual skills necessary for quality contributions to science include communication, planning, foresight, prediction and critical thinking. More abstract skills, however, can be improved while participating in almost any activity. Aspects of science process skills include forming a hypothesis, planning experiments, collecting data, interpreting results and communication of those results. Any activity that forces a person to exercise his or her mental faculties in any of those directions will help improve science process skills. Participating in activities that arouse one's curiosity will help encourage a continuous state of inquiry. Exposing oneself to new information that warrants further questioning often leads to forming a hypothesis. As more information is gained and more questions arise, predictions are naturally made. A participant in good science process skills will often begin an experiment with a hypothesis, stemming from a situation where information was gained and a prediction was made about why things are how they are.

Assessment, monitoring and feedback are also essential part of this model. Interactive invention approach is reported to be effective with students generally but distinctively effective with students from diverse background, (Gersten et al., 1999).

2.6 Empirical Studies on Interactive-Invention Strategy and Achievement in Physics Concepts

Eggen and Kauchak (2006) reported that the explicit approach to teaching concepts and skills provides culturally and linguistically diverse students with additional structure, which facilitates learning. Okoromeh (2008) used interaction invention strategy with other retention enhancing strategies to teach the concepts of sets, statistics and probability to 346 SS II students from Delta State, Nigeria, and reported that the treatment had a significant effect on students achievement in mathematics with $F_{(3,329)}$=116.06; P<.05.On conducting MCA on the result the analysis showed that students in the interactive invention strategy group obtained the highest post-test mean score (X=17.62; SD=1.48), than those exposed to meaning focus (X=15.99;SD=.45), interaction discussion (15.77; SD=.23)and control (X=12.57; SD=-2.97). Based on his analysis he concluded that interactive invention strategy is most effective in improving students' achievement in mathematics.

Gbolagade (2009) also conducted a study which used constructivist model based strategies which involved interactive approach to train 36 pre-service teachers on some concepts in mathematics He used ANCOVA to analyze the data obtained $F_{(2.32)}$ = 11.23 ; P< .05 which shows that the treatment had significant effect on the post training knowledge on the pre-service teachers. The accompanying MCA showed that problem based learning obtained adjusted mean post training knowledge score (X =15.25, SD = 1.64). Interactive approach group (X = 13.21; SD =44), while control group got the lowest (X = 12.42;SD = -1.19). From these results he concluded that interactive approach enhances student achievement in mathematics more than the traditional instructional strategy.

Asim (1998) also reported a significant main effect of treatment and pupils' ability on concept attainment in a study involving 88 males and 74 female primary school pupils in the Cross River State of Nigeria using the interactive teaching strategy. Osibodu (2004) studied on the use of CM and a meta-cognitive strategy as determinants of learning outcomes in which 152 pupils (74 females and 78 males) were used. The results showed that the combination of both interactive method and concept mapping were better in enhancing achievement in primary science than the normal traditional performance of the pupils exposed to the combination of concept mapping and interactive method showed that, there was a gain in achievement by the treatment groups when compared with the control group.

Ekwere (1998) used a sample of 200 senior secondary school two students (96 girls 104 boys) in intact classes within Ibadan Municipality of Oyo State in Nigeria. She used a quasi-experimental pre-test post-test 4x2x2 factorial design. Results showed that the three treatment categories including interactive method were effective in enhancing concept attainment in chemistry with the combined strategy being the most effective than concept mapping alone.

2.7 Self-Efficacy and Pre-Service Teachers' Achievement in Physics

Self efficacy is one's self - judgments of personal capabilities to initiate and successfully perform specified tasks at designated levels, expend greater effort, and persevere in the face of adversity (Bandura, 1994). Wagner (2005) defines self-efficacy as the person's belief in his or her ability to succeed in particular situations. Pajares (1996) also defines self-efficacy as the belief that one is capable of performing in a certain manner to attain certain goals.

It is a belief that one has the capabilities to execute the course of actions required to manage prospective situation and to have a measure of control over individual's thoughts, feelings and actions. In other words, the beliefs that individuals hold about their abilities and outcome of their efforts influence in great ways how they will behave. Therefore, it is not surprising that many research show that self efficacy influences learning and academic achievement (Pajares, 1996 and Schunk, 1995).

Self-efficacy is explained in the theoretical framework of social cognitive theory by Bandura (1986, 1997) which states that human achievement depends on interactions between one's behaviours, personal factors and environmental conditions. The behaviour of an individual depends largely on early experiences at home. The home environment that stimulates curiosity will help build self-efficacy just as displaying more of that curiosity, and exploring activities would invite active and positive reciprocity. This stimulation enhances the cognitive and affective structures of the individual which include his ability to sympathise, learn from others, plan alternative strategies and regulate his own behaviour and engage in self reflection (self efficacy).

Bandura (1997) maintained that people's actions and behaviors are guided by their beliefs about how successful they can be in performing a task, termed as *self-efficacy*. Not only do people need to have the skills and knowledge to execute a task successfully, they also have to have a certain level of expectation for success before they take on the assignment. Researchers (e.g. Jackson, 2002; Lane and Lane, 2001; Pajares, 1996; Pajares, 2003) have found that individuals who believe that they can successfully complete a task (or those who have high self-efficacy) tend to perform better as compared to those who lack such a belief. They also suggest that individuals' self-efficacy beliefs may influence the types of goals they adopt for learning. Such reasons students have for learning are termed as *goal orientation* (Elliot and Harackiewicz, 1996).

It is the goals that individuals set that influence their actions, reactions, and motivation for learning (Shim and Ryan, 2005). The purposes that students have for completing an academic task, have received much attention due to its influential role on students' performances (Ames, 1992; Dweck, 1986). Detailed in the literature are three types of goal orientations. The first is a mastery goal, where students focus on mastery of a task and have the desire to acquire new skills.

The second is a performance-approach goal, where learners' main concern is how competent they look in front of others, focusing on receiving favorable judgments of ability from others. The third is a performance-avoidance goal, where students attempt to avoid unfavorable judgments of capabilities and looking incompetent and may stay away from challenging tasks (Elliot and Harackiewicz, 1996). Out ofthe three types of goal orientations, the two that have received researchers' consensus in their findings on its relationship with students' actions and learning outcomes are the mastery and performance-avoidance goal orientations.

Researchers have consistently found that students who adopt mastery goals tend to have higher self-efficacy, positive patterns of learning (such as paying more attention in class and processing information in a more meaningful fashion), and higher achievement (Middleton and Midgley, 1997; Midgley and Urdan, 1995; Pajares, Britner, and Valiante, 2000), while students who have performance-avoidance goals tend to have lower self-efficacy and have less challenge-seeking behaviors and intrinsic value for learning (Elliot, 1999; Hidi and Harackiewicz, 2000; Middleton and Midgley, 1997; Pajares et al., 2000; Skaalvik, 1997). Students often develop goals for learning through the examination and their understanding about themselves, the task, and their expectations of success.

The encyclopedia Britannica distinguishes between efficacy and self-efficacy; efficacy is the power to produce an effect (competence) while self-efficacy is the belief (whether or not accurate) that one has the power to produce that effect. They also went further to distinguish between self-efficacy and self-esteem. Self-efficacy relates to perception of ability to reach a goal where as self esteem relates to a person's sense of self - worth.

Perceived self - efficacy is defined as peoples' beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives (Bandura 1997). Bandura further explained that self -efficacy beliefs determine how people feel, think, motivate themselves and behave, and that such believes produce these diverse effects through four major processes that include cognitive, motivation, affective and selection processes. He asserts that a strong sense of self-efficacy enhances human accomplishment and personal well being in many ways:

* People with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided.
* They set themselves challenging goals and maintain strong commitment to them.
* They heighten and sustain their efforts in the face of failure.
* They quickly recover their sense of efficacy after failures or setbacks.
* They attribute failure to insufficient effort or deficient knowledge and skills, which are acquirable.
* They approach threatening situations with assurance that they can exercise control over them.

Such an efficacious outlook produces personal accomplishments, foster interest and deep engrossment in activities, reduces stress and lowers vulnerability to depression, but people who doubt their capabilities

*shy away from difficult tasks, which they view as personal threats.

* They have low aspirations and weak commitment to the goals they choose to pursue.
* When faced with difficult tasks, they dwell on their personal difficulties and the obstacles they will encounter
* They slacken their efforts and give up quickly in the face of difficulties; they are slow to recover their sense of efficacy following failure or setbacks.
* They fall victim to stress and depression.

Supporting the forgoing, Pajares (2006) explained that students with a strong sense of efficacy are more likely to challenge themselves with difficult tasks and be intrinsically motivated. That these students will put forth a high degree of effort in order to meet their commitments and attribute failure to things which are in their control rather than blaming external factors and they are likely to achieve their personal goals. Also that students with low self - efficacy believe they cannot be successful and are less likely to make any concerted, extended effort and may consider challenging task as threat that are to be avoided. As a result, they have low aspirations which may result in disappointment with academic achievement becoming part of a self - fulfilling feedback.

Fend and Scheed (2005) in their study of the effects of teaching strategies on self - efficacy and course climate in a non major's physics course reported that self-efficacy is the key predictor of achievement and retention in most academic areas including the sciences. Also, Wood and Locke (1987) had early investigated the relation of self-efficacy and grade, goals and academic achievement and submitted that self-efficacy is related to academic achievement and to self-set academic grade goals.

Elsevier (2009) investigated the structural relations among self- efficacy, academic aspirations, delinquency and academic achievement of 935 students aged 11-18 years from ten schools in Australia and found that academic and self-regulatory efficacy had an indirect negative effect through delinquency and a direct-positive effect on academic achievement. But that academic and social self-efficacy had positive and negative relationships respectively with academic aspiration and academic achievement

Mahyuddin, Elias, Cheong, Muhamad, Noordin and Abdullah (2006) conducted a study on the relationship between students' self-efficacy and their English language achievement. The respondents consisted of 1,146 form four students chosen from eight secondary schools in the Petaling district in Selangor. Subjects were chosen using the stratified random sampling technique. There were 646 (56.4%) male respondents and 499 (43.1%) female respondents. In terms of ethnic groups, there were 491 (43.6%) Malays, 374 (32.9%) Chinese, 248 (21.8%) Indians, 25 (2.2%) and others. Among the respondents, 419 (36.6%) were from urban schools and 727 (63.4%) were from rural schools. The research design was descriptive correlation. The instruments used to measure self efficacy were the Self Efficacy Scale by Bandura (1997) and Kim Chung and Kim (2001).

The dimensions within the Bandura's Self Efficacy Scales included academic achievement, self regulated learning, extra curricula activities, meeting others' expectations, self assertiveness and motivation self regulation. The correlation analysis of this study shows that there were significant positive correlations between several dimensions of self-efficacy and academic achievement in the English language. The dimensions included academic achievement efficacy ($r = 0.48$, $p = 0.001$), other expectancy beliefs ($r = 0.34$, $p = 0.005$) and self assertiveness ($r = 0.41$, $p = 0.005$).

The perceptions that the research subjects have of their academic competence (academic self efficacy) had a positive effect on their English language achievement. This result is in line with the findings of Zimmerman, Bandura, and Martinez-Pons

(1992) who found that academic self-efficacy influenced achievement directly (beta = 0.21) as well as indirectly raising students' grades (beta = 0.36). These researchers explained that when there is academic self-efficacy or self perceptions of competence, the students succeed in their English language performance. As Bandura (1986) had stated the stronger the self-efficacy, the more likely the students select challenging tasks, persist at them and perform them successfully.

They further explained that the positive correlation between other expectancy beliefs and English language performance simply strengthen the fact that when students perceive they have competence in their knowledge, beliefs and feelings about their capabilities plus their expectation of success (Boekaerts, 1991) they will show improvement in performance in English language. Self assertiveness is associated with high self efficacy. Therefore when there is high self-efficacy, it influences the academic persistence and this is necessary to maintain high academic achievement (Boekaerts, 1991). This explains the positive correlation between self assertiveness and English language achievement in this study. The key element is the beliefs the students have of themselves and this will lead to confidence and competence in doing the task.

Mahyuddin et al's (2006) further analyses using multiple regressions was conducted to identify significant predictors of science achievement and to examine the interaction effects of performance avoidance goals and self-efficacy on achievement. Results indicated that the interaction between self-efficacy and performance-avoidance goal was significant in predicting science achievement (β = -.59, p < .05). To better interpret this finding, they used graph to illustrate the significant interaction between self-efficacy and performance-avoidance goals. Results revealed that the effect of self-efficacy on achievement differs as a function of the level of performance-avoidance goal orientation.

They reported specifically that self-efficacy had a more noticeable positive effect on science achievement especially for students who reported having lower performance-avoidance orientation, indicating that those students low in performance-avoidance orientation who reported having higher self-efficacy reported significantly higher achievement Goal Orientation, Self-efficacy, and Achievement than those who reported having lower self-efficacy.

On the other hand, for students who reported having high endorsement of performance-avoidance goals, no significant differences were found between those who reported having high self-efficacy and those with low self-efficacy on science achievement. This is to say that the effect of self-efficacy on achievement is moderated by the adoption of performance-avoidance goals. Even though students reported having high self-efficacy for science, adopting performance-avoidance goals seem to have interfered with their science achievement.

Additionally, results of this study supported previous research findings indicating that self-efficacy correlated positively with students' performances. Researchers have suggested that students with high self-efficacy tend to learn and achieve more than students with low self-efficacy even when actual ability levels are the same (Bandura, 1986). This is partly because efficacious students tend to engage in cognitive processes that promote learning, such as paying attention, persisting longer at difficult tasks, and organizing and elaborating new information being presented to them (Bandura, 1986; Pintrich and Schunk, 2002).

Their results indicated a strong positive relationship between students' self-efficacy and mastery and performance-approach goals. Inconsistent with findings of previous studies, no significant relationship was found between self-efficacy and performance-avoidance goal orientation (Pajares et al., 2000). Further analysis was performed to better understand students with seemingly conflicting beliefs and goals, and it was found that the interaction between self-efficacy and performance-avoidance goals was significant in predicting achievement. Though self-efficacy has been considered to be one of the most powerful predictors of achievement, their results indicated that self-efficacy exerts a stronger positive influence on achievement in absence of performance-avoidance goal orientation. The interaction effect between performance avoidance goals and self-efficacy indicated that the joint effects of self-efficacy and goal orientation may offer key information in explaining student achievement better than the separate independent effects of each individual variable

The predictive utility of self-efficacy has also been tested using causal models. This was carried out by Schunk and Pajares (2001) who employed path analysis to reproduce the correlation matrix comprising long-division instructional treatment, self-efficacy, persistence, and achievement. The most parsimonious model showed a direct effect of treatment on achievement and an indirect effect through persistence and self-efficacy, an indirect effect of treatment on persistence through self-efficacy and a direct effect of self-efficacy on achievement and persistence.

Mathematics self-efficacy has been found to be a better predictor of mathematics performance than mathematics self concept, math anxiety, perceived usefulness of mathematics, or prior experience (Pajares and Miller, 1994) and it has as powerful a direct effect on mathematics performance as does mental ability, a variable often presumed to be the strongest predictor of academic achievement (Pajares and Kranzler, 1995). Self-efficacy affects achievement directly and indirectly through its influence on goals (Zimmerman and Bandura, 1994).

2.8 Gender Issues in Physics Achievement

Smith and Hoersch (1995) observed that gender affects educational achievement. The trend of Physics enrolment and achievement of boys and girls in different countries of the world varies. In the United Kingdom for instance, it had been reported that there has been more' 'than a decade of declining recruitment of students to Physics A- level courses together with the closure of a significant number of Physics departments in higher institutions, (Murphy and Whitelegg, 2005). They pointed out that in U.K., more boys than girls show preference for Physics and consequently choose to study the subject. On achievement they observed that in both higher and lower tests, generally boys did better in Physics than girls.

The decline in enrolment has also been reported in Austria by Dickers and Delaeter (2001), in Canada by Bordet et al (2001) in Japan by Goto (2001) and in the USA by National Science Foundation (2002). Mak and Chan (1995) and Woolnough (1994) have reported that the decisions to take physical science courses are associated with being a male. In USA, women are still not equally represented in many careers in technology and science even though the young women possess equal abilities in scientific skills in the elementary schools but their enrolment in science related classes diminish as they enter high school and College (Norby, 1999).

Barbosa observed in Physics World (2003) that women are generally greatly under-represented in Physics than all the sciences. Physics is the subject in which the increase in the number of women involved has been 'particularly low. She further said that many of the women who do take Physics end up running away from it and that statistics show that a higher proportion of women than men leave Physics at each stage of their career - a phenomenon that is often dubbed the "the leaky pipeline".

In Germany, Wells (1990) has it that girls show much less interest in sciences particularly in Physics and Chemistry than boys and the more they grow up, the more the interest in science decreases. As a consequence, very few girls chose advanced courses in science and technology. Regarding achievement of boys and girls in science and even in Physics in terms of test reports, there is no significant difference between their achievements. This achievement cannot explain the low number of choices of advanced science courses and in the scientific and technological field of occupation by girls, but he pointed out that girls' diminishing interest in Physics as they grow up correlates closely with the growing acceptance of their gender role.

Italy situation is better than some of the other countries that had been considered above. According to Molinari, Bonfigli, Mignani and Paciello (2003) Italy is often considered a fortunate country for women in Physics. Undergraduate courses in Physics in Italy now witnesses the presence of many women who are generally very successful in their studies. The percentage of women among students has grown from 20.8% in 1960 to 36.4% in 1999. Also, those among condensed matter Physics, a large fraction of those who entered the very first level of the career with a post - doctoral position are women. This situation gives a very hopeful future than what have been considered earlier even though it is not up to 50%.

Better still, based on the overall participation and achievement of the secondary and tertiary levels in Jamaica and other Caribbean territories, Miller (2000), noted that on the average, girls start schooling earlier, attend school more regularly, drop out of school less frequently, stay in school longer and achieve higher levels of functional education at the end of schooling than boys. .That whatever progress was made in literacy in the Caribbean's, women made more progress than men and so on the whole are more literate than men.

In Africa, according to Barbosa (2003), women in this continent face the hardest situation of all in the field of science. Very few women become scientists because society expects them to bear the brunt of childcare and to look after elderly parents. Hoffmann (1999) pointed out the inequalities between girls and boys particularly in science education in Africa. In post primary level, they showed some percentage representation in some countries. Like in Zambia, 15-16% of students in physics and chemistry are females; in Mali 10% , Burundi and Tanzania 13%, Ghana 16%, Zimbabwe 2%. They observed that the question of gender difference in academic achievement in African secondary schools is neither conclusive nor unanimous. In some countries, girls have lower academic achievement than boys in examination and in other countries, girls perform better than or at least as well as boys as in the case of Mali.

Looking at the university education in Africa, they observed lower participation rate of females in science and technology courses though there was a general increase in enrolment in these fields. In Togo and Swaziland for example, the percentage has doubled for general enrolment but girls' percentage is still lower than that of boys.

In Togo, there is no girl in the centre of computing and calculations, 2.15% at the University of Agronomy and only 6.52% at the University for Engineers. In Benin, in 1986, girls represented 17% of female students at University and only15% in 1999. In Nigeria, Engineering recorded 5.4% of female students in 1985/86 and 10.9 % in 1991/92. Zimbawe increased from 22.4% in 1985 to 26.6% in 1993. In Kenya in the 1990/91 academic year, only 18.7% of girls enrolled for undergraduate courses in medicine, 23% in pharmacy, 36% in Dental surgery, 21% in Agric and 16% in science. In Ghana, slight increase-is observed over the years. In 1994, women constituted 5.8 % in science related departments at the University of Ghana, 4.7% at the University of Cape Coast 11.5% at the University of Science and Technology and 7.5% at the University College of Education, Winneba University of Burundi recorded 27.49%0f total enrolment but only 3.9 % are in applied science. Chad had no women in the second year of mathematics physics and physics chemistry for 1995/96 and only 4 women in the faculty of Health sciences.

Elaborating more on Nigeria's situation, there has been great concern on the under-representation of females in scientific studies and careers (Iroegbu, 1998). This shows an under utilization of female talents which in turn affects the progress of scientific and technological development of the nation. (Raimi and Adeoye; 2002). Oyedeji (1996) observes that less than 30 % of the total number of school enrolment for females' proceeds beyond secondary school levels. Of the few, the number who pursues careers in the science and mathematics related courses are extremely low. Oduwaje (1997) stressed the lack of adequate number of girls and women in science and technology in Nigeria and observed that gender may still be a factor in science education. In line with this, Debez (1994) says that gender can influence students' achievement, especially in science-oriented subjects. That the sex difference was in the direction of inferior achievement of girls compared with boys and that boys perform better than their female counterparts in science subjects.

Jimoh's (2004) study on gender disparity in Quantitative Analysis practical among Chemistry students in Kwara State College of Education, Oro indicated that the gender difference has no influence on students' achievement in Quantitative Analysis. Jimoh and Amoo (2001) had earlier reported that gender difference has no influence on students' achievement in Chemistry. Also Yusuf (2004) investigated a comparative study of male and female students' academic achievement in Agricultural Education in Colleges of Education in Nigeria and found out that there is no significant difference in the achievement of male and female students.

Raimi and Adeoye (2002) in their study on gender differences among college students as determinants of performance in Integrated Science reported that there exists no significant difference between male and female students in terms of their cognitive achievement in the course. This is in agreement with Iroegbu (1998) but it contradicts the findings of Okeke (1986) who found significant gender-group difference in favour of boys. Several other studies support this that there is a correlation between achievement and gender of the learner (Adegoke 1999; Akande 2002; Erinosho 1997; Olajide 1997 and Serenade 2003).

On enrolment in Nigeria generally, it has been observed that enrolment in science thins out as one move up the educational ladder (Ogunleye, 1999). On female in science, Idris and Ayeni (2001) in their study on a College of Education for ten years reported (a) A low enrolment in Physics compared with other science subjects and (b) Low enrolment of female in Physics that ranges between 13% and 39%.

Also, Ukpene (2001) in his study on enrolment pattern of three (3) Colleges of Education obtained similar results of low Physics enrolment relative to other sciences as well as low enrolment of females compared with males. Adepitan (2003) in his study of pattern of enrolment in Physics and students evaluation of the contributory factors in Nigerian Colleges of Education observed that it is difficult to adduce experimentally whether the enrolment in Physics is reducing or increasing because he reported a 3 year periodic pattern of increase- decrease -decrease and that more male enrolled for Physics at N.C.E level than females. The above contradictory views call for further studies into the area to find out what the present state is whether gender has any influence on enrolment and achievement in Physics.

2.9 Appraisal of literature

Literature reviewed indicates that students' achievement in physics has been generally and consistently poor (Oludipe, 2003; Adepitan, 2003; Ivowi and Oludotun, 2001 and Iroegbu, 1998). Reviewed literature shows the effectiveness of Problem–based learning instructional strategy in the area of Medicine (Koh, Wong and Koh, 2008; Stepien and Gallagher 2002; Kinimitt and Sledge, 2002; Gallagher, Stepien and Resenthal 1992; Barrow, 1992 and Birch, 1996; Bickley, Dormar, Ubuker and Tift, 1990), Engineering Woods, (1996), and in some secondary schools Iroegbu, (1998). This strategy has proved to be very effective in improving cognitive development and science process skills acquisition (Gbalagade, 2009; Hmelo-silver, Durcan and Chinn, 2007; Eggen and Kanchak, 2006; Kreger, 2004; Levine, 2001; Iroegbu, 1998; Birch, 1996; Barrow and Myers, 1993 and Rossman, 1993). Literature reviewed also shows that in Nigeria Colleges of Education, lecture method is the major method of instruction (Oludipe, 2003 and Akinsola, 1994). However, Problem–based learning instructional strategy has not been in use.

Most of the literatures reviewed indicate that interactive invention strategy has been used in many secondary schools and is reported to be good for students from diverse background. Also, that this strategy produces better scores on standardized test of basic skills than other strategies (Okurumeh, 2008; Mckevitt and Ormrod, 2002; Eggen and Kauchak, 2006; Gardner, 2002; Ezenweani, 2002; Johnson and Johnson, 1994; Slavin, 1995; Cohen, 1994). Literature showed that studies were found investigating the relationship between self efficacy and academic achievement and found that self-efficacy influence academic achievement (Bandura, 1994; Wagner, 2005; Pajares, 2008; Fend and Scheed, 2005; Elsevier; 2009).

Researchers (like Serenade, 2003; Akande, 2002; Adegoke 1999; Olajide, 1997; Erinosho, 1997; Okpala and Onocha, 1995) reported that there is a correlation between achievement and gender of the learner. Others (like Jimoh, 2004; Raimi and Adeoye, 2002; Iroegbu, 1998) reported no significant difference between male and female students in terms of their cognitive achievement in Physics and Chemistry. This study therefore would determine the effect of problem-based learning and interactive invention strategies on pre-service teachers' achievement in physics concepts and acquisition of science process skills.

CHAPTER THREE

METHODOLOGY

This chapter focuses on the research methodology: the research design, selection of participants, instrumentation, experimental procedure, data collection and the methods of data analysis.

3.1 Research Design

A pretest posttest control- group quasi-experimental research design was adopted for this study. This design is schematically represented as follows:

Experimental group I O_1 X_1 O_2

Experimental group II O_1 X_2 O_2

Control group O_1 X_3 O_2

Where O_1 represent the pre-test observations for experimental groups I, II and control groups and O_2, represent the post test observations for experimental groups I, II and control groups

X_1 is experimental treatment for group 1; problem-based learning strategy.

X_2 is experimental treatment for group 2; interactive invention strategy.

X_3 is treatment for control group; conventional lecture method for group 3.

3x2x3factorial matrix is used for the matching of variables as in Table 3.1

Table 3.1: 3x3x2 Factorial Matrix of the Design

Treatment	Gender	Self efficacy		
		Low	Medium	High
Problem-based Learning Strategy	Male			
	Female			
Interactive Invention Strategy	Male			
	Female			
Conventional Lecture Method	Male			
	Female			

Total 3x2x3 = 18 cells

3.2 Variables in the Study

These are summarized in figure 3.1 below:

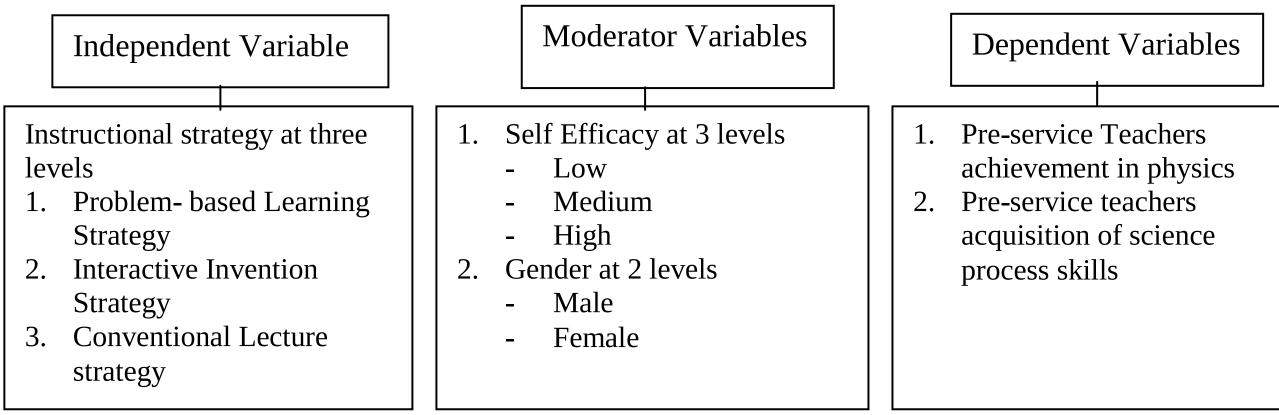

Figure 3.1. Variables in the study.

In this study, the independent variable is instructional strategy stratified at three levels:

1. Problem-based learning strategy

2. Interactive Invention strategy

3. Conventional Lecture method

The moderator variables are two:

(a) Pre-service teachers' physics self-efficacy at three levels

(1) High

(2) Medium

(3) Low

(b) Pre-service teachers' gender at two levels

(1) Male

(2) Female

Dependent variables:

1. Pre-service teachers' achievement in physics

2. Pre-service teachers' acquisition of science process skills

3.3 Selection of Participants

The target population for this study comprised all the NCE III pre-service teachers studying physics with other combinations in Colleges of Education in the South Western Nigeria. What informed the choice of NCE III is that these students have spent considerable time in the colleges to have acquired necessary content knowledge, theories and principles of learning and are getting ready to go to the field as professional teachers. Three out of seven State and three out of four Federal Colleges of Education were purposively selected based on their offering physics as NCE course, having physics teachers and functional internet facilities which is one of the information resources that will be used during the experiment. These colleges were assigned to treatment conditions such that there was one state college and one Federal College in each treatment group. These groups were randomly assigned to treatment conditions. From the selected colleges, all available NCE III students offering physics were used for the study. The lecturers used as instructors in the study were the regular physics lecturers assigned by the Head of Department to handle the course-Electromagnetism III (PHY 321). The criteria for the selection of colleges were:

(1) State or Federal government owned college of education

(2) The College must have been in existence for at least three years

(3) The students would not have been exposed to the chosen content area of course prior this study.

3.4 Selection of Topics

Of the three courses to be offered during the second semester, which include, PHY 321-Electtromagnetism III, PHY322-Atomic and Quantum Physics II and Practical Physics III-PHY 323, the researcher decided to choose PHY 321, which is Electromagnetism III. This particular aspect of physics had been reported by Thomas, Marr and Walker (2005) to be the most difficult part of physics and that it gives students problems (difficult to learn). So, the researcher wanted to see if the use of the active learning strategies would help the students to understand the course better which would reflect in their performances at the end of the treatment. The following topics were selected-ferromagnetism, electromagnet, force effect on current carrying conductor in a magnetic field and electromagnetic induction.

3.5 Instrumentation:

The following seven research instruments were used in this study:

(A) Response instruments

1 Physics Achievement Test (PAT)

2 Students' Physics Self-Efficacy Questionnaire (SPSQ)

3 Science Process Skills Worksheets (SPSW)

(B) Observational instrument

4 Classroom Activities Evaluation Rating Scale(CAERS)

(C) Stimulus instruments

5 Teachers' Instructional Guide on Problem Based Learning strategy (TIGPBLS).

6 Teachers' Instructional Guide on Interactive Invention Strategy (TIGIIS).

7 Teachers' Instructional Guide on Conventional Lecture Method (TIGCLM).

3.4.1 Physics Achievement Test (PAT)

This is a researcher developed multiple choice objective test, made up of forty items. Each item has one correct option and four distractors. The instrument tested the pre-service teachers' intellectual achievement in ferromagnetism, electromagnet, force effect of current- carrying-conductor in magnetic field and electromagnetic induction.

The scoring of items of PAT was done on a dichotomous basis. The correct response earned one mark while an incorrect response earned zero. To reduce guessing of the correct answers five options were used and students were given enough time to work on the questions. Items of the test were formed from a test blue print on table 3.2 showing cognitive domain of Blooms' taxanomy of knowledge, comprehension, application, analysis, synthesis and evaluation and the contents covered.

Table 3.2: Table of Specification for PAT

Topic	Knowledge	Comprehension	Application	Analysis	Synthesis	Total
Ferro-magnetism	4	3	1	2	3	13
Electro-magnet	1	1	1	1	2	6
Force effect of current carrying conductor	5	3	6	2	2	17
Electromagnetic induction	1	2	-	1	-	4
Total	11	9	7	6	7	40

Originally the researcher constructed a test with eighty items for PAT. To establish PAT content and face validity, copies of the initial test draft that contained eighty (80) items were given to three physics educators and modifications based on their suggestions were made. This led to the dropping of nine items. The seventy one (71) item test was thereafter administered on thirty four (34) NCE III students in a representative College of Education outside the sample used. The reactions of the students to the test were noted and the result used for item analysis. The test item analysis provided basis for reducing the test items to forty (these were items with difficulty indices between 0.35-0.75). The forty (40) items were administered on another sixty (60) NCE III students and the results were analyzed using Kuder-Richardson formula 20. The reliability index obtained was 0.875.

3.4.2 Students' Physics Self Efficacy Questionnaire (SPSQ)

A general self-efficacy questionnaire was adopted from Ashimalowo (2006) and modified by the researcher to measure students' self-efficacy in physics. This consists of ten (10) items to be graded based on four point Likert scale ranging from Strongly Agree, Agree, Disagree and Strongly Disagree. The positive statements were graded 4,3,2,1, respectively while the reverse was the case for the negative statement thus clearing out the undecided column in order to commit students to either the positive or negative side of the issues.

The instrument was given to three experts in the department of educational Psychology for their expert advice in respect to the language level, suitability and over all face validity of the instrument, based on their input, corrections were made. Also, the instrument was given to my supervisor who read though to make the final modifications. Then, the instrument was administered to 60 N.C.E III students who were not part of the main study. The reliability coefficient of the instrument was calculated using the Cronbach alpha method and the value obtained was .9561 indicating that the instrument was reliable.

3.4.3 Science Process Skills Worksheets (SPSW)

Science process skills assessment was based on skills which are discernible from written scripts or those which may be inferred from such scripts. Work sheets were developed by the researcher to assess the pre-service teachers' science process skills during every lesson for the different experimental groups. Interactive invention strategy treatment group and the conventional lecture method group used the same worksheets which has five items each with four points to be completed by the students during the lesson. Two marks were awarded to each of the four points making a total of forty marks But the worksheets for those in problem-based learning group were slightly different because it incorporated few items of the inquiry process used in that study group. Each contained eight items three of which assessed their ability to investigate on how to solve the given problem while five assessed ability to observe, identify, classify, measure, formulate hypothesis, gather data, test hypotheses, and making inference based on data collected. Five marks were awarded to each item making a total of forty marks. These worksheets were given to the supervisor to read and make necessary corrections to ascertain the face validity of the instrument. These worksheets were given to each participant during every lesson to fill during the lesson as they are interacting with the materials.

3.4.4 Classroom Activities Evaluation Rating Scale (CAERS).

This is to measure the pre-service teachers' classroom practice and the teacher-students' interactive activities and was adapted from Omosehin (2004) and made into two scales. The first one measured the instructors adherence to the teachers' guide given and was used during the training period and during lessons by the two research assistants. The second measured the pre-service teachers' involvement during the lessons and also items dealing with group activities and whole class activities involving teacher and the students. Group activities involving the teacher included placing students in mixed-gender and self-efficacy groups, assigning specific roles to students and monitoring students' interactions.

The ones involving students included asking each other some questions, performing specific roles and challenging each others' reasoning and conclusions. For the whole class activities, teacher's activities included passing facts and information, giving direct instructions, demonstration with apparatus among others, while the students' activities include listening attentively as well as asking and answering questions and carrying out experiments. The activities were scored on a four-point scale ranging from zero (0) to three (3).

To establish the content and face validity of this instrument, copies of the first draft were given to experts in the field of education especially in the area of classroom observation for necessary comments as regards the instrument. Based on their comments, wordings of some items were changed and some items were droped. The inter-rater reliability index of the instrument was estimated using Scott's π. Reliability index of 0.76, 0.71 and 0.82 were obtained for teachers' classroom rating scale, problem-based learning group and interactive invention group respectively. These instruments were given to the research assistants to complete as the classes were in progress. This was to motivate the groups to be serious knowing that they were being graded but the scores obtained were not part of the final grading of the participants.

3.4.5 Teachers' Instructional Guide on Problem-Based Learning Strategy (TIGPBLS).

This outlines the steps involved in presenting the PBLS package to the pre-service teachers in problem based learning group (Experimental group I); it has three phases: (i) Problem presentation by the instructor (ii) Self–Study / research, students work on issues. (iii) Class presentations and summary/conclusion.

3.4.6 Teachers Instructional Guide on Interactive Invention Strategy (TIGIIS)

This outlines the steps involved in presenting the course content to the students in interactive invention strategy group (Experimental group II). It has the following steps (i) Review of previous lesson (ii) Over view of the day's lesson (iii) Guided practice (iv) individual practice (v) Monitoring and assessment.

3.4.7 Teachers' Instructional Guide on Conventional Lecture Method (TIGCLM)

Here, students sit individually throughout the lesson. The treatment for each lesson is in form of lecture.

(i) The instructor presents the lesson in form of lecture

(ii) Students listen to the teacher and write down chalkboard summaries.

(iii) Students ask the teacher questions on areas of the topic that is not clear to them.

(iv) Students answer the teacher's questions individually.

(v) Students are given take home assignment.

The manual in form of lesson note was prepared by the researcher and supplied to the instructors.

3.5 Procedure for Data Collection:

Table 3.3: Work Schedule Template

Weeks	Activities
1 – 2	Training of instructors and research assistants
3	Pretest
4-11	Treatment
12	Posttest

Training of Instructors and Research Assistants

The investigator, six (6) instructors and twelve (12) research assistants (graduate students in the department of Teacher Education, Faculty of Education, University of Ibadan) used the seven instruments to collect the required data directly from the selected Colleges of Education. To ensure uniformity and clarity in the data collection, the six instructors and twelve research assistants were trained on how to use the instruments, purpose, principles and procedures governing each group and the use of each treatment. The training involved orientation; discussion and practice and lasted for two weeks. This was done on college basis because the colleges operate different academic calendars.

Pretest

The instructors and research assistants were also trained on how to administer the instruments. The Pre-test materials were given to the trained instructors shortly after the training. Their first contact with the students in the classroom was to introduce the package, prepare the pre-service teachers' minds and inform them of the purpose, principles and procedures governing the research. The students were also told the benefits of fully participating from the beginning of the programme to the end.

More importantly, this research incorporated topics to be taught during the second semester and that it would contribute to their semester's examination. They were reminded that the course lecturers, who are the research instructors, might not have another opportunity to re-teach these topics before the semester's examination. After the introduction, the pre-test was administered.

This included the Physics Achievement Test (PAT) and Student Physics Self Efficacy Questionnaire (SPSQ) which were made into a booklet form containing the two instruments with demographics at the beginning followed by the PAT, and lastly

SPSQ and the students were asked to attempt it in that order and it lasted for one hour which was fixed after the trying out period. The pretest was done in the first week.

Treatment

Each treatment group used all the periods slated for the course that is, two hours per week and the treatment lasted for eight weeks after which the post test was administered. The trained lecturers (instructors) taught as directed and in accordance with the objectives of the treatments. The evaluating sheet for assessing instructors' performance during training was used to assess their performance and all the participating instructors scored above 85%.

Experimental group I: Problem Based Learning strategy.

The process is as follows:

Phase I

Activity i: Problem Presentation and grouping based on mixed gender (by the instructor)

Activity ii: Brainstorming on the problem to identify issues involved- by the students (while the research assistants distribute the work sheets to the students). The issues, questions and given data are arranged along three columns that may represent a response to the questions: What do we know (given)? What do we need? (Missing data or information, solution) and finally, what do we do? These questions guided the drawing up of learning objectives for each activity.

Activity iii: Scheduling of duties

The groups of five students each, then scheduled who will do what. However, everyone researches on all the objectives but individuals were made to be responsible in reporting particular objectives/ questions assigned to the individual by the group. The results of the learning or information which a learner gathered in the other objectives which may not specifically be assigned to him/her were used to corroborate the submissions of peers or refuting wrong ideas.

Phase II: Information Search.

Activity i: Self Study: Students' work on issues identified along side with the work sheets. This included library search, internet search, interviews and use of resource person,

Activity ii: collations of findings, experimentation and simple but detailed observations.

Phase III: Class activity-Presentation of findings, summary and conclusion

Activity i: Whole class activity. Teacher calls on different groups to present their group findings and discussion of issues is done by the whole class.

Activity ii: Classification of findings. New and consequent issues arise and questions may arise. The teacher harmonizes their findings.

Activity iii: Summary and Evaluation. A summary of what has been learnt is made. An evaluation of learning outcomes is carried out. The process is reiterative especially when the outcome of process is inconclusive.

Experimental group 2: Interactive invention strategy.

Phase1: Presentation

Activity i: Review previous work by giving worksheets to the students and asking them to answer some questions based on previous lesson.

Activity ii: Overview of new lesson

1. What? (Introducing the specific concept(s) and skill(s) to be learnt).
2. Why? (state reasons or need for learning the skill(s) or concept(s)).
3. Explanation (develops or explains the concepts and skills to be learnt.)
4. Probes and responds (probes students as to their understanding of the concepts and skills)

Phase II Practice

Activity i: Guided practice: Lecturers closely supervise the students as they work in groups of five, increasing proficiency by completing given task, asking questions where they need clarifications.

Activity ii: Independent practice: Allows the students to work independently with little or no teacher's interaction to reinforce individual proficiency with concepts and skills.

Activity iii: Periodic review to provide students with the opportunity to practice on previously covered content and skills.

Phase III: Monitoring and Assessment

Activity i: Formative (daily success at the end of each activity) checks students' work and offers correction and instructions as necessary.

Activity ii: Summation (mastery) checks student's work sheets at the end of each unit of instruction. Feed backs are given throughout the lesson as needed. Clues and prompts are given to provide students with signals and reminders designed to sustain the learning activity and to hold students accountable. Corrective feedback to tell students whether their answers are correct or not, the correct answers are made known and reasons why those answers were correct.

Control Group:

Conventional lecture Method. Here, the lecturers use the instructional guide provided by the researcher containing the lesson as follows;

- ✓ Lecturer introduces the lesson
- ✓ Explains theoretical bases for the topic
- ✓ Solves problems with examples and application
- ✓ Solicits questions from the class and give class work
- ✓ Marks the students' work.

Permission to use the colleges for this study was sought and obtained from the College Registrars who informed the Heads of departments and the course lecturers. These physics lecturers were trained before the study. The classes met two hours a week. The pretest was administered at the first meeting. The first week of the study was used for giving orientation to the subjects and the demands of their treatment conditions as well as giving them practice in their classroom environment with their intended learning techniques. After an additional eight weeks of treatment (main study), the posttests was administered. .

3.6 Procedure for Data Analysis

`The data obtained from the pretest and post test were analyzed, using Analysis of Covariance (ANCOVA) with the pretest scores as covariates.

Where the main effects were significant, the Multiple Classification Analysis (MCA) technique was used to find the direction of the difference among the groups. The

Scheffe tests were employed as post- hoc measures to know the specific effect of each treatment. In the case of significant interaction effect, a separate examination of the differences among categories of one factor at different levels of the other factor(s) involved in the interaction was conducted. This simple effect analysis was supported by graphical illustrations.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the empirical results of this experiment. The results and analyses of the data obtained in the study are presented below according to the order the hypotheses were stated.

4.1 Testing of Hypotheses

4.1.1Hypothesis one

HO_1 a: There is no significant main effect of treatment on pre-service teachers' achievement in physics concepts.

Table 4.1: Summary of Analysis of Covariance of Physics Achievement Test (PAT) Scores by Treatments, Self Efficacy and Gender.

Source of Variation	Sum of squares	DF	Mean Square	F	Sig.of F
Covariates	8266.387	1	8266.387	59.730*	.000
Main Effects	12244.615	5	2448.923	17.695*	.000
TREATMENT	12025.799	2	6012.899	43.447*	.000
EFFICACY	215.166	2	107.583	.777	.461
GENDER	3.650	1	3.650	.026	.871
2-way Interactions	1007.510	8	125.939	.910	.510
TREATMENT x EFFICACY	189.524	4	47.381	.342	.849
TREATMENT x GENDER	30.847	2	15.424	.111	.895
EFFICACY x GENDER	791.827	2	395.913	2.861	.060
3-way Interactions	1359.690	3	453.230	3.275*	.022
TREATMENT x EFFICACY x GENDER	1359.690	3	453.230	3.275*	.022
Explained	22878.202	17	1345.777	9.724	.000
Residual 1	24080.984	174	138.396		
Total	46959.186	191	245.860		

* = Significant at .05 level.

Table 4.1 Shows that there is significant main effect of treatment on pre-service teachers' achievement in physics concepts $F_{(2,174)} = 43.447$, $P < .05$.

Hypothesis 1a is therefore rejected.

In order to determine the magnitude and direction of the observed significant effect, Multiple Classification Analysis (MCA) was carried out and the result shown in table 4.2.

Table 4.2 Multiple Classification Analysis (MCA) of PAT Scores by Treatment Groups, Self Efficacy and Gender.

Grand Mean = 40.02

Variable and Category	N	Unadjusted Deviation	Eta	Adjusted for independence & Covariates Deviation	Beta
TRTGRP					
1 PBLS (Experimental 1)	47	11.96		12.48	
2 IIS (Experimental 2)	85	.30		-1.69	
3 Control.	60	-9.79		-7.38	
EFFICACY			.48		.52
1 LOW	17	-2.70		-2.52	
2 MEDIUM	139	- .62		.12	
3 HIGH.	36	1.11		-1.65	
GENDER			.07		.07
1 MALE	94	.15		-.51	
2 FEMALE	98	-.14		-.49	
Multiple R Squared			.03		.01
Multiple R					.437
					.661

From the data in the MCA Table 4.2, the students in problem-based learning experimental group had the highest adjusted mean score in achievement ($\bar{x}$ = 51.98; adj. dev. = 11.96) followed by those in interactive invention experimental group ($\bar{x}$ = 40.32; adj. dev. = 0.30) while the control group conventional lecture method had the lowest mean score ($\bar{x}$ = 30.23, adj. dev. =9.79). This order can be represented as PBL> IIS > CLM. MCA in table 4.2 also shows that the treatment main effect accounted for 27 percent $(.52)^2$ of the observed variance in achievement in physics.

In order to determine the treatment condition which caused the rejection of null hypothesis 1 a Scheffe Multiple Comparison was carried out on the adjusted mean scores of the three treatment groups for PAT. The results of the comparison are summarized in table 4.3. To know the group that caused the difference in treatment conditions.

Table 4.3: Scheffe Multiple Comparison of Treatment Group Mean Scores for PAT

Groups	**Mean Score**	**Treatment Group**		
CLM	32.6417	CLM	IIS	PBL
IIS	38.3235			
PBL	52.5000	*	*	

Key * = pairs of groups significantly different at P<.05

The result of this Scheffe multiple test shows that the experimental group 1 subjects (PBLS) earned a mean score that is significantly higher than those of groups two (IIS) and group 3 (control). The values are 52.5000, 38.3235 and 32.6417 respectively.

Ho_1b: There is no significant main effect of treatment on pre-service teachers' acquisition of science process skills.

Table 4.4: Summary of ANCOVA of Science Process Skills Score by Treatment]Groups, Self Efficacy and Gender.

Source of Variation	Sum of squares	DF	Mean Square	F	Sig.of F
Covariates	9588.341	1	9588.341	59.103*	.000
Main Effects	69496.986	5	13899.397	74.123*	.000
TREATMENT	68933.381	2	34466.690	183.805*	.000
EFFICACY	495.841	2	247.926	1.322	.269
GENDER	67.765	1	67.765	.361	.549
2-way Interactions	1145.688	8	143.211	.764	.635
TREATMENT x EFFICACY	630.135	4	157.534	.840	.501
TREATMENT x GENDER	47.709	2	23.854	.127	.881
EFFICACY x GENDER	282.508	2	141.254	.753	.472
3-way Interactions	1643.408	3	547.803	2.921*	.035
TREATMENT x EFFICACY x GENDER	1643.408	3	547.803	2.921*	.035
Explained	72286.082	16	4517.880	24.093	.000
Residual1	32815.573	175	197.518		
Total	105101.655	191	550.270		

* = Significant at .05 level.

Table 4.4 shows that there was significant effect of treatments on acquisition of science process skills of pre-service teachers. ($F_{(2, 175)}$ = 183. 80, P<.05). Hence hypothesis 1b is rejected. This implies that the treatment groups differ significantly in their acquisition of science process skills. To locate the direction and magnitude of the observed significant difference in the groups the multiple classification analysis was conducted and the results shown in table 4.5.

Table 4.5: MCA of Science Process Skills by Treatment Groups Self Efficacy and Gender

Grand Mean = 53.09

Variable and Category	N	Unadjusted Deviation	Eta	Adjusted for independence & Covariates Deviation	Beta
TRTGRP					
1 PBLS (Experi-	47	20.58		20.79	
mental 1)	85	7.13		7.73	
2 IIS (Experimental 2)	60	-27.03		-26.36	
3 Control.			.81		.79
	17	12.03		3.05	
EFFICACY	139	-2.92		-1.09	
1 LOW	36	5.9		2.75	
2 MEDIUM			.21		.08
3 HIGH.	94	-2.52		-.63	
GENDER	98	2.42		.60	
1 MALE			.11		.03
FEMALE					.661
Multiple R Squared					.813
Multiple R					

Table 4.5 shows that students in the problem-based learning experimental group had the highest adjusted mean score in science process skills ($\bar{x}$ = 73.67; adj. dev.= 20.79) followed by those in interactive invention experimental group ($\bar{x}$ = 60.21; adj. dev.=7.13) while the control (conventional lecture method) had the lowest mean score ($\bar{x}$=26.73; adj.dev = 26.36) . This order can be represented as PBL> IIS > CLM. The MCA in Table 4.5 also shows that the treatment accounted for 62 percent ($.79^2$x100%) of the observed variance in acquisition of science process skills.

To find out the group that caused the difference in treatment conditions the Scheffe multiple comparism of treatment groups was carried out and the result indicated in table 4.6.

Table 4.6: Scheffe Multiple Comparison of Treatment Troup Mean Scores for Science Process Skills.

Group	Mean	Treatment Groups		
CLM	26.0250	CLM	IIS	PBLS
IIS	60.8176	*		
PBLS	73.6702	*	*	

Key * = Pairs of groups significantly different at P< .05

The results of this Scheffe multiple test shows that the experimental group one subjects (PBLS) earned a mean score of (73.6702) that is significantly higher than those of group two (IIS) 60.8176 and group 3 (control) 26.0250. Similarly, group two (IIS) subjects achieved significantly higher than group 3 (control) subjects. There were no other significantly different pairs of means among the treatment conditions.

4.1.2 Hypotheses Two

$H0_2a$: There is no significant main effect of self-efficacy on pre-service teachers' achievement in physics concepts.

The data in table 4.1 shows that there is no significant main effect of self-efficacy on pre-service teachers' achievement in physics.

[$F_{(2,174)}$ = .777, P>.05]. Therefore the null hypothesis $H0_2a$ was not rejected.

$H0_2b$: There is no significant main effect of self-efficacy on pre-service teachers' acquisition of science process skills.

The data in table 4.4 shows that there is no significant main effect of self-efficacy on pre-service teachers' acquisition of science process skills.

[$F_{(2175)}$ = 1.322, P>.05]. Therefore the null hypothesis $H0_2b$ was not rejected.

4.1.3 Hypotheses Three

$H0_3$a: there is no significant main effect of gender on pre-service teachers' achievement in physics.

From table 4.1, the data shows that there is no significant main effect of gender on pre-service teachers' achievement in physics concepts. [$F_{(1, 174)} = .026$ $P > .05$]. Hence the null hypothesis is not rejected.

$H0_3$b: There is no significant main effect of gender on pre-service teachers' acquisition of science process skills.

The data in table 4.4 shows that there is no significant main effect of gender on pre-service teachers' acquisition of science process skills. [$F_{(1,175)} = .361$, $P > .05$]. Therefore the null hypothesis was not rejected.

4.1.4 Hypotheses Four

$H0_4$a: There is no significant interaction effect of treatment and self-efficacy on pre-service teachers' achievement in physics.

The covariance analysis of PAT score, contained in table 4.1 reveals that the two way interactions among treatment and self-efficacy is not significant [$F_{(4,174)} = .342$ $P > .05$]. Therefore hypothesis Ho_4a was not rejected.

$H0_4$b: There is no significant interaction effect of treatment and self-efficacy on pre-service teachers' acquisition of science process skills.

The analysis of covariance of Table 4.4 reveals that the two way interactions of treatments and self-efficacy is not significant. [$F_{(4,175)} = .840$, $P > .05$)].
Therefore the $H0_4$b was not rejected.

4.1.5 Hypotheses Five

$H0_5$a: There is no significant interaction effect of treatment and gender on pre-service teachers' achievement in physics.

The covariance analysis of PAT score, contained in Table 4.1 reveals that the two way interaction amongst treatments and gender is not significant.
[$F_{(2, 174)} = .111$, $P > .05$]. Therefore the $H0_5$ (a) was not rejected.

$H0_5b$: There is no significant interaction effect of treatment and gender on pre-service teachers' acquisition of science process skills.

The covariance analysis of acquisition of science process skills in Table 4.4 reveals that the two way interaction amongst treatments and gender is not significant. [$F_{(2,175)}$ = .127 ,P>.05]. Therefore hypothesis Ho_5 (b) was not rejected.

4.1.6 Hypotheses Six

$H0_6a$ There is no significant interaction effect of self-efficacy and gender on pre-service teachers' achievement in Physics

The two-way interaction of self-efficacy and gender, the covariance analysis of the data on Physics concepts achievement in table 4.1 shows that the interaction of self-efficacy and gender is not significant [$F_{(2,174)}$ = 2.861, P>.05]. Therefore the hypothesis 6(a) is not rejected.

HO_6 b: There is no significant interaction effect of self efficacy and gender on pre-service teachers' acquisition of science process skills

This is the null hypothesis in relation to two–way interaction effect of self efficacy and gender on acquisition of science process skills. The covariance analysis of the data on table 4.4 shows that it is not significant [$F_{(2, 175)}$ =.753, P>.05]. Therefore the $H0_6$ b was not rejected.

4.1.7 Hypotheses Seven

$H0_7a$. There is no significant interaction effect of treatments, self-efficacy and gender on pre-service teachers' achievement in Physics concepts.

Null hypothesis 7(a): Null hypothesis in respect of treatments by self-efficacy by gender interactions in physics concepts achievement, the covariance analysis of PAT score, contained in Table 4.1 reveals that the three–way interactions amongst treatment, self- efficacy and gender is significant.

[$F_{(3,174)}$ = 3.275 ,P<.05]. The null hypothesis 7a is therefore rejected.

The interaction among these three variables is plotted in the graph of fig 4.1.

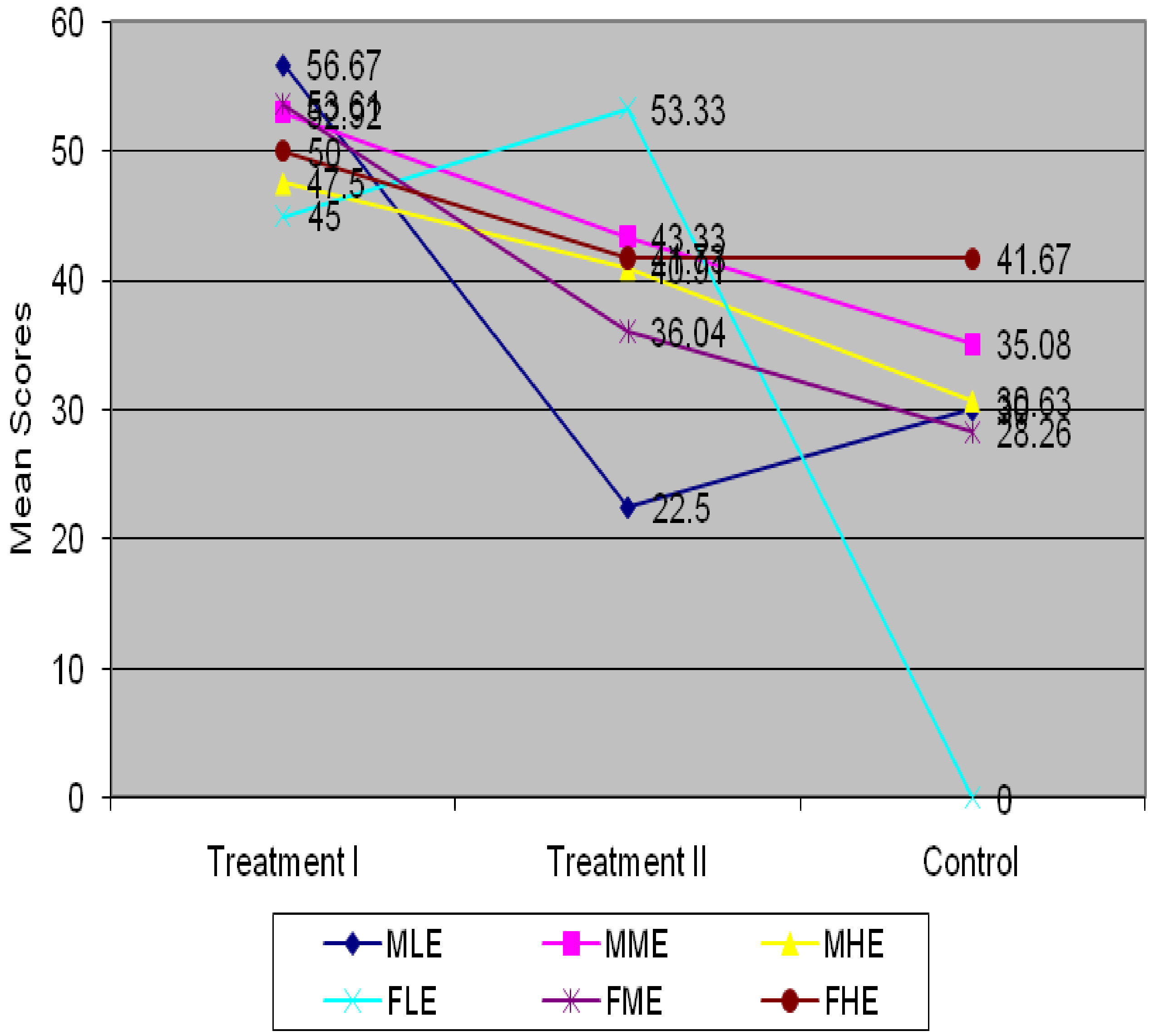

Fig.4.1: Line graph showing the significant interaction effects of Treatment, Self-Efficacy and Gender on Physics Achievement of Pre-Service Teachers

MLE = Male with low self – efficacy. MME = Male with medium self -efficacy.

MHE= Male with high self-efficacy. FLE= Female with low self –efficacy.

FME= Female with medium self – efficacy. FHE = Female with high self-efficacy.

Treatment I: Problem – Based Learning Instructional Strategy (PBLS)

Treatment II: Interactive Invention strategy (IIS)

Control: Conventional Lecture Method. (CLM)

The figure shows that the interaction present is disordinal in nature. A further examination of the graph shows the interactions of treatments, self-eficacy and gender produced the highest mean score of 56.67 for male with low self-efficacy and lowest of 45.00 for female with low self-eficacy in problem-based learning. The difference between the highest and lowest mean score is 11.67 for problem-based learning, 20.83 for interactive invention (tretment 2) and 41.67 for conventional lecture method. This means that the mean scores are more narrowly spread in treatment 1(PBLS) than treatment 2 (IIS) and control (CLM). This indicates that problem-based learning strategy (treatment 1) plays down gender and self-efficacy effects so it is good when mixed gender and diferent efficacy levels are involved. Interactive invention strategy (Treatment 2) and Conventional lecture method widen the diference in achievement for gender and self- eficacy levels. That is, it is gender and self-efficacy sensitive so these treatments should not be reommended for groups with different gender and self-efficacy except it is used with other strategies that can eliminate these effects.

Problem-based learning (Treatment 1) is most favorable for most groups except female with low self-efficacy but most favorable for male with low self-efficacy. Interactive invention strategy (Treatment 2) exaggerates the difference between groups and so it will not be very useful to use alone except if you want a condition that will favor females with low self-efficacy. Conventional lecture method (Treatment 3) is not as promoting as problem-based learning strategy (experiment 1) but it reduces the difference in groups except for females with low self-efficacy. So conventional lecture method and interactive invention strategy (treatment 2) will not be very useful if one wants to reduce the difference between groups but problem-based learning (treatment 1) is most appropriate to reduce the difference in achievement between males and females.

HO_7 b: There is no significant interaction effect of treatment, self efficacy and gender on pre-service teachers' acquisition of science process skills.

This is the null hypothesis 7b in respect of treatment by self-efficacy by gender interactions, on acquisition of science process skills. The covariance analysis for science process skills acquisition is contained in Table 4.4, and it reveals that the three way interaction amongst treatment, self-efficacy and gender is significant.

$F_{(3,175)} = 2.921, P<.05$. The null hypothesis is therefore rejected.

The interaction among the three variables is plotted in the graph of figure 4. 2.

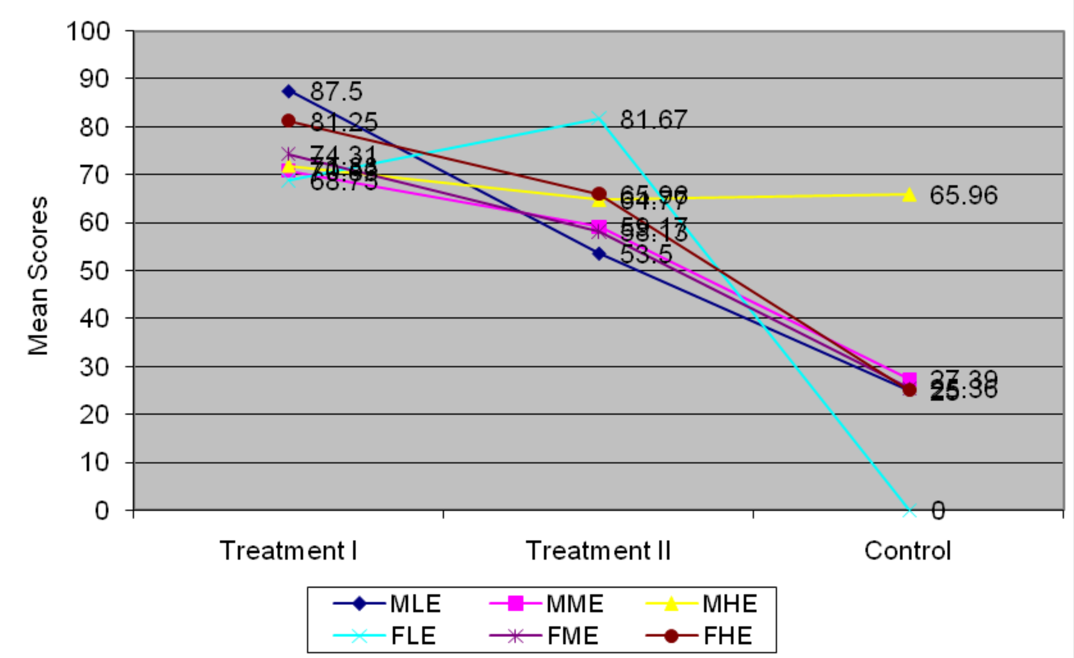

Fig. 4.2: Line graph showing significant interaction effects of Treatment, Self-Efficacy and Gender on acquisition of Science Process Skills of Pre-Service Teachers

Key

MLE = Male with low self – efficacy. MME = Male with medium self - efficacy.

MHE= Male with high self-efficacy. FLE= Female with low self –efficacy.

FME= Female with medium self – efficacy. FHE = Female with high self-efficacy.

Treatment I: Problem – Based Learning Instructional Strategy (PBLS)

Treatment II: Interactive Invention strategy (IIS)

Control: Conventional Lecture Method. (CLM)

The figure shows that the interaction is disordinal in nature. A further examination of the graph shows that interactions of treatment conditions for science process skills acquisition with self-efficacy and gender is more facilitating. The range of mean scores for problem-based learning strategy (treatment 1) is 18.75, interactive invention strategy (treatment 2) is 28.17, and conventional lecture method (control) is 67.96. The differece in mean scores in problem-based learning (treatment 1) is narrowest that is, the subgroups found the treatment most than interactive invention strategy (treatment 2) and conventional lecture method (control). This means that problem-based learning (treatment 1) is good for everybody and it facilitates acquisition of science process skills than interactive invention strategy (treatment 2) and conventional lecture method (treatment 3). For situation where both males and females are to be helped to compete favourably together then problem-based learning strategy (treatment 1) is recommended.

Conventional lecture method (treatment 3) had the widest gap which was worst for low self-efficacy followed by interactive invention (treatment 2). If a teacher wants a teaching condition that will deemphasize gender and promote acquisition of science process skills problem-based learning strategy is most appropriate. The use of conventional lecture method is worst because it promote the widening of the gap between the subgroups making the difference in performance very pronounced.

4.2. Discussion of findings

The major issue addressed in this study was the effects of problem-based learning and interactive invention instructional strategies on NCE pre-service teachers' achievement in physics and science process skills acquisition. In addition, it sought to find out any interaction effects among treatment, self-efficacy and gender of pre-service teachers on their achievement in physics and science process skills acquisition.

4.2.1 Effects of Problem-Based Learning and Interactive Invention Strategies on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills

Over the years, the decline in students' achievement in physics has been attributed to the teacher-centered teaching methods with the teacher dominating at the expense of students not being encouraged to construct their own knowledge or take active part in their learning. The problem has also been compounded by the abstract nature of some of the physics concepts coupled with the high quantitative demands of the subject. In this study therefore, the two constructivist strategies, problem-based learning and interactive invention strategies, sought to empower learners to take charge of their own learning by providing hands-on and minds-on activities lessons.

The results of this study showed that the problem-based learning instructional strategy and the interactive invention strategy were superior to the conventional lecture method in enhancing achievement in physics concepts over what is attainable with conventional lecture method. This finding is in agreement with the findings of Iroegbu (1998) who reported that problem-based learning instructional strategy enhances physics achievement, problem solving skills and line graphing skills over what is attained with conventional instruction in secondary schools. This is also in agrement with the findings of Gbolagade (2009) and Adedigba (2002). Problem–based learning instructional strategy was also found to enhance the acquisition of science process skills significantly. This is in line with the report of Yilman (2005) and Miller (2004) who separately repoted that problem-based learning facilitates cognitive and science process skills development.

This may not be unconnected with the rigorous hands and mind on materials associated with the strategy. In this research group, students were allowed to take charge of their learning as Kinshuk (2003) reported that it has been found that students are able to learn and retain knowledge better by actively participating rather than learning passively. In the PBL classes, students work in teams to solve one or more complex and compelling 'real world' problems. They develop skills in collecting, evaluating, and synthesizing resources as they first define and then propose a solution to a multi-faceted problem. Students also summarized and presented their solutions. The instructor only facilitated the learning process by monitoring the progress of the learners and asking questions to move the students forward in the learning process; the instructor was not the sole resource for content or process information, but instead guided students as they searched out appropriate resources (Major and Palmer, 2001). So as Major and Palmer (2001) had reported earlier, this strategy provides students with the opportunity to gain content knowledge and skills and helps students develop advanced cognitive abilities such as critical thinking, problem solving and communication skills and improve students' attitudes toward learning. So it is not surprising that students in this study did better than the other two study groups.

Interactive invention strategy was found to enhance achievement in Physics concepts more than conventional lecture method. This is in agrement with the findings of Okurumeh (2009) and Grouws and Cebulla (2000) who reported that interactive invention strategy improves students achievement in mathematics. This strategy was also found to enhance the acquisition of science process skills of pre-service teachers. This finding is in agreement with the findings of Aydogdu (2009) and Millar (2004) who reported that interactive invention strategy facilitates the acquisition of science process skills. The forgoing discussion answers research questions one and two: Will NCE students' performance depend on instructional strategy employed? and will acquisition of science process skills be affected by mode of instruction? Since students exposed to problem-based learning and interactive invention strategies perform better both in achievement in physics and acquisition of science process skills than those in the conventional lecture method group it is clear that instructional strategies used determines achievement in physics concepts and acquisition of science process skills.

The improvement in achievement in physics concepts and acquisition of science process skills as evident in the use of these two instructional strategies may not be unconnected with the hand-on activities provided by these strategies. This is in line with the observation of Iroegbu (1998) and Albanese and Mitchel (1993) who are of the opinion that learners will be more able to exhibit higher level of cognitive outputs if they are given oportunity to interact with materials and peers. The low performance of the conventional lecture strategy (control) group in the post–test achievement means score compared with the other treatment groups may not be unconnected with the fact that the strategy is teacher centred. This strategy does not offer students oppotunities to develop their ability to interact, communicate, think or solve problems (Ezenweani, 2002). Research findings in support of lack of preference of conventional lecture strategy are overwhelming, nevertheless, some researchers are in support of the conventional lecture method. Those in suport include Oludipe (2003) and Ukpene (2001). They noted that the conventional lecture method is administratively convenient to use in a large class and helps to cover large volume of content in short time.

4.2.2 Effects of Self-Efficacy on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills

Self-efficacy was found to have no effect on achievement in physics concepts and acquisition of science process skills. This is contradicting the findings of Wagner (2005) and Fend and Scheed (2005) who reported that self-efficacy is a major determinant of achievement. May be this effect was eliminated by the use of these activity-based instructional strategies that provided hands-on science learning programme and also students with mixed self-efficacy level were made to work together. This may have helped to minimize whatever effect self-efficacy could have on learning. Otherwise, It could be that the students' assessment of their efficacy was wrong.

4.2.3 Effects of Gender on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills

Gender was not found to be a significant variable for influencing the level of physics achievement and acquisition of science process skills. This finding tends to agree with those of (Molinari, Bonfigli, Mignani and Paciello (2003), Raimy and Adeoye (2002) and Ireogbu (1998) who have independently observed that although boys tend to have a slight advantage over girls in physics achievement, such differences have not been significant. It should be noted that the non significance observed in gender differences in achievement might have been caused by the prevailing experimental conditions the students were exposed to. This shows that both males and females could do well in the course if they are exposed to appropriate learning situations. This contradicts the findings of the following researchers: Murphy and Whitelegg (2005), Serenade (2003), Akande (2002) and Adegoke (1999) who reported that gender influence academic achievement of students. In answering research question three: Will pre-service physics teachers' self-efficacy and gender have any influence on their performance? Base on the findings of this study on self-efficacy and gender, these two constructs have no influence on student's performance in physics. This could be as the result of the homogeneity of intelligence and commitment of both males and females students.

4.2.4 Two-way Interactions among Treatment and Self-Efficacy on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills

There is no significant interaction effect of treatment and self-efficacy on pre-service teachers' achievement in physics concepts and acquisition of science process skills. This contradicts the findings of Fend and Scheed (2005) who reported that self-efficacy is a major determinant of achievement. Also, Mahyuddin et al's (2006) findings on the relationship between students' self-efficacy and their English language achievement shows that there were significant positive correlations between several dimensions of self-efficacy and academic achievement in English language. The dimensions included academic achievement efficacy ($r = 0.48$, $p = 0.001$), other expectancy beliefs (r = 0.34, p = 0.005) and self assertiveness (r = 0.41, p = 0.005). Also, the findings of Zimmerman, Bandura, and Martinez-Pons (1992) indicated that academic self-efficacy influenced achievement directly (beta = 0.21) as well as indirectly raising students' grades (beta = 0.36). These researchers explained that when there is academic self-efficacy or self perceptions of competence, the students succeed in their English language performance. As Bandura (1986) had earlier stated, the stronger the self-efficacy, the more likely the students select challenging tasks, persist at them and perform them successfully.

The present study findings that shows no significant interaction effect of treatment and self-efficacy on pre-service teachers' achievement in physics concepts and acquisition of science process skills may be because the effect was eliminated by the use of these activity-based instructional strategies that provided hands-on science learning programme and also students with mixed self-efficacy level were made to work together this may have helped to minimize whatever effect self-efficacy could have on learning. It could also be that the non significance observed in the interactions among treatment and self-efficacy differences in achievement might have been as a result of the prevailing experimental conditions the students were exposed to. This shows that students with different physics self-efficacy level could do well in the course if they are exposed to appropriate learning situations.

4.2.5 Two-way Interactions among Treatment and Gender on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills

The findings of this study show that there is no significant interaction effect of treatment and gender on pre-service teachers' achievement in physics concepts. This finding is in agreement with the findings of Jimoh (2004) on gender disparity in Quantitative Analysis practical among Chemistry students in Kwara State College of Education, Oro who reported that students' gender has no influence on their achievement in Quantitative Analysis. Also Yusuf (2004) investigated a comparative study of male and female students' academic achievement in Agricultural Education in Colleges of Education in Nigeria and found out that there is no significant difference in the achievement of male and female students.

The above submission contradicts the findings of Murphy and White-legg (2005) and Serenade (2003) who reported that gender influence academic achievement of students. Also Debez (1994) says that gender can influence students' achievement, especially in science-oriented subjects and that the sex difference was in the direction of inferior achievement of girls compared with boys and that boys perform better than their female counterparts in science subjects.

The present study findings could be because of the nature of the problem-based learning and interactive invention instructional strategies which emphasis students being in control of their learning. The improvement in achievement in physics concepts and acquisition of science process skills as evident in the use of these two instructional strategies may not be unconnected with the hands-on activities provided by these strategies. This is in line with the observation of Iroegbu (1998) and Albanese and Mitchel (1993) who are of the opinion that learners will be more able to exhibit higher level of cognitive outputs if they are given oportunity to interact with materials and peers.

4.2.6 Two-way Interactions among Self-Efficacy and Gender on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills

The findings of this study showed that there is no significant interaction effect of self-efficacy and gender on pre-service teachers' achievement in Physics concepts and acquisition of science process skills. This findings contradict the findings of Pajares and Miller (1994) who reported that Mathematics self-efficacy is a better predictor of mathematics performance than mathematics self concept, math anxiety, perceived usefulness of mathematics, or prior experience and it has a powerful direct effect on mathematics performance as does mental ability, a variable often presumed to be the strongest predictor of academic achievement (Pajares and Kranzler, 1995). Agreeing with the above, Bandura (1986), Zimmerman and Bandura (1994) and Pintrich and Schunk (2002) stated that self-efficacy affects achievement directly and indirectly through its influence on goals. They explained that students with high self-efficacy tend to learn and achieve more than students with low self-efficacy even when actual ability levels are the same and that this is partly because high self-efficacy students tend to engage in cognitive processes that promote learning, such as paying attention, persisting longer at difficult tasks, and organizing and elaborating new information being presented to them

Gender on the other hand, has been reported in agreement with the findings of this study to have no effect on achievement. Raimi and Adeoye (2002) in their study on gender differences among college students as determinants of performance in Integrated Science reported that there exists no significant difference between male and female students in terms of their cognitive achievement in the course. This is in agreement with Iroegbu (1998) findings but it contradicts the findings of Serenade (2003), Akande (2002), Adegoke (1999) and Okeke (1986) who found significant gender-group difference in favor of boys.

4.2.7 Three Way Interactions among Treatments, Self-Efficacy and Gender on Pre-Service Teachers' Achievement in Physics and Acquisition of Science Process Skills

The three – way interactions amongst treatment, self- efficacy and gender on pre-service teachers' achievement in physics and acquisition of science process skills was significant. The figures 4.1 and 4.2 show that the interactions present is disordinal in nature. The difference between the highest and lowest mean score is 11.67 for problem-based learning, 20.83 for interactive invention strategy (tretment 2) and 41.67 for conventional lecture method. This means that the mean scores are more narrowly spread in treatment 1(PBLS) than treatment 2 (IIS) and control (CLM). This indicates that problem-based learning strategy (treatment 1) plays down gender and self-efficacy effects so it is good when mixed gender and different efficacy levels are involved. Interactive invention strategy (Treatment 2) and Conventional lecture method widen the difference in achievement for gender and self- efficay levels that is, it is gender and self-efficacy sensitive so these treatments should not be reommended for groups with different gender and self-efficacy except it is used with other strategies that can eliminate these effects.

Problem-based learning (Treatment 1) is most favorable for most groups except female with low self-efficacy but most favorable for male with low self-efficacy. Interactive invention strategy (Treatment 2) exaggerates the difference between groups and so it will not be very useful to use alone except if you want a condition that will favor females with low self-efficacy. Conventional lecture method (Treatment 3) is not as promoting as problem-based learning strategy (experiment 1) but it reduces the difference in groups except for female with low self-efficacy group. So conventional lecture method and interactive invention strategy (treatment 2) will not be very useful if one wants to reduce the difference between groups but problem-based learning (treatment 1) is most appropriate to reduce the difference in achievement between males and females.

Also for science process skills acquisition, the range of mean scores for problem-based learning strategy (treatment 1) is 18.75, interactive invention strategy (treatment 2) is 28.17, and conventional lecture method (control) is 67.96. The differece in mean scores in problem-based learning (treatment 1) is narrowest that is, the subgroups farewell under this treatment than interactive invention strategy (treatment 2) and conventional lecture method (control). This means that problem-based learning (treatment 1) is good for everybody and it facilitates acquisition of science process skills than interactive invention strategy (treatment 2) and conventional lecture method (treatment 3). For situation where both males and females are to be helped to compete favourably together then problem-based learning strategy (treatment 1) is recommended.

Conventional lecture method (treatment 3) had the widest gap which was worst for females with low self-efficacy followed by interactive invention (treatment 2) which was worst for males with low self efficacy. If a teacher wants a teaching condition that will deemphasize gender and promote acquisition of science process skills problem-based learning strategy is most appropriate. Interactive invention strategy is exceptionally good for females with low self efficacy. The use of conventional lecture method is worst because it promote the widening of the gap between the subgroups making the difference in performance very pronounced.

4.3 Summary of Findings

The findings of this study revealed:

1. Significant main effects of treatment on achievement in physics concepts and acquisition of science process skills were obtained. Problem-based learning instructional strategy and interactive invention strategy were found to enhance concepts and science process skills achievement in physics over what is attained with conventional lecture instruction.
2. Self-efficacy was found to have no effect on achievement in physics concepts and acquisition of science process skills.

3. Gender not found to be a significant variable for influencing the level of physics achievement and acquisition of science process skills.
4. No significant two-way interactions effect of treatment and self–efficacy on achievement in physics concepts and acquisition of science process skills.
5. No significant two-way interactions effect of treatment and gender on achievement in physics concepts and acquisition of science process skills.
6. No significant two-way interactions of self–efficacy and gender on achievement in physics concepts and acquisition of science process skills.
7. A significant three-way interaction was found to exist among treatment, self-efficacy and gender on achievement in physics concepts and acquisition of science process skills.

CHAPTER FIVE

SUMMARY, EDUCATIONAL IMPLICATIONS, CONTRIBUTION TO THE BODY OF KNOWLEDGE, RECOMMENDATION AND LIMITATIONS

5.0 SUMMARY

This study determined the effects of problem–based learning and interactive invention instructional strategies on NCE pre-service teachers' achievement in physics and acquisition of science process skills. A pretest-posttest, control-group, quasi–experimental research design with a 3x2x3 factorial matrix was used. Three state and three federal colleges of education from South-western Nigeria were purposively selected. Ninety eight female and 94 male final year NCE physics students with high, medium and low self-efficacy constituted the sample. One state and one federal college of Education were used for each of the two experimental groups and the control group. The Instruments used were: Physics Achievement Test (r=0.875), Students' Physics Self–Efficacy Questionnaire (r=0.956), Science Proces Skills Worksheets (SPSW), Classroom Activities Evaluation Rating Scale (r=0.820), Teachers' Instructional Guides for Problem-Based Learning Strategy (PBLS), Interactive Invention Strategy (IIS) and Conventional Lecture Method (CLM). Three research questions were answered and seven null hypotheses were tested at 0.05 level of significance. Data were analysed using Analysis of Covariance (ANCOVA), Multiple Clasification Analysis (MCA) and Scheffe post hoc analysis.

The following were found:

1. Significant main effects of treatment on achievement in physics and acquisition of science process skills were obtained. Problem-based learning instructional strategy and interactive invention strategy were found to enhance concepts and science process skills achievement in physics over what is attained with conventional lecture instruction.
2. Self-efficacy has no significant effect on achievement in physics concepts and acquisition of science process skills.
3. Gender does not significantly influence the level of physics achievement and acquisition of science process skills.
4. Non significant two-way interaction effect of treatment and self–efficacy on achievement in physics concepts and acquisition of science process skills.
5. No significant two-way interactions effect of treatment and gender on achievement in physics concepts and acquisition of science process skills.

6. No significant two-way interactions of self–efficacy and gender on achievement in physics concepts and acquisition of science process skills.
7. A significant three-way interaction exists among treatment, self-efficacy and gender on achievement in physics concepts and acquisition of science process skills.

5.1 CONCLUSION

Based on the findings of this study, the following conclusions are drawn:

1. Problem-based learning instructional strategy was found to enhance achievement and science process skills acquisition in physics over what is attained with conventional lecture instruction.
2 Interactive invention strategy was found to enhance achievement and science process skills acquisition in physics over what is attained with conventional lecture instruction.
3. Self-efficacy has no effect on achievement in physics concepts and acquisition of science process skills.
4. Gender has no influence on the level of physics achievement and acquisition of science process skills.
5. The use of problem–based learning stategy nullifies the effect of gender and self-eficacy in achievement in physics concepts and in acquisition of science process skills

5.2 EDUCATIONAL IMPLICATIONS

The differential achievement of males and females who have different self efficacy level to various study groups, coupled with the nature and levels of interaction among strategies of instruction indicate a need of considering these variables in future instructional arrangements.

The importance of this condition becomes more obvious when objective of promoting the level of achievement and encouraging more equitable gender participation in physics are considered. There is therefore a need to intensify the effort of exposing teacher educators to theories of instructional strategies such as problem-based learning. It is also important that textbook authors should be aware of these new theories of instruction and content organization so that they may reflect them in their writings.

5.3 CONTRIBUTION TO THE BODY OF KNOWLEDGE

(1) From the findings of this study, it is evident that it is possible to use problem-based learning strategy as an alternative method of instruction at the college level.

(2) Problem-based learning could produced a better level of achievement in physics than the traditional method that is often used.

(3) The use of problem–based learning stategy nullifies the efect of gender and self-eficacy in achievement in physics concepts and in acquisition of science process skills. This is because the strategy is not sensitive to gender and levels of self efficacy.

(4) Interactive Invention strategy produces a better level of achievement in physics concepts and acquisition of science process skills than the traditional lecture method of teaching physics.

(5) Both Interactive Invention strategy and conventional lecture method are sensitive to gender and self-efficacy so they are not suitable to be used when different levels of self-efficacy and gender are involved.

(6) Since interactive invention strategy and conventional lecture method are sensitive to gender and levels of self-eficacy, these strategies could be used in selection process like during interviews where different self-eficacy levels are required.

5.4 RECOMMENDATIONS

On the basis of the findings summarized above, and the general experience during this study, the following recommendations are considered necessary.

1. Teacher educators should be discouraged from using teacher centered instructional strategies in training pre-service teachers but learner–centered instructional strategies such as problem based learning and interactive invention strategies should be used. The periodic use of such and other innovative strategies will promote high level learning achievement as well as acquisition of science process skills.

2. As far as possible, girls should be encouraged to take up the study of physics as there is nothing masculine about the subject as already observed from the findings of the study.

3. Physics teachers (educators) should be encouraged to use appropriate learning programmes to facilitate hands-on practices to prove that physics is not as abstract as many people think.
4. Facilities should be provided for the retraining of teachers in the use of innovative techniques in science instruction through seminars and workshops.

5.5 LIMITATIONS OF THE STUDY

The study findings, implications and recommendations are subject to the following limitation.

1. Physics achievement score in this study was based on the subjects' performance on ferromagnetism, electromagnets, force effect of current carrying conductors and electromagnetic induction alone. No attempt was made to extend the coverage to other principles or content other than these. The reason is because of the difficulty of constructing and managing problem-based instructional scheme, which will cover larger pieces of content. Such will be difficult to manage in a research of this type and also too costly to execute.
2. Science process skills assessment was based on skills which are discernible from written scripts or those which may be inferred from such scripts.
3. Assessment of science process skills in problem-based learning treatment group was slightly different from the other groups because of the steps involved in the inquiry process they had to follow.

5.6 SUGGESTIONS FOR FURTHER STUDIES

Based on the findings of this study the following suggestions are made for further studies

This study should be replicated in other parts of the country and in other science subjects

Studies on Problem-based learning and interactive invention could be carried out in other teacher education institutions in Nigeria.

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APPENDIX Ia

PHYSICS ACHIEVEMENT TEST

Time allowed: 1 Hour

INSTRUCTION: This test intends to examine your knowledge of some aspect of Electromagnetism. Please respond as honestly as possible.

Section A: Personal Data

Please complete as appropriate

Student Name---

Name of College--

Sex: (a) Male ( ) (b) Female ( )

Section B

Instruction: Read the following questions carefully and choose the right option.

Circle the correct option from A-E on the answer sheet provided. Please do not write on the question paper.

1 Those material which exhibit very strong magnetic effects are said to be.
(a) magnet
(b) Paramagnetic
(c) Diamagnetic
(d) Ferromagnetic
(e) Demagnetized

2 Which of these is not a ferromagnetic material?
(a) Iron
(b) Nicked
(c) Cobalt
(d) Gadolinium
(e) Copper

3 _______ substances are affected by magnetic fields.
(a) All
(b) Non
(c) One
(d) Two
(e) Three

4 Values of relative permeability of ferromagnetic material are typically.
(a) Slightly less than 1
(b) Slightly greater than 1
(c) 1.0×10
(d) 1.0×10^2
(e) 1.0×10^4

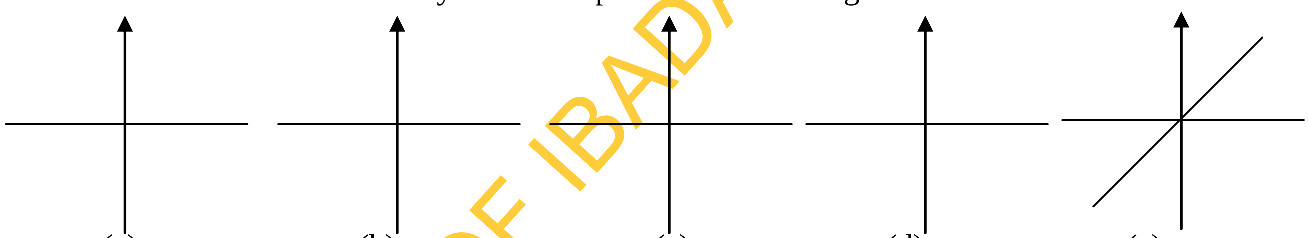
5 soft magnetic materials have.
(a) Wide hysteresis loop.
(b) Narrow hysteresis loop.
(c) low coercively.
(d) High saturations thin density.
(e) High romance.

6 hysteresis loss is explain to mean-------
(a) Energy dissipated by transformer core.
(b) Energy absorbed by transformer core.
(c) Energy gained by transformer core.
(d) Energy retained by transformer core.
(e) Energy transformed by transformer core.

7 The following diagrams illustrate the effect of an external field on the domain structure of a ferromagnetic material.

8. Soft magnetic material has
   (a) A narrow hysteresis loop
   (b) Low coactivity
   (c) High saturation flux density
   (d) High remanence
   (e) None of the above

9. Which of these indicate Hysteresis loops for hard ferromagnetic materials?



(a) (b) (c) (d) (e)

10. At what temperature does iron becomes paramagnetic
   (a) Absolute temperature
   (b) Zero temperature
   (c) Room temperature
   (d) Newton’s temperature
   (e) Curie temperature

11. A small amount of double ionized manganese (mn^{H}) is distributed uniformly throughout a crystal of Nacl so that it sample is 150 tropic and paramagnetic. The magnitude of the magnetization is 6.6 A/M at 310k in a magnetic field of magnitude 0.87T. Determine curie’s constant for this sample
   (a) 2.7×10^{-3} k
   (b) 2.5×10^{-3} k
   (c) 2.0×10^{-3} k
   (d) 2.6×10^{-3} k
   (e) 2.4×10^{-3} k

12. Which of these statements is not true?
   (a) Magnetic moments align spontaneously in a ferromagnetic material
   (b) Para magnetism is due to the partial alignment of the permanent magnetic moments with the applied magnetic field

(c) For both diamagnetic and paramagnetic materials, the magnetization is non zero only if an applied magnetic field is prevent
(d) in diamagnetic materials, M and B are opposite.
(e) Ferromagnetic, paramagnetic and diamagnetic materials field.

13. Which of these is said to be magnetically soft?
(a) Iron (b) Nickel (c) Steel (d) Cobalt (e) Mumetal

14. If an electric current flows through a coil of wire, a magnetic field forms around the coil. What does this create? (a) Magnet (b) Electricity (c) Coil (d) Electromagnet (e) Light

15. Electromagnet can be explain to be a magnet that
(a) Can be built up or built down (b) Can be injected in or injected out
(c) Can be switched on or switched off (d) can be step up or step down (e) Bind up or bind down

16. When the switch of an electromagnet is opened
(a) The current flows
(b) The magnetic field increase
(c) The magnetic field disappears
(d) The electromagnetic is switched on
(e) The magnetic field decrease

17. If the direction of the current is reversed, what happens to the electromagnet formed?
(a) The poles reverse
(b) The strength reduce
(c) The strength increases
(d) The magnet attracts.
(e) The magnetic field disappears

18. Which of these is the application of electromagnet?
(a) Water heater
(b) Circuit breaker
(c) Electric bulb
(d) Electric iron
(e) Wind breaker

19. When making electromagnet
(a) Weak magnetic material should be used
(b) Strong magnetic material should be used
(c) Hard magnetic material should be used
(d) Soft magnetic material should be used
(e) None of the above

20. The following are the possible effect of the magnetic field except
(a) Attraction
(b) No effect
(c) Heating effect

(d) Repulsion
(e) Movement

21. When a wire carrying an electric current is placed in a permanent magnetic field the following happens except
(a) The magnetic field is formed around the wire
(b) Interaction with the permanent magnetic field
(c) Causing the wire to experience a force which causes it to move
(d) Causes the wire to melt.
(e) Nothing happens

22. Placed in a permanent magnetic field, the size of the force on the current carrying conductor can be increased by the following ways except
(a) Increasing the size of the wire
(b) Increasing the size of the current
(c) Increasing the strength of the magnetic field
(d) Replacing the magnet with stronger magnets.
(e) Increasing the length of the wire

23. How can the direction of the force on the wire be reversed?
(a) By increasing the size of the force
(b) By increasing the strength of the field
(c) By reversing the direction of the magnetic field
(d) By increasing the current
(e) By increasing the length of the wire

24. The direction of the force on the wire can be reversed by the following except
(a) Reversing the direction of flow of the current
(b) By turning the cell round
(c) By increasing the current
(d) By reversing the direction of the magnetic field
(e) By reversing the poles of the magnet

25. Which of the following is true of the magnetic induction?
(a) When a wire cuts through the lines of force of a magnetic field voltage is induced
(b) When a wire carrying current is cut into two, voltage is induced
(c) When a wire carrying current is heated voltage is induced
(d) When a wire carrying current melts voltage is induced
(e) When the wire carrying current is best

26. The followings describe the way the size of induced voltage can be increased except
(a) Decreasing the area of the coil
(b) Increasing the speed of movement of the magnetic in the coil
(c) Increasing the strength of the magnetic filed
(d) Increasing the area of the coil.
(e) By increasing the number of turns of coil

27. When the number of turns on the coils is increase
   (a) The poles of the magnet changes
   (b) The magnet demagnetized
   (c) The induced voltage increase
   (d) The induced voltage decreases.
   (e) The poles of the current changes

28. Which of the following statements does not describe how current can be induced?
   (a) Moving the magnet into the coil induces a current in one direction
   (b) By keeping the magnet stationary current is induced
   (c) By moving the magnet out of the coil current is induced
   (d) By moving the other pole of the magnet into the coil current is induced
   (e) By moving the coil through a magnet

29. The magnitude of the force on a current caring conductor in a magnetic field become Zero
   (a) When the conductor is parallel to the filed
   (b) When the conductor is at 60^0 with the field
   (c) When the conductor lies parallel to the field
   (d) When the conductor is at 30^0 with the field
   (e) When the conductor lies 10^0 with the field

30 The magnetic force on the coil is at maximum when
   (a) The conductor is parallel to the filed
   (b) The conductor is perpendicular to the field
   (c) When the conductor is at 60^0 with the field
   (d) When the conductor is at 30^0 with the field
   (e) When the conductor lies 10^0 with the field

31. The force in a current carrying conductor is
   (a) Directly proportional to current, the field strength and the angle between the conductor and the field.
   (b) Directly proportional the current but inversely proportional to the field strength and angle between the conductor and the field.
   (c) Inversely proportional to the current, the field strength and the angle between the conductor and the field
   (d) Inversely proportional to the field strength and the angle between the conductor and the field
   (e) Inversely proportional to current

Use the question below to answer question 32 - 34
A wire carrying a current 10 A and 2 m in length is placed in a field of flux density 0.15T. What is the force on the wire if it is placed?

32. At right angles to the field (a) 1N (b) 2N (c) 3N (d) 4N (e) 5N

33. At 45^0 to the field (a) 2.12N (b) 2.11N (c) 2.13N (d) 2.14N (e) 2.0N

34. Along the field (a) 0 N (b) 1N (c) 2N (d) 3N (e) 4N

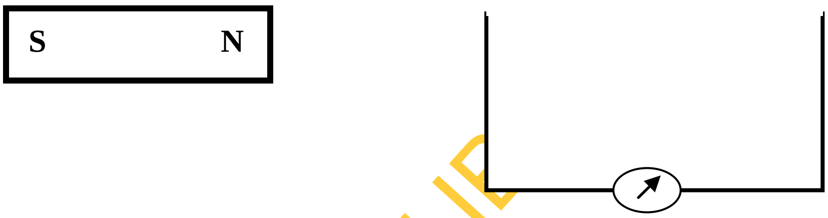
35. What is the unit of the magnetic flux density?
(a) Meter (b) Newton meters (c) Rho (d) Tesla (e) Ohms

36. A vertical straight conductor X of length of 0.5m is situated in a uniform horizontal magnetic field of *0.1T*. Calculate the force on X when a current of 4A is passed into it.
(a) 0.02 (b) 0.2 (c) 2.0 (d) 20 (e) 0.22

37. In the above question through what angle must X be turned in a vertical plane so that the force on X is halved? (a) 15^0 (b) 30^0 (c) 45^0 (d) 60^0 (e) 10^0

38. Identify the force fields from the following
(a) Gravitational field (b) Magnetic field (c) Electric field (d) Temperature (e) Electrostatic filed

Use this figure to answer question 39 and 40



What happens to the needle of the ammeter if
(a) It deflect to the right (b) If deflect to the left (c) It remains at Zero (d) All of the above (e) It melts

40. The magnet is pulled out of coil?
(a) It deflect to the right (b) It deflect to the left (c) It remains at Zero (d) None of the above (e) It melts

APPENDIX 1b

ANSWER SHEET
PHYSICS ACHIEVEMENT TEST

Instruction: Tick the best option from A-E
Name of student……………………………………………………..
Name of College……………………………………………………
Sex: Male ( ) **Female ( )**

S/N	A	B	C	D	E
1					
2					
3					
4					
5					
6					
7					

8					
9					
10					
11					
12					
13					
14					
15					
16					
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39					
40					

APPENDIX1C

ANSWERS TO THE PHYSICS ACHIEVEMENT TEST

1. D
2. E
3. A
4. E
5. A
6. A
7. C
8. E
9. A
10. E
11. B
12. E

13. A
14. D
15. C
16. C
17. A
18. B
19. D
20. C
21. D
22. C
23. C
24. C
25. A
26. A
27. C
28. B
29. C
30. B
31. A
32. C
33. A
34. A
35. D
36. B
37. C
38. D
39. A
40. B

APPENDIX ll

STUDENTS PHYSICS SELF-EFFICACY QUESTIONNAIRE (SPSQ)

Introduction: This questionnaire seeks to investigate your self-efficacy level in Physics.

Section A: Personal Data

Tick as appropriate

Name of student…………………………………………………..

Name of College………………………………………………….

Sex: Male ( )   Female ( )

Section B

Introduction: The following statements are based on some aspect of your Physics self-efficacy. Please read each statement and give your opinion by ticking the appropriate column against each statement. There are four options ranging from Strongly Agree (SA); Agree (A); Disagree (D) to Strongly Disagree (SD)

S/N	SATEMENT	SA	A	D	SD
1	I can always manage to solve difficult problems in Physics				
2	I am not afraid of challenges in Physics				
3	It is easy for me to stick to my objectives and accomplish my objective in Physics				
4	I am confident that I can deal with unexpected problems in Physics				
5	I know how to handle most unseen situation in Physics				
6	I can solve most problems in Physics if I invest the necessary effort and patience				
7	I am calm when facing difficulties in Physics because I rely on my coping ability				
8	When I am confronted with problems in Physics I usually find solutions				
9	I am always afraid of Physics				
10	I cannot do well in Physics				

APPENDIX lll a1

SCIENCE PROCESS SKILLS WORKSHEET
WORHSHEET FOR PROBLEM-BASED LEARNING GROUP
Introduction: This worksheet is to guide the students in in the Problem-based their search

Name---
Name of School--
Sex--
Topic FERROMAGNETISM

1. Write down what you know about the question given

----

2. List what you need to know about the question

.--

.---

----

3. List what you think you need to do to solve the problem

.---

.--

4. Write down the ways that the rods could be identified without using any instrument---

5. Write down how the rod could be tested for magnetism--

6. Group the rods into

Magnetic	Non-Magnetic
I	
Ii	
Iii	

7. Write down what could be done to the coil to create magnetic field around it.

----

8. Suggest what could cause increase in the magnetic field as some rods were placed in the coil ---

APPENDIXIII a 2

SCIENCE PROCESS SKILLS WORKSHEET

WORHSHEET FOR PROBLEM-BASED LEARNING GROUP

Introduction: This worksheet is to guide the students in in the Problem-based their search

Name---

Name of School--

Sex--

TOPIC: MAKING AN ELECTROMAGNET

1. Write down what you know about the question given

----

2. List what you need to know about the question

----

3. List what you think you need to do to solve the problem

.--

.---

4, Identify and write down the names of the apparatus provided
(i). --

(ii). --

(iii) --

(iv) --

5. Identify by name the device you are just given and state what it is used for-----
----

6. Write down your observations as you move the compass around the current coil---
------

7. Tabulate your observation similarities

Field of a current carrying coil	Field of a bar Magnet
I	
Ii	
Iii	

8. State what you think could cause the effect you observed-----------------------------
----

APPENDIX lll a 3
SCIENCE PROCESS SKILLS WORKSHEET
WORHSHEET FOR PROBLEM-BASED LEARNING GROUP
Introduction: This worksheet is to guide the students in in the Problem-based their search

Name---
Name of School---
Sex--

TOPIC : FORCE ON A CURRENT CARRYING CONDUCTORS IN A MAGNETIC FIELD

1. Write down what you know about the question given

----

2. List what you need to know about the question

----

3. List what you think you need to do to solve the problem

.---

.--

4. Write down what you can do to cause current to flow through the conductor with the materials provided --

5. Write down what you observe when the current carrying conductor is placed in the magnetic field.--

6. Make a list of what could be done to increase the force on the current carrying conductor

(i). --

(ii). --

(iii) --

(iv) --

7. List out what could be done to reverse the direction of the current

(i). --

(ii). --

(iii) --

(iv) --

8. Make a general statement on What you can do to increase the force on a current carrying conductor--

----

APPENDIX lll a 4

SCIENCE PROCESS SKILLS WORKSHEET

WORHSHEET FOR PROBLEM-BASED LEARNING GROUP

Introduction: This worksheet is to guide the students in in the Problem-based their search

Name---

Name of School--

Sex---

TOPIC: Variation of force direction of current carrying conductor and the effect of varying the length of the conductor

1. Write down what you know about the question given

----

2. List what you need to know about the question

----

3. List what you think you need to do to solve the problem

.--

.---

4. Write down what can be done to change the direction of the force
(i). --

(ii). --

5. What do you observe if the direction of the flow of the current is reverse
(i). --

(ii). --

6. What happens if the direction of the magnetic field is reversed
(i). --

(ii). --

7. If the length of the conductor is increase what happens to the force
(i). --

(ii). --

8 Write your final conclusion of your observation.

APPENDIX lll a 5
SCIENCE PROCESS SKILLS WORKSHEET
WORHSHEET FOR PROBLEM-BASED LEARNING GROUP
Introduction: This worksheet is to guide the students in in the Problem-based their search

Name---
Name of School---
Sex--

TOPIC: Making electricity by electromagnetic induction

1. Write down your observations as a magnet is moved through a coil of a complete circuit.

2. Write down what you know about the question given

----

3. List what you need to know about the question

----

4. List what you think you need to do to solve the problem

(i). --

(ii). --

(iii) --

(iv) --

5. As you move the magnet out of the coil, what do you observe in the meter

(i). --

(ii). --

(iii) --

(iv) --

6. Leaving the magnet stationary in the coil write down your observations

(i). --

(ii). --

(iii) --

(iv) --

7. Make a general statement on generating electricity by magnetic induction

……………………………………………………………………

…………………………………………………………………………..

APPENDIX lll a 6

SCIENCE PROCESS SKILLS WORKSHEET

WORHSHEET FOR PROBLEM-BASED LEARNING GROUP

Introduction: This worksheet is to guide the students in in the Problem-based their search

Name---

Name of School---

Sex---

TOPIC: Making electricity by electromagnetic induction

1. Write down what you know about the question given

----

2. List what you need to know about the question

----

3. List what you think you need to do to solve the problem

(i). ---

(ii). ---

(iii) ---

(iv) ---

Topic: INCREASING THE SIZE OF THE INDUCED VOLTAGE

4. What are the ways the induced voltage can be increased?

(i). ---

(ii). ---

(iii) ---

(iv) ---

5. What do you observe if the speed of movement of the magnet or the coil is increased?

(i). ---

(ii). ---

(iii) ---

(iv) ---

6. If the number of turns on the coil is increased what happens to the induced voltage?

(i). ---

(ii). ---

(iii) ---

(iv) ---

7. Increase the area of the coil and state your observations

(i). ---

(ii). ---

(iii) ---

(iv) --

8. What happens when the strength of the magnetic field is doubled
   (i). --

   (ii). --

   (iii) --

   (iv) --

APPENDIX lll b1

WORHSHEET 1

FOR INTERACTIVE INVENTION LEARNING GROUP

Name--
Name of School--
Sex--

TOPIC : FERROMAGNETISM

1. Write down the ways that the rods could be identified without using any instrument---
----
----

2. Write down how the rod could be tested for magnetism---------------------------
----
----

3. Group the rods into

Magnetic	Non-Magnetic
I	
Ii	
Iii	

4. Write down what could be done to the coil to create magnetic field around it.

---

5. Suggest what could cause increase in the magnetic field as some rods were placed in the coil ---
----

APPRENDIX lll b2

WORHSHEET 2 FOR INTERACTIVE INVENTION LEARNING GROUP

Name---
Name of School--
Sex---

TOPIC: MAKING AN ELECTROMAGNET

1. Identify and write down the names of the apparatus provided

(i). ---

(ii). ---

(iii) ---

(iv) ---

2. Identify by name the device you are just given and state what it is used for-----
----
----

3. Write down your observations as you move the compass around the current coil---
----

4. Tabulate your observation similarities

Field of a current carrying coil	Field of a bar Magnet
I	
Ii	
Iii	

5. State what you think could cause the effect you observed--------------------------
----

APPENDIX lll b3

WORHSHEET 3

FOR INTERACTIVE INVENTION LEARNING GROUP

Name---
Name of School--
Sex---

TOPIC : FORCE ON A CURRENT CARRYING CONDUCTORS IN A MAGNETIC FIELD

1. Write down what you can do to cause current to flow through the conductor with the materials provided ---
2. Write down what you observe when the current carrying conductor is placed in the magnetic field.---

3. Make a list of what could be done to increase the force on the current carrying conductor

(i). ---

(ii). ---

(iii) ---

(iv) ---

4 List out what could be done to reverse the direction of the current

(i). ---

(ii). ---

(iii) ---

(iv) ---

5.Make a general statement on What you can do to increase the force on a current carrying conductor--

APPENDIX lll b4

WORHSHEET 4 FOR INTERACTIVE INVENTION LEARNING GROUP

Name---

Name of School--

Sex---

TOPIC: Variation of force direction of current carrying conductor and the effect of varying the length of the conductor

1. Write down what can be done to change the direction of the force

(i). ---

(ii). ---

(iii) ---

(iv) --

2. What do you observe if the direction of the flow of the current is reverse(i).

(ii). --

(iii) --

(iv) --

3. What happens if the direction of the magnetic field is reversed
(i). --

(ii). --

(iii) --

(iv) --

4. If the length of the conductor is increase what happens to the force
(i). --

(ii). --

(iii) --

(iv) --

5. Write your final conclusion of your observation.

APPENDIX lll b5

WORHSHEET 5 FOR INTERACTIVE INVENTION LEARNING GROUP

Name---
Name of School---
Sex---

TOPIC: Making electricity by electromagnetic induction
Write down your observations as a magnet is moved through a coil of a complete circuit.

(i). --

(ii). --

(iii) ---

(iv) ---

1. As you move the magnet out of the coil, what do you observe in the meter
   (i). ---
   (ii). ---

   (iii) ---

   (iv) ---

2. Leaving the magnet stationary in the coil write down your observations
   (i). ---

   (ii). ---

   (iii) ---

   (iv) ---

3. Make a general statement on generating electricity by magnetic induction

APPENDIX lll b6

WORHSHEET 6 FOR INTERACTIVE INVENTION LEARNING GROUP

Name---

Name of School--

Sex---

Topic: INCREASING THE SIZE OF THE INDUCED VOLTAGE

1. What are the ways the induced voltage can be increased?
   (i). ---

   (ii). ---

   (iii) ---

(iv) --

2. What do you observe if the speed of movement of the magnet or the coil is increased?

(i). --

(ii). --

(iii) --

(iv) --

3. If the number of turns on the coil is increased what happens to the induced voltage?

(i). --

(ii). --

(iii) --

(iv) --

4. Increase the area of the coil and state your observations

(i). --

(ii). --

(iii) --

(iv) --

5. What happens when the strength of the magnetic field is doubled

(i). --

(ii). --

(iii) --

(iv) --

APPENDIX IVa

CLASSROOM ACTIVITIES EVALUATION RATING SCALE.(PROBLEM BASED LEARNING)

Name---
Name of School--
Sex--

	GROUP ACTIVITIES	SCORING			
	TEACHER	0	1	2	3
I	Placing pre-service teachers' in groups				
Ii	Asking guiding questions to give students direction in the information search				

Iii	Monitoring pre-service teachers interactions in the groups				
Iv	Guiding groups to collate their finding				
V	Guiding group presentations				
Vi	Coordinating presentations				
Vii	Attainment of stated objectives				
viii	Adequate management of time				
ix	Summarizing the whole lesson				
B	Pre-service teacher				
Ii	Discussing the problem in different groups				
iii	Describe the product and performance required in different groups				
A	WHOLE CLASS ACTIVITIES				
I	Passing facts and information to the group members				
Ii	Giving direct instructions to all the groups				
iii	Giving feedback on the problems				
iv	Summarizing their findings.				
B	PRE-SERVICE TEACHER				
I	Listening attentively to the teacher				
Ii	Asking questions on the problem				
iii	Answering questions on the problem				
iv	Participating on the performance required				
V	Participating on the discussion on the findings.				

APPENDIX IVb

CLASSROOM ACTIVITIES RATING SCALE.

Name---

Name of School--

Sex--

	GROUP ACTIVITIES	**SCORING**			
A	TEACHER	0	1	2	3
I	Review of previous lesson				
Ii	Overview of the day's lesson				
Iii	Demonstration of experiment on the explained concept				

Iv	Grouping pre-service teachers in groups of five				
V	Guiding pre-service teachers in their groups to demonstrate the concept experimentally				
Vi	Monitoring pre-service teachers interactions in their groups				
Vii	.Guiding individual students to perform the experiment				
B	PRE-SERVICE TEACHERS				
I	Asking each other some questions				
Ii	Seeking assistance from each other				
Iii	Offering assistance to each other				
Iv	Performing specific roles				
V	Discussing what is being learnt and how to solve the problem				
Vi	Encouraging each other				
Vii	Challenging each other's reasoning and conclusion				
Viii	Providing each other with feedback				
ix	Discussing their progress				
X	Identifying problems being encountered				

A	WHOLE CLASS ACTIVITIES			
I	Passing facts and information			
Ii	Giving direct instructions			
iii	Asking questions			
iv	Teaching some skills.			
V	Giving feedback			
vi	Summarizing the lesson			
vii	Giving assignment			
B	PRE-SERVICE TEACHER			
I	Listening attentively to the teacher			
Ii	Ask question			
iii	Participating in the experiment			
iv	Answer questions			
V	Copying the question from the chalkboard.			

APPENDIX Va

TEACHERS' INSTRUCTIONAL GUIDE ON PROBLEM-BASED LEARNING STRATEGY

LESSON ONE

EXERCISES IN PROBLEM BASED LEARNING INSTRUCTION

PROBLEM 1

A manufacturing company that produces electric fan uses magnets made from two metallic materials. The users claim that fans made from one of the metallic materials work better than the other. You are provided with

Two rods each made from each of the metallic materials and you are Required to determine the truth or otherwise of this clamed. How do you know that your conclusion is correct?

INSTRUCTION TO STUDENTS ON EACH QUESTION:

(a) Read the question carefully and think about it for some time

(b) Are there any things about this problem that you have found interesting and will want to discuss?

(c) Discuss in your group what you know about the problem, what you need to know and what you are going to do to solve the problem.

(d) Choose your group leader and share duties to group members.

(e) Go on information search (internet, library, resource person).

(f) Submit your findings to the group.

(g) Collate your group findings and verify experimentally with the materials provided following the worksheet guide.

(h) Present your findings

LEARNING OBJECTIVES: At the end of the activities, students should be able to:

1.Identify rod made of magnetic materials and rod made of non magnetic materials.

2. Give reasons why the magnetic effect of the current carrying coil increased in some cases and not in all cases.

3. Group the rods made of magnetic materials under magnetically hard and magnetically soft.

4. Explain the concept of ferromagnetism

APPENDIX Vb

TEACHERS' INSTRUCTIONAL GUIDE ON PROBLEM-BASED LEARNING STRATEGY

LESSON TWO

EXERCISES IN PROBLEM BASED LEARNING INSTRUCTION

PROBLEM 2

To construct a circuit breaker as a project topic, a final year physics student was provided with a current carrying coil and a permanent magnet and was asked to choose which one to use. Advice him on which one to use stating why you feel your suggestions should be taken.

INSTRUCTION TO STUDENTS ON EACH QUESTION:

(a) Read the question carefully and think about it for some time

(b) Are there any things about this problem that you have found interesting and will want to discuss?

(c) Discuss in your group what you know about the problem, what you need to know and what you are going to do to solve the problem.

(d) Choose your group leader and share duties to group members.

(e) Go on information search (internet, library, resource person).

(f) Submit your findings to the group.

(g) Collate your group findings and verify experimentally with the materials provided following the worksheet guide.

(h) Present your findings

LEARNING OBJECTIVES: At the end of the activities, students should be able to: (i) explain what is meant by electromagnets

ii. Make an electromagnet

iii. Trace the line of field of the electromagnet

iv. Compare the magnetic field of an electromagnet with that of a bar magnet.

v. State the applications of electromagnet

APPENDIX Vc

TEACHERS' INSTRUCTIONAL GUIDE ON PROBLEM-BASED LEARNING STRATEGY

LESSON THREE

EXERCISES IN PROBLEM BASED LEARNING INSTRUCTION

PROBLEM 3

When a wire carrying an electric current is placed in a permanent magnetic field, the magnetic field formed around the wire interacts with the permanent magnetic field causing the wire to experience a force which causes it to move. A student was given an assignment to find out what could be done to increase the size of this force on the wire, but could not think out what could be done. Act as a resource fellow. Tell him the possible things to be done to increase the force supporting your opinion with proves and give a relationship between the force F and current I and magnetic field strength B.

INSTRUCTION TO STUDENTS ON EACH QUESTION:

(a) Read the question carefully and think about it for some time

(b) Are there any things about this problem that you have found interesting and will want to discuss?

(c) Discuss in your group what you know about the problem, what you need to know and what you are going to do to solve the problem.

(d) Choose your group leader and share duties to group members.

(e) Go on information search (internet, library, resource person).

(f) Submit your findings to the group.

(g) Collate your group findings and verify experimentally with the materials provided following the worksheet guide.

(h) Present your findings

LEARNING OBJECTIVES

At the end of the activities, students should be able to:

(i) Explain how the size of the force on the wire can be increased

(ii) State the effect of increasing the current flowing in the conductor.

(iii) Explain how the strength of the magnetic field could be increased

(iv) Work out the relation between force, magnetic flux, current and length of the current carrying conductor

APPENDIX Vd

TEACHERS' INSTRUCTIONAL GUIDE ON PROBLEM-BASED LEARNING STRATEGY

LESSON FOUR

EXERCISES IN PROBLEM BASED LEARNING INSTRUCTION

PROBLEM 4

The above student got the assignment right but was given another assignment to determine how the direction of the force could be reverse and what the effect of the length of the conductor will be on the force and the student comes back to you. Tell him what should be done.

INSTRUCTION TO STUDENTS ON EACH QUESTION:

(a) Read the question carefully and think about it for some time

(b) Are there any things about this problem that you have found interesting and will want to discuss?

(c) Discuss in your group what you know about the problem, what you need to know and what you are going to do to solve the problem.

(d) Choose your group leader and share duties to group members.

(e) Go on information search (internet, library, resource person).

(f) Submit your findings to the group.

(g) Collate your group findings and verify experimentally with the materials provided following the worksheet guide.

(h) Present your findings

LEARNING OBJECTIVES: At the end of the activities, students should be able to:

(i) Outline what could be done to reverse the direction of the force

(ii) Explain the effect of swapping the magnets around

(iii) To state what happens if the poles of the cell are interchanged.

(iv) Explain the effect of varying the length of the conductor on the force.

APPENDIX Ve

TEACHERS' INSTRUCTIONAL GUIDE ON PROBLEM-BASED LEARNING STRATEGY

LESSON FIVE

EXERCISES IN PROBLEM BASED LEARNING INSTRUCTION

PROBLEM 5

A generator manufacturing company wants to improve on the output voltage of their products and they require researchers to put in their submissions of what to do to get the required output. Workout your submission stating reasons for your conclusions.

INSTRUCTION TO STUDENTS ON EACH QUESTION:

(a) Read the question carefully and think about it for some time

(b) Are there any things about this problem that you have found interesting and will want to discuss?

(c) Discuss in your group what you know about the problem, what you need to know and what you are going to do to solve the problem.

(d) Choose your group leader and share duties to group members.

(e) Go on information search (internet, library, resource person).

(f) Submit your findings to the group.

(g) Collate your group findings and verify experimentally with the materials provided following the worksheet guide.

(h) Present your findings

LEARNING OBJECTIVES: At the end of the activities, students should be able to:

(i) Explain how electricity can be produced by electromagnetic induction

(ii) State that rotating a coil of wire within a magnetic field or moving a magnet inside a coil produces electricity.

(iii) Explain that if there is no movement of magnet or coil there is no induced current.

APPENDIX Vf

TEACHERS' INSTRUCTIONAL GUIDE ON PROBLEM-BASED LEARNING STRATEGY

LESSON SIX

EXERCISES IN PROBLEM BASED LEARNING INSTRUCTION

PROBLEM 6

A boy in the village noticed that his grandfather's bicycle can bring light in the night when the old man is on the bike returning home but that the light goes off as he highlights from the bike. Curious as usual the boy tries to find out how but only discovered that there is a wire connected to a Bottle-like object fixed close to the tyre of the bike. Explain to this boy how the light comes.

INSTRUCTION TO STUDENTS ON EACH QUESTION:

(a) Read the question carefully and think about it for some time

(b) Are there any things about this problem that you have found interesting and will want to discuss?

(c) Discuss in your group what you know about the problem, what you need to know and what you are going to do to solve the problem.

(d) Choose your group leader and share duties to group members.

(e) Go on information search (internet, library, resource person).

(f) Submit your findings to the group.

(g) Collate your group findings and verify experimentally with the materials provided following the worksheet guide.

(h) Present your findings

LEARNING OBJECTIVES

At the end of the activities, students should be able to:

(i) Explain how electricity can be produced by electromagnetic induction

(ii) State that rotating a coil of wire within a magnetic field or rotating a magnet inside a coil produces electricity.

(iii) Explain that if there is no movement of magnet or coil there is no induced current.

APPENDIX VIa

TEACHERS' INSTRUCTIONAL GUIDE ON INTERACTIVE INVENTION STRATEGY

LESSON ONE

TOPIC: FERROMAGNETISM

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Plastic rod, rubber rod, cobalt rod, bar magnet, current carrying coil, compass and stop watch.

Behavioral objectives: At the end of the lesson, students should be able to do the following:

1.Identify rod made of magnetic materials and rod made of non magnetic materials.

2.Give reasons why the magnetic effect of the current carrying coil increased in some cases and not in all cases.

3.Group the rods made of magnetic materials under magnetically hard and magnetically soft.

4.Explain the concept of ferromagnetism

Entry behavior: The students have been taught the following under electromagnetism I and II

1.Introduction to the concept of magnetism

2.how to make magnet

3.how to demagnetize magnet

4.Introduction to magnetic field.

Phase1:Presentation

Step l: Review

Review previously learnt lesson and state objectives of the day's lesson The teacher reviews the concept of magnetism stating the effects caused by magnets and how magnets could be made and destroyed. Then he states the day's lesson objectives and writes them on the board.

Step2. Overview:

The teacher presents the concept of magnetism as being a situation where magnetic material gets strongly magnetized when placed in a current carrying coil called solenoid. The teacher mentions examples of such materials to include iron rod, steel rod, and cobalt rod and nickel rod and notes these on the board for the students.

He goes further to state that out of these examples some can retain the effect for longer time than others and they are said to be magnetically hard while those with low retention are said to be magnetically soft.

The teacher uses the materials provided to demonstrate the topic ferromagnetism. He distinguishes magnetic materials from non magnetic materials by using bar magnet and then puts the magnetic materials into the coil carrying current and letter test their retention abilities with the compass.

Phase 2 Practice

Step 1 Guided practice stage

The teacher shares the students into groups of five (5) students each and presents the materials to each group and ask them to try out the information presented in the lesson while the teacher goes round to see what they are doing and makes corrections where necessary and tells the groups that have done well that they are correct, that is the students connect the coil to electric source and put the different rods inside the coil and after test if they behave as magnetic or not and then differentiate those that are not magnetic and also put the magnetic materials into the coil carrying current and after removing test after every 2 minutes to know their retention abilities.

Step 2 Individual practice

Each student is allowed to practice alone with less teacher's interference. At the end, the student is given feed back if correct and if not the teacher guides the students to do it right.

Phase 3 Monitoring and Assessment The teacher and the students restates the objectives of the lesson to see if the objectives are met if not the teacher goes over the lesson again.

APPENDIX VIb

TEACHERS' INSTRUCTIONAL GUIDE ON INTERACTIVE INVENTION STRATEGY

LESSON TWO

TOPIC: Making an Electromagnet

Time: 2 hours

Instructional materials: Switches, cells, Solenoid, Compass, bar magnets

Behavioral Objective: (i) explain what is meant by electromagnets

ii. Make an electromagnet

iii. Trace the line of field of the electromagnet

v. Compare the magnetic field of an electromagnet with that of a bar magnet.

v. State the applications of electromagnet

Entry Behavior: The student have been taught the

i. Introduction to the concept of magnetism

ii. The making of a magnet

iii. Introduction of magnetic materials.

Phase 1 Presentation

Step l Review

The teacher reviews the previous lesson on ferromagnetism and states the day's lesson objectives writing them also on the board.

Step 2 Overview

The teacher explains to the class that if an electric current flow through a coil of a wire a magnetic field is formed around the coil creating an electromagnet. This is a magnet which can be switched on and off. When the switch is close a current flows and a magnetic field is formed which is very similar to that of a bar magnet. One end becomes a north seeking Pole. When the switch is open a current no longer flows and the magnetic field disappears the electromagnet is switch off. The teacher goes ahead to demonstrate on electromagnet for students to see testing the field and the poles.

Phase 2 Practice

Step I Guided Practice

The students are group into small group and provided with coils and other materials to demonstrate the lesson. They are ,guided to connect the coil to the current and to test what happens to the coil by testing the magnetic field the compass provided and to test the four poles with the bar magnet given.

Step 2 Individual Practice

The teacher asks each student to try out what they did in the group and see if he / she can do it on his / her own detecting the magnetic field and the poles without assistance and the teacher assist the slow learners.

Phase 3 Monitoring and Assessment

The teacher and the students restate the objectives of the lesson and assess if they have been attained. He gives same exercises to the students.

APPENDIX VI c

TEACHERS' INSTRUCTIONAL GUIDE ON INTERACTIVE INVENTION STRATEGY

LESSON THREE

TOPIC: The relationship between the force on current carrying conductor in a permanent magnetic field and the current flowing in the conductor and the magnetic field strength of the magnet.

Time: 2 hours

Instructional Materials: Current carrying conductor, Magnets, cells, Rheostats

LEARNING OBJECTIVES

At the end of the lesson, students should be able to:

(i) Explain how the size of the force on the wire can be increased
(ii) State the effect of increasing the current flowing in the conductor.
(iii) Explain how the strength of the magnetic field could be increased

(iv) Work out the relation between force, magnetic flux, current and length of the current carrying conductor

Phase1Presentation

Step 1: Overview

The lesson on electromagnet is reviewed and the objectives of the day's lesson are stated and written on the board.

Step 2 Direct instruction stage: The teacher explains that when a wire carrying an electric current is placed in a permanent magnetic field formed around the wire interacts with the permanent magnet field causing the wire to experience a force which causes the wire to move. The teacher goes further to point out that the size of the force on the wire can be increased by increasing the amount of the current increasing the strength of the magnetic field. The teacher demonstrates the effects for the students to observe.

Phase II Practice

Step 1 Guided Practice: The students in groups of four (4) are allowed to demonstrate the ideas using the materials provided under the guidance of the teacher demonstrating the force experienced by a current carrying conductor when placed in a magnetic field .

Manipulating the instruments to observe the effect of varying the current flowing in the conductor to see the effect it will have on the force. Replacing the magnet with another magnet that have stronger field strength and observe the effect it will have on the force.

Step 2: Independent practice stage: The students now work on their own to observe all the effect and also to make tentative conclusions (Statement) based on his or her observations. F=Q IB

Phase III Monitoring and Assessment

The teacher goes round to check the students work and give them feedback. And give them some questions to clarify the topic the more and give them home work.

APPENDIX VId

TEACHERS' INSTRUCTIONAL GUIDE ON INTERACTIVE INVENTION STRATEGY

LESSON FOUR

Topic: Variation of force with length of the conductor and variation of the direction of the force.

TIME: 2 Hours

Instructional Materials: Current carrying conductor of various lengths, Magnets, cells,

LEARNING OBJECTIVES:

At the end of the activities, students should be able to:

(i) Outline what could be done to reverse the direction of the force

(ii) Explain the effect of swapping the magnets around

(iii) To state what happens if the poles of the cell are interchanged.

(iv) Explain the effect of varying the length of the conductor on the force.

Phase 1:Presentation

Step 1:Review

Variation of force with varying current and varying magnetic field is reviewed. Objectives of the day's lesson is stated and written on the board.

Step 2: Overview

The teacher explains that the direction of the force on the wire can be changed by changing the direction of flow of the current or by reversing the poles of the magnet. Also that varying the length of the conductor alters the force. He demonstrate (model) these with the materials provided for the students to observe.

Phase 2 Practice

Step 1: guided Practice

The students working in groups of five to try out what the teacher demonstrated and make observations. They ask questions where they need clarification.

Step 2:Iindividual practice .

Students works individually to tryout what was demonstrated and also making observation and filling the worksheet. Asking questions where necessary.

'phase 3: Monitoring and Assessment

Teacher goes round to see what the students are doing and assessing their work. He corrects where necessary and gives feed back to the students.

APPENDIX VIe

TEACHERS' INSTRUCTIONAL GUIDE ON INTERACTIVE INVENTION STRATEGY

LESSON FIVE

TOPIC: Making Electricity by electromagnetic induction

Time: 2 Hours

Instructional Materials: Current carrying coil and bar magnet, Voltmeter

Entry Behavior: Students are familiar with the effect of magnetic field on current carrying conductor'.

LEARNING OBJECTIVES

At the end of the lesson, students should be able to:

(i) Explain how electricity can be produced by electromagnetic induction

(ii) State that rotating a coil of wire within a magnetic field or moving a magnet inside a coil produces electricity.

(iii) Explain that if there is no movement of magnet or coil there is no induced current.

Phase 1: Presentation

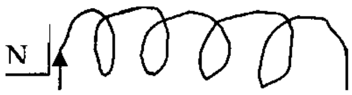
Step 1 Review

The previous lesson on the' relationship between force and current, magnetic field and length of conductor is reviewed and the behavioral objectives for the days lesson is stated and written on the board.

Step 2 Overview

The teacher explains that if a wire or a coil of wire cuts through the lines of force of a magnetic field, or vice-versa, then a 'voltage is induced. (Produced) between the ends of the wire and a current will be induced in the wire if it is part of a complete circuit.

Moving the magnet into a coil induces a current in one direction
Also that current can be induced in the opposite direction by moving the magnet out of the coil



He makes it clear that the generators use this principle for generating electricity by rotating a coil of wire within a magnetic field or rotating a magnet inside a coil of wire, creating an induced voltage. However, if there is no movement of magnet or coil there is no induced current. Stating further that in electromagnetic induction movement produces current. This is really the opposite of what happens in the motor effect where current produces movement.

He demonstrates the effect for the students to see.

Phase 2 Practice

Step I Guided discovery stage:

Students are grouped into groups of four and in try out what the teacher demonstrated asking questions where they have difficulties with the guidance of the teacher; demonstrate that rotating a coil within a magnetic field or rotating a magnet inside a coil produces electricity.

Step 2 Individual practice

At this stage each students works individually verifying the points raised by the teacher and the teacher goes round to see how they are doing it ·with less interference. The students make individual conclusions.

Phase 3 Monitoring and Assessment

The teacher assesses the conclusions of the students and make corrections where necessary. He gives exercises to the class as home work.

APPENDIX VIf
TEACHERS' INSTRUCTIONAL GUIDE ON INTERACTIVE INVENTION STRATEGY

LESSON SIX

TOPIC: Increasing the size of the induced voltage

Time: 2hours

. **Instructional Materials:** bar magnet, current carrying coils and voltmeter **Entry behavior:** The students have been taught about making electricity by electromagnetic induction.

At the end of the lesson, students should be able to:

(i) Explain how electricity can be produced by electromagnetic induction

(ii) State that rotating a coil of wire within a magnetic field or rotating a magnet inside a coil produces electricity.

(iii) Explain that if there is no movement of magnet or coil there is no induced current.

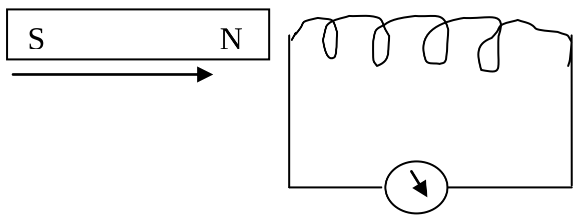
Phase 1 Presentation. **Step l Review**

The teacher reviews the previous lesson on making electricity by electromagnetic induction and states the behavioral objectives of the day's lesson.

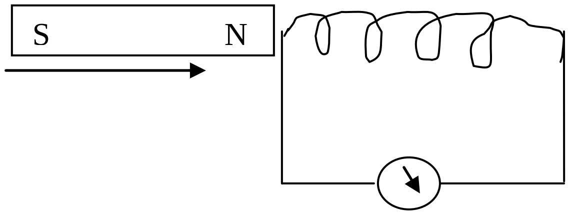
Step 2 Overview

The teacher explains to the students that the size of the induced voltage can be increased if we.

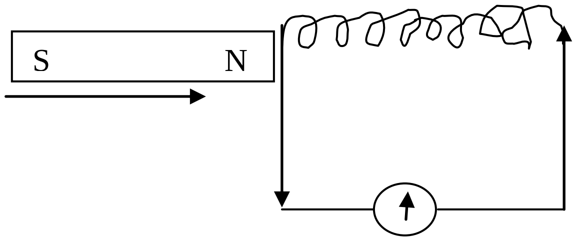
a. increase the speed of movement of the magnet or the coil



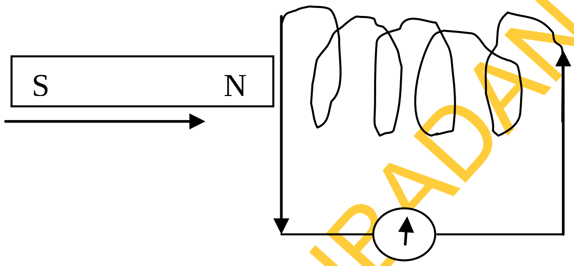
b. Increase the strength of the magnetic field



c. increase the number of the coil



d. increase the area of the coil



Phase 2 Practice

Step I Guided discovery stage:

Students are grouped into groups of four and in try out what the teacher demonstrated asking questions where they have difficulties with the guidance of the teacher; demonstrate that rotating a coil within a magnetic field or rotating a magnet inside a coil produces electricity.

Step 2 Individual practice

At this stage each students works individually verifying the points raised by the teacher and the teacher goes round to see how they are doing it ·with less interference. The students make individual conclusions.

Phase 3 Monitoring and Assessment

The teacher assesses the conclusions of the students and make corrections where necessary. He gives exercises to the class as home work.

APPENDIX VIIa

TEACHERS' INSTRUCTIONAL GUIDE ON CONVENTIONAL LECTURE STRATEGY

LESSON ONE

TOPIC: FERROMAGNETISM

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Chart showing magnets and some magnetic materials

Behavioral objectives: At the end of the lesson, students should be able to do the following:

5.Identify rod made of magnetic materials and rod made of non magnetic materials.

6.Give reasons why the magnetic effect of the current carrying coil increased in some cases and not in all cases.

7.Group the rods made of magnetic materials under magnetically hard and magnetically soft.

8.Explain the concept of ferromagnetism

Entry behavior: The students have been taught the following under electromagnetism I and II

i. Introduction to the concept of magnetism

ii. how to make magnet

iii. how to demagnetize magnet

iv. Introduction to magnetic field.

Step l: Review

Review previously learnt lesson and state objectives of the day's lesson. The teacher reviews the concept of magnetism stating the effects caused by magnets and how magnets could be made and destroyed. Then he states the day's lesson objectives and writes them on the board.

Step2. Overview:

The teacher presents the concept of magnetism as being a situation where magnetic material gets strongly magnetized when placed in a current carrying coil called solenoid. The teacher mentions examples of such materials to include iron rod, steel rod, and cobalt rod and nickel rod and notes these on the board for the students.

He goes further to state that out of these examples some can retain the effect for longer time than others and they are said to be magnetically hard while those with low retention are said to be magnetically soft.

The teacher distinguishes between ferromagnetism, paramagnetism and diamagnetism. He writes some lesson summaries on the chalkboard.

Step 3. Summary

The teacher goes over the lesson asking the students some questions. Students jot down the points made on the board. Teacher gives home work

APPENDIX VII b
TEACHERS' INSTRUCTIONAL GUIDE ON CONVENTIONAL LECTURE STRATEGY

LESSON TWO

TOPIC: Making an Electromagnet

Time: 2 hours

Instructional materials: Switches, cells, Solenoid, Compass, bar magnets

Behavioral Objective: (i) explain what is meant by electromagnets

ii. Make an electromagnet

iii. Trace the line of field of the electromagnet

iv. Compare the magnetic field of an electromagnet with that of a bar magnet.

v. State the applications of electromagnet

Entry Behavior: The student have been taught the

i. Introduction to the concept of magnetism

ii. The making of a magnet

iii. Introduction of magnetic materials.

Step l Review

The teacher reviews the previous lesson on ferromagnetism and states the day's lesson objectives writing them also on the board.

Step 2 Overview

The teacher explains to the class that if an electric current flow through a coil of a wire a magnetic field is formed around the coil creating an electromagnet. This is a magnet which can be switched on and off. When the switch is close a current flows and a magnetic field is formed which is very similar to that of a bar magnet. One end becomes a north seeking Pole. When the switch is open a current no longer flows and the magnetic field disappears the electromagnet is switch off.

Step 3. Summary

The teacher goes over the lesson asking the students some questions. Students jot down the points made on the board. Teacher gives home work

APPENDIX VIIc

TEACHERS' INSTRUCTIONAL GUIDE ON CONVENTIONAL LECTURE STRATEGY

LESSON THREE

TOPIC: The relationship between the force on current carrying conductor in a permanent magnetic field and the current flowing in the conductor and the magnetic field strength of the magnet.

Time: 2 hours

Instructional Materials: Current carrying conductor, Magnets, cells, Rheostats

LEARNING OBJECTIVES

At the end of the lesson, students should be able to:

(i) Explain how the size of the force on the wire can be increased
(ii) State the effect of increasing the current flowing in the conductor.
(iii) Explain how the strength of the magnetic field could be increased

(iv) Work out the relation between force, magnetic flux, current and length of the current carrying conductor

Step 1: Review

The lesson on electromagnet is reviewed and the objectives of the day's lesson are stated and written on the board.

Step 2 Overview: The teacher explains that when a wire carrying an electric current is placed in a permanent magnetic field formed around the wire interacts with the permanent magnet field causing the wire to experience a force which causes the wire to move. The teacher goes further to point out that the size of the force on the wire can be increased by increasing the amount of the current increasing the strength of the magnetic field.

Step 3. Summary

The teacher goes over the lesson asking the students some questions. Students jot down the points made on the board. Teacher gives home work

APPENDIX VIId

TEACHERS' INSTRUCTIONAL GUIDE ON STRATEGY CONVENTIONAL LECTURE

LESSON FOUR

Topic: Variation of force with length of the conductor and variation of the direction of the force.

TIME: 2 Hours

Instructional Materials: Current carrying conductor of various lengths, Magnets, cells,

LEARNING OBJECTIVES:

At the end of the activities, students should be able to:

(i) Outline what could be done to reverse the direction of the force

(ii) Explain the effect of swapping the magnets around

(iii) To state what happens if the poles of the cell are interchanged.

(iv) Explain the effect of varying the length of the conductor on the force.

Step 1:Review

Variation of force with varying current and varying magnetic field is reviewed. Objectives of the day's lesson is stated and written on the board.

Step 2: Overview

The teacher explains that the direction of the force on the wire can be changed by changing the direction of flow of the current or by reversing the poles of the magnet. Also that varying the length of the conductor alters the force.

Step 3. Summary

The teacher goes over the lesson asking the students some questions. Students jot down the points made on the board. Teacher gives home work

APPENDIX VIIe

TEACHERS' INSTRUCTIONAL GUIDE ON CONVENTIONAL LECTURE STRATEGY

LESSON FIVE

TOPIC: Making Electricity by electromagnetic induction

Time: 2 Hours

Instructional Materials: Current carrying coil and bar magnet, Voltmeter

Entry Behavior: Students are familiar with the effect of magnetic field on current carrying conductor'.

LEARNING OBJECTIVES

At the end of the lesson, students should be able to:

(i) Explain how electricity can be produced by electromagnetic induction

(ii) State that rotating a coil of wire within a magnetic field or moving a magnet inside a coil produces electricity.

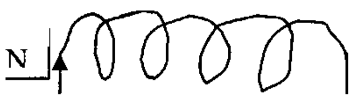
(iii) Explain that if there is no movement of magnet or coil there is no induced current.

Step 1 Review

The previous lesson on the' relationship between force and current, magnetic field and length of conductor is reviewed and the behavioral objectives for the days lesson is stated and written on the board.

Step 2 Overview

The teacher explains that if a wire or a coil of wire cuts through the lines of force of a magnetic field, or vice-versa, then a 'voltage is induced. (Produced) between the ends of the wire and a current will be induced in the wire if it is part of a complete circuit. Moving the magnet into a coil induces a current in one direction. Also that current can be induced in the opposite direction by moving the magnet out of the coil



He makes it clear that the generators use this principle for generating electricity by rotating a coil of wire within a magnetic field or rotating a magnet inside a coil of wire, creating an induced voltage. However, if there is no movement of magnet or coil there is no induced current. Stating further that in electromagnetic induction movement produces current. This is really the opposite of what happens in the motor effect where current produces movement.

Step 3. Summary

The teacher goes over the lesson asking the students some questions. Students jot down the points made on the board. Teacher gives home work

APPENDIX VII f
TEACHERS' INSTRUCTIONAL GUIDE ON CONVENTIONAL LECTURE STRATEGY

LESSON SIX

TOPIC: Increasing the size of the induced voltage

Time: 2hours

. **Instructional Materials:** bar magnet, current carrying coils and voltmeter **Entry behavior:** The students have been taught about making electricity by electromagnetic induction.

At the end of the lesson, students should be able to:

(i) Explain how electricity can be produced by electromagnetic induction

(ii) State that rotating a coil of wire within a magnetic field or rotating a magnet inside a coil produces electricity.

(iii) Explain that if there is no movement of magnet or coil there is no induced current.

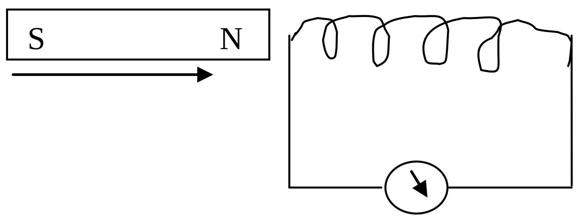
. **Step l Review**

The teacher reviews the previous lesson on making electricity by electromagnetic induction and states the behavioral objectives of the day's lesson.

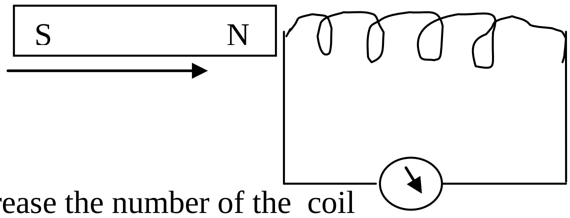
Step 2 Overview

The teacher explains to the students that the size of the induced voltage can be increased if:

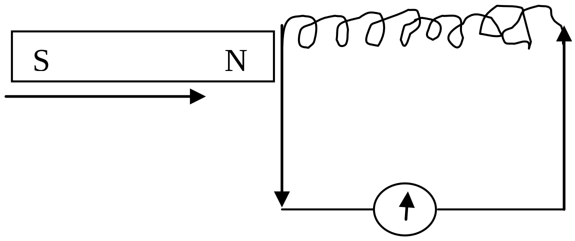
d. increase the speed of movement of the magnet or the coil



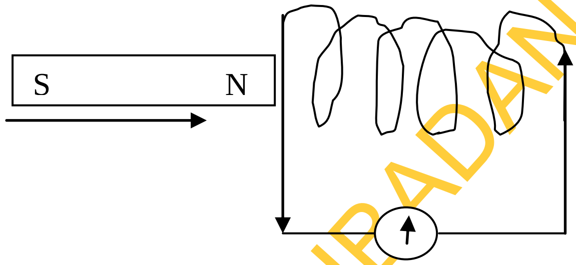
e. Increase the strength of the magnetic field



f. increase the number of the coil



d. increase the area of the coil



Step 3. Summary

The teacher goes over the lesson asking the students some questions. Students jot down the points made on the board. Teacher gives home work

Week 1&2	At the end of the lesson Pre-service teachers should be able to 1) Identify rods made of magnetic materials and rods made of non-magnetic materials . 2) Give reasons why the magnetic effect of the current carrying coil increased in some cases and not in all 3) Group the rods made of magnetic materials under magnetically hard and magnetically soft. 4) Explain the concept of ferro-magnetism	Ferromagnetism		Instructor asks related questions on magnetism and summarizes previous lesson.	Students listen and take some reviews where necessary.	Oral question
				The instructor presents the concept of ferromagnetism as being a situation where magnetic materials gets magnetism when placed in a current carrying coil called Solenoid. The teacher mentions examples of such materials to include iron rod, steel rod and cobalt and nickel rods and note these on the board for the students. He goes further to state that out of these examples some can retain the effect for longer time than others and is said to be magnetically hard while those with low retention are said to be magnetically soft. The instructor uses the materials provided to demonstrate the topic. He distinguishes magnetic materials from non magnetic materials by using the magnet.	Students pay attention and write down notes as the instructor is teaching asking questions where necessary.	Plastic rods , Rubber rod, Cobalt rod, Iron rod, Steel rod, nickel rod, bar magnet, Current carrying coil, compass, Stop watch.

	Lecture Content	Stages	Instructor's /Research Assistance Activities	Pre-service teachers activities	Instructional Materials	Assessment
the pre- able to : gnet. e of elec- [illegible]	Electromagnet	Phase I step I	The instructor asks individual students questions based on the previous lesson e.g 1) What is electromagnetism? 2) Distinguish between magnetically hard and soft magnetic materials? 3) State the application(s) of ferromagnetic materials	Students answer the questions as asked.	Previous note and reading materials	Oral assessment
		Step II	The instructor explains to the class that if a electric current flow throws a coil of a wire a magnetic field is formed around the coil creating an electromagnet whose strength could be increased by placing a soft iron rod into the coil. He went further to explain that this electromagnet could be switch on or off. That when the switch is closed a current flows and a magnetic field is formed which is very similar to that of a bar magnet. Also, that one end becomes a north seeking pole while the other is south seeking when the switch is open and current no longer flows and the magnetic field disappears then the electromagnet is switch off.	Students listen and take note. Students ask questions Where they do not understand.	Chalkboard summary and teaching materials	Oral question

Learning programme for Interactive Invention Strategy Group

Week 4	At the end of the lesson the pre-service teachers will be able to	Force on current carrying by	Phase 1 step 1	The instructor reviews the lesson on making of electromagnet and asks the students questions to remind them of what they had learnt e.g In making electromagnet what type of magnet is required. 2) What are the industrial applications of electromagnet. He goes further to write the topic for			
	Explain how the size of the force on the wire can be increased.	conductor in a magnetic field.	Step III	Teacher demonstrates the concepts with the materials provided.	Students observe and ask questions		
	2) Explain that a current carrying conductor when placed in a permanent magnetic field experienc-		Phase II Step I	The instructor groups the students into groups of five (5) students mixed gender and self efficacy. The research assistants distribute the learning material to the groups. The instructor guides the group members to make the connections. And the observation they are also guided to test the fields using the compass and to also test for the poles.	Students work in their groups carrying out what they saw their teacher did they connect the solenoid and put soft iron in the coil and put on the switch. They use the compass to indicate the pressure of magnetic field and the use the compass too to trace the field pattern and also to indicate the poles of the field. They also complete their worksheet along side.	Flexible wire, dry cells, soft iron, compass, bar magnet, plane sheet work sheets.	Direct observation
				Instructor instructs individual group members to handle the materials individually to make the connections and observations.	Individual students work using the materials and making observation and indicating the poles of the field. Also, completing the worksheets as work progresses.	Same	Direct assessment
			Phase III	The instructor goes round to see how the students are working giving assistance where necessary, instructor assesses if the objectives have been attained.	Individual students complete the work asking questions where they need some explanation and round-off work on the work sheet.	Same	Evaluation and corrective feed back.

	es a force. 3) State the effect of increasing the current flowing in the conductor . 4) Explain how the strength of the magnetic field could be increased 5) work out the relation F=QBISINΘ			the day on the board and to state the objectives for the day.			
			Step II	Instructor explains that a current carrying conductor placed in a permanent magnetic field experiences a force which causes it to move. The instructor goes on to explain other ways that the force experienced by the current carrying conductor could be increased: 1) Increasing the current flowing in the conductor. (2) Increasing the field strength of the magnet (3) the angle between the conductor and magnetic field. The instructor writes the relation F = QBI SinΘ and explains the relation, He further demonstrates these with the materials to the class.	Students listen and take note asking questions where need arises. They observe the effects of increasing the currents, field, strength and varying the angles between the field and the current.	Reading materials summaries on the board. Current carrying conductor , horse shoe magnets cells, Rheostat	Oral
			Phase 2 Step1	The instructor /research assistants guide the students in their groups to set up the apparatus and to make their observations .Instructor goes round to see what the groups are doing.	The students in their groups set up the apparatus and observe the force on the conductor. They increase the current flowing in the conductor and observe the effect it will have on the force experienced. They change the magnet with a stronger one and observe the effect it has on the force. Also varying the angle between current and magnetic field and noting their observation.	same	Direc tion
			Step2	Instructor /research assistant guide individual students to set up the apparatus and to make their observations. Instructor goes round to see what the groups are doing.	Individual students sets up the apparatus and observe the force on the conductor They vary the current , magnetic strength and angles between current and magnetic field and makes individual observation and also work to complete the work sheets asking questions where necessary.		
Phase III				Instructor goes round to see what the students are doing to assess if they are doing it well where other wise to correct them and put them through.	Students assess themselves to see if they are able to get what their teacher got and to see the relationships that exist with them.	same	Corr feedb

Week 5	At the end of the lesson the pre-service teachers will be able to (1) Explain the effect of varying the length of the conductor on the force . 2)outline what could be done to reverse the direction of the force. (3) Explain the effect of the magnet around. (4) To state what happens if the poles of the cell are inter-changed.	To determine the effect of varying the length of the conductor of the force and how the direction of the force could be reversed.	Step1 phase I	Review of previous lesson. The Instructor explains that varying the length of the conductor affect the force. That if the length of the conductor is increased that the force will also increase and if it is reduced the force will also reduce. The instructor demonstrates this to the students. T he instructor explains that the direction of the force on the wire can be changed by changing the direction of flow of the current and by reversing the poles of the magnet. He also demonstrates this to the class.	Students listen and take down note and also observe what the instructor demonstrates asking questions where necessary.	Horse shoe magnet, current carrying conductor	Oral questions
			Instructor put the students in groups of five and guides them to put the apparatus together and to vary the length of the conductor and observe what happens. They also are guided to exchange the poles of the cell to observe the change. In the direction of the force. The instructor guides the students to swap the poles of the magnet	Groups set up the apparatus and vary the length of the conductor and they take note of the effect observed. They exchange the poles of the cells and observe the direction of the force. also swap the magnetic poles. Make their observations noting all the observa-	Same	Direct observation.	

			to observe its effect on the direction.	tions.			
		Step 2	The Instructor / research assistance guides individual students to set up the apparatus and to vary the length of the conductor to observe the effect on guided to change the poles of both the cells and the magnet to observe change in direction of the force.	Individual students make their corrections and their observations as did the teacher and the groups. They also complete their work sheets.	Same	Direct observations.	
			The instructor goes round to monitor and assess the students' individual progress.	Students checks if they are able to achieve the set objectives.			
At the end of the lesson the pre-service teachers will be able to : 1) Explain how electricity can be produced by electromagnetic induction. 2) State that moving a coil of wire within a magnetic field or moving a magnet inside a coil produces electricity. 3) Explain that if there is no movement of magnet or coil there is no induced current.							
		Step2	The teacher explains that if a coil of wire cuts through the lines of force of a magnetic field or vice-versa, then voltage is induced between the ends of the wire and current will be induced in the wire if it is part of a complete circuit. He goes further to say moving the magnet into a				

			coil induces current in one direction. Also, that current can be induced in the opposite direction by moving the magnet put of the coil. He makes it clear that the generator use this principle for generating electricity by rotating a coil of wire within a magnetic field or rotating a magnet inside a coil of wire. This creates induced voltage. However, if there is no movement of magnet or coil as the case may be, there is no induced current. Stating further that in electromagnetic induction, movement produces current. This is really the opposite of what happens in the motor effect where current produces movement. The instructor demonstrates the effect for the students to see.				
		Phase 2 step 1	The instructor guides the students in their groups to make the connections and to move magnet into the coil to observe what happens by observing the voltmeter.	Students in groups make their connection and insert the magnet into the coil taking note of the reading of the voltmeter. They also observe what happens if the magnet is stationary.	Same	Direct observations	
		Step1	Instructor guide individual students to put the apparatus together to do the connections and to make the ob-	Individual students do as above and make their observations and also filling the work sheets.	Same		

			servations.				
		Phase 3	The instructor goes round to check how students are working with the materials and how they are filling their worksheet. He commends those that are doing well while he corrects those that need.	Student round up their work and complete their worksheets.	Same with worksheet	Observation and oral questions.	
At the end of the lesson the pre-service teachers should be able to- 1) Explain that the induced voltage could be increased by increasing the speed of movement of the magnet. 2) State the effect of increasing the strength of the magnetic field. 3) Mention other ways of increasing the induced voltage.							
		STEP 2		Instructor put the students in groups of five and guides them to put the apparatus together and to vary the length of the conductor and observe what happens. They also are guided to exchange the poles of the cell to observe the change. In the direction of the force. The instructor guides the students to swap the poles of the magnet to observe its effect on the direction.	Groups set up the apparatus and vary the length of the conductor and they take note of the effect observed . They exchange the poles of the cells and observe the direction of the force. also swap the magnetic poles. Make their observations noting all the observations.	Same	Direct observation.
			Step 2	The Instructor / research assis-	Individual students make their	Same	Direct observations.

				tance guides individual students to set up the apparatus and to vary the length of the conductor to observe the effect on guided to change the poles of both the cells and the magnet to observe change in direction of the force.	corrections and their observations as did the teacher and the groups. They also complete their work sheets.		

Week 7	At the end of the lesson the pre-service teachers will be able to : 1) Explain how electricity can be produced by electromagnetic induction. 2) State that moving a coil of wire within a magnetic field or moving a magnet inside a coil produces electricity. 3) Explain that if there is no movement of magnet or coil there is no induced current. electricity. 3) Explain that if there is no movement of magnet or coil there is no induced current.	Magnetic induction	Phase 1 Step1	The instructor reviews the previous lesson	Student listens and takes down note asking questions where necessary. The watch the instructor as he makes the demonstration.	Magnet, coil, Voltmeter	Oral questions.
			Step2	The teacher explains that if a coil of wire cuts through the lines of force of a magnetic field or vice-versa, then voltage is induced between the ends of the wire and current will be induced in the wire if it is part of a complete circuit. He goes further to say moving the magnet into a coil induces current in one direction. Also, that current can be induced in the opposite direction by moving			

				the magnet put of the coil . He makes it clear that the generator use this principle for generating electricity by rotating a coil of wire within a magnetic field or rotating a magnet inside a coil of wire. This creates induced voltage. However, if there is no movement of magnet or coil as the case may be, there is no induced current. Stating further that in electromagnetic induction, movement produces current. This is really the opposite of what happens in the motor effect where current produces movement. The instructor demonstrates the effect for the students to see.			
			Phase 2 step 1	The instructor guides the students in their groups to make the connections and to move magnet into the coil to observe what happens by observing the voltmeter.	Students in groups make their connection and insert the magnet into the coil taking note of the reading of the voltmeter. They also observe what happens if the magnet is stationary.	Same	Direct observations
			Step1	Instructor guide individual students to put the apparatus together to do the connections and to make the observations.	Individual students do as above and make their observations and also filling the work sheets.		
			Phase 3	The instructor goes round to check how students are working with the materials and how they are filling their worksheet. He commends those that are doing well while he corrects those that need.	Student round up their work and complete their worksheets.	Same with worksheet	Observation and oral questions.

Week 8	At the end of the lesson the pre-service teachers should be able to- 1) Explain that the induced voltage could be increased by increasing the speed of movement of the magnet. 2) State the effect of increasing the strength of the magnetic field. 3) Mention other ways of increasing the induced voltage.	Increas creasing the size of the induced voltage.	Phase 1 Step1	Reviews of previous lesson with related oral questions.	Students contribute as they are answering questions.	Notebooks	Oral questions.

			step 2	Instructor explains to the students that the size of the induced voltage could be increase through the following ways i) increasi creasing the speed of movement of the magnet or the coil. ii) Increase the strength of the magnetic field. iii) Increase the number of turns in the coil iv) Increase the area of the coil. The instructor goes on to demonstrate these one after the other asking the students to pay close attention.	Students watch and take down note asking questions where necessary	Reading materials, summary on the board, magnet, coil and voltmeter	Oral questions
			Step 2	Instructor guides the students individually to make their connections	Individual students do as above	Same as above and	Direct observation

				and observations.	and make personal observations. Asking questions where necessary. Also completing their worksheets.	worksheet	
			Phase iii	Instructor goes round to assess the work for the day commending and correcting where necessary.	Student take corrections complete the worksheet and self assessment is also done.	Same as above	Assessment of the worksheet