EFFECT OF REFLECTIVE-RECIPROCAL TEACHING STRATEGIES ON PRE-SERVICE TEACHERS' ACHIEVEMENT IN INTEGRATED SCIENCE AND SCIENCE PROCESS SKILLS IN NIGERIAN COLLEGES OF EDUCATION

BY

Aminat Aderonke AGORO

(84912)

B. Ed. MATHEMATICS/INTEGRATED SCIENCE (OAU),
M.Inf Sc. (IBADAN), M.Ed (Sci. Ed). (IBADAN)

UNIVERSITY OF IBADAN LIBRARY

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 (Ph.D.) Science Education
of the
UNIVERSITY OF IBADAN

APRIL, 2013

ABSTRACT

The low level of performance of pre-service teachers in Integrated Science has been a recurrent problem in science education. Poor instructional strategies employed by lecturers in colleges of education have been adduced as one of the reasons for this low level of performance in Integrated Science. Previous researches have focused on collaborative teaching and self-regulation strategy without considering opportunity for reflection before, during and after lessons which the Reflective-Reciprocal Peer Tutoring (RRPT) addresses. This study, therefore, determined the effect of Reflective-Reciprocal Teaching (RRT) and Reflective-Reciprocal Peer Tutoring strategies on pre-service science teachers' achievement in Integrated Science and Science Process Skills. It also determined the moderating effect of mode of entry and numerical ability on the dependent variables.

The pretest-posttest, control group, quasi experimental design with a 3x3x2 factorial matrix was used. Three colleges of education were purposively selected from each of the state and federal colleges in Southwestern Nigeria. One intact class of Nigeria Certificate in Education year two was selected from each of the six colleges making a total of 295 pre-service teachers. Six instruments were developed, namely: Pre-service Teachers' Achievement Test ($r_=$ 0.85); Pre-Service Teachers' Science Process Skills Rating Scale ($r_=$0.82), Pre-Service Teachers' Numerical Ability Test ($r_=$0.79); Operational Guides for RRT, RRPT and Modified Conventional Teaching Strategy ($r_=$0.75, 0.72 and 0.77 respectively). Seven hypotheses were tested at 0.05 level of significance. Data were subjected to Analysis of Covariance and Scheffé Post-hoc test.

Treatment had a significant effect on pre-service teachers' achievement in Integrated Science ($F_{(2,276)}$ = 56.15; p<.05) and science process skills ($F_{(2,276)}$ = 33.53; p< 0.05), Pre-service teachers exposed to RRPT obtained a higher achievement score ($\bar{x}$ =24.8) than those in the RRT ($\bar{x}$ = 21.02) and control group ($\bar{x}$ = 18.89). For Science Process skills, the RRT group had a higher achievement score ($\bar{x}$ = 57.50) than those in the RRPT ($\bar{x}$ = 49.28) and control ($\bar{x}$ = 47.04) groups. Mode of entry and numerical ability had no significant effect on pre-service teachers' achievement in Integrated Science and science process skills. The interaction effects of treatment and mode of entry, treatment and numerical ability, as well as the interaction effect of treatment, mode of entry and numerical ability on pre-service teachers' achievement in Integrated Science and science process skills were not significant.

The Reflective-Reciprocal Teaching and Reflective-Reciprocal Peer Tutoring strategies enhanced pre-service science teachers' achievement in Integrated Science and science process skills. When employed by the teachers of the subject, the two strategies could help pre-service Integrated Science teachers to gain more in achievement and science process skills, enhance their professional development and encourage social interaction in the learning environment. These strategies are therefore, recommended for teaching Integrated Science at the college of education level.

Key words: Reflective-reciprocal teaching, Reflective-reciprocal peer tutoring, Colleges of education, Achievement in integrated science, Science process skills

Word count: 449

UNIVERSITY OF IBADAN LIBRARY

CERTIFICATION

I certify that this research work was carried out by Aminat Aderonke AGORO of Science Education Unit in the Department of Teacher Education, Faculty of Education, University of Ibadan.

……………………………………….

(SUPERVISOR)

DR M. K. Akinsola

B.Sc (Ed.) (Hons) Lagos, M Ed., Ph.D. (Ibadan)
Reader in Mathematics Education,
Department of Teacher Education,
Faculty of Education,
University of Ibadan, Ibadan.

Date: ………………………..

UNIVERSITY OF IBADAN LIBRARY

DEDICATION

This study is dedicated to my husband Hon. Lanre Adeniran AGORO and my children AbdulBasit, Ameerah, Moh'd Jameel and Moh'd Kamil AGORO.

UNIVERSITY OF IBADAN LIBRARY

ACKNOWLEDGEMENTS

Praise and adoration to Almighty ALLAH, the creator of heaven and earth, who granted me the opportunity to commence this programme and saw me through to the end. But for His grace, insight and empowerment, I would not have finished. Alhamdul-lil-lahi Robil Alamin..

My heartfelt gratitude and sincere appreciation goes to Dr M. K. Akinsola my supervisor who provides ray of light when all hope seems to have been lost on the programme. Also, to Dr Bamikole Oludare Ogunleye, a mentor, an erudite scholar. Both of them carefully and painstakingly read every line of this thesis offering constructive criticisms as well as providing advice and suggestions on the improvement of the work. May you continue to wax stronger, may God bless the work of your hands and make you eat the fruit of your labour. Helper will always be at the doorstep of your family (Amen). I am equally grateful to Dr T. O. Iroegbu who started this work. His valuable contribution towards the success of this programme is appreciated. God bless you sir. My profound gratitude goes to the Head of Teacher Education Department, Prof. Francis A. Adesoji for ensuring the successful completion of this work. He painstakingly finds time out of his tight schedule to offer advice and constructive criticism. Almighty God will always be with you and your family. He will shower you with good health to enjoy the fruit of your hard work. My gratitude also goes to Dr Alice M. Olagunju for her efforts at ensuring the success of all students. Specifically, for her motherly role, words of encouragement and inspiration to the success of this research work. You are a “mother” indeed; you shall continue to be remembered for your good works (Amen). I also appreciate the effort and prayer of Dr B. O. Lawal that seems to give breakthrough to this work. My profound

UNIVERSITY OF IBADAN LIBRARY

gratitude also goes to Sub dean in person of Dr A. O. Adegbesan for his effort in painstakingly going through the abstract and make valuable corrections even during public holiday. May you continue to grow stronger in knowledge. I equally appreciate the efforts of the Dean, Prof. C. O. O. Kolawole, and my lecturers in the Department of Teacher Education, Faculty of Education for their contributions to the success of this research work: Prof. Oluremi Bamisaiye, Dr S. A. Babarinde, Dr Segun Ajiboye, Dr R. A. Akinbote, Dr Esther. A. Oduolowu, , Dr Temisan Ige, Dr S. O. Ajitoni, Dr D. O. Fakeye, and Dr A. A. Adeyinka. I acknowledge Dr M. Modupe Osokoya of the Institute of Education for being a mentor and the motherly role that she played towards the success of this programme. May you continue to grow stronger in knowledge.

The assistance of my colleague at the Integrated Science Department of Emmanuel Alayande College of Education, Oyo, Adeyemi College of Education ,Ondo, Adeniran Ogunsanya College of Education,Oto Ijanikin, Federal College of Education, Osiele Abeokuta, Osun State College 0f education, Ila-Orangun, Federal College of Education (Special) Oyo who served as research assistants as well as their Integrated Science students who constituted the sample of the study, and their respective Head of Department who granted the permission for the study in their respective department, I say thank you all. I appreciate the support of my colleagues and senior colleagues at Emmanuel Alayande College of Education, Oyo; Mrs I. F. Adeoye, Mrs A. A. Ahmed, Mr Oyediran, Mrs. M. E. Adebiyi, Dr (Mrs) G. A. Akanbi, Mrs O. O. Adeboye ,Mr. Ibikunle and others who have contributed in one way or the other to the success of this programme. I also acknowledge the support of Dr V. F. T. Babajide. I say thank you all

UNIVERSITY OF IBADAN LIBRARY

I also acknowledge the efforts and support of my dear supportive and caring husband, Hon Lanre Adeniran Agoro and my children; Abdulbasit, Ameerah, Moh'd Jameel and Moh'd Kamil Agoro as well as that of my sister, Mrs Haulat Mustapha and her family for their prayers and support. May you all live to witness the dividend of the programme (Amen). I cannot but remember the words of encouragements of my compassionate mother, Alhaja Sabitiyu Aduke Oke. You are all darlings; I thank you all. To my in-laws, Mrs Wasilat Iya Ibeji, Mr. I.A. Adenle and his family, Barr. Bolaji Agoro and his family, my brothers Sarafa Lasisi, Jacob Kutu, I thank you all for your prayers and support towards the success of this work. May God bless all your undertakings (Amen).

Finally, I recognize the untiring effort of my brother Mr Tajudeen Wahab (T. J) who assisted in the typing of the manuscript. I say thank you and I appreciate your endurance and patience.

UNIVERSITY OF IBADAN LIBRARY

TABLE OF CONTENTS

PAGE

UNIVERSITY OF IBADAN LIBRARY

UNIVERSITY OF IBADAN LIBRARY

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

UNIVERSITY OF IBADAN LIBRARY

APPENDICES

UNIVERSITY OF IBADAN LIBRARY

LIST OF TABLES

UNIVERSITY OF IBADAN LIBRARY

LIST OF FIGURES

UNIVERSITY OF IBADAN LIBRARY

UNIVERSITY OF IBADAN LIBRARY

LIST OF ABBREVIATIONS

FGN	Federal Government of Nigeria
ANCOVA	Analysis of Covariance
OGRRTS	Operational Guide on Reflective-Reciprocal Teaching Strategy
OGRRPTS	Operational Guide on Reflective-Reciprocal Peer Tutoring Strategy
OGMCTS	Operational Guide on Modified Conventional Teaching Strategegys
PSTATIIS	Pre-service Teachers' achievement Test in Integrated Science
PTSPSRS	Pre-service Teachers' Science Process Skills Rating Scale
PTNAT	Pre-service Teachers' Numerical Ability Test
MCA	Multiple Classification Analysis
RRT	Reflective-Reciprocal Teaching
RRPT	Reflective-Reciprocal Peer Tutoring
N.C.E.	Nigeria Colleges of Education
FME	Federal Ministry of Education
U.M.E	University Matriculation Examination
J.A.M.B	Joint Admission and Matriculation Board
P.E.	Potential Energy
K.E.	Kinetic Energy

UNIVERSITY OF IBADAN LIBRARY

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Science as a discipline stands out as a major factor in developmental effort of a nation. Its knowledge is used in the production of materials that reduce people's stress, suffering and hunger, protects as well as make life more enjoyable and secured. It iss also a necessary factor for the economic development of a nation (Adepitan,2003; Olagunju, Adesoji, Iroegbu, & Ige 2003). It therefore, implies that for any meaningful national growth and development to be achieved, Science and Technology must be an essential part of the nation's culture (Nwagbo, 2003; Olagunju et al, 2003; Adeniyi, 2005). Science is also one of the ways through which human beings search for the truth and achieves understanding of the environment and the universe.

The Nigerian government realized the importance of science education as the basic requirement for economic and social development, hence, science education forms the major part of the country's education at all levels (FRN, 2004). Indeed, science is one of the core subjects offered at all levels of the Nigerian education system.

National standard and goals for reforming science education have placed a demand for more academic rigor in the teaching and learning of complex subject- matter (National Research Council, 2000; American Association for the Advancement of Science, 1989). Embedded in the science education community's reform effort is a belief that rigorous standards backed by quality curricula and effective teaching, often identified as a form of inquiry, will translate into a robust learning and high levels of achievement for all students. Modern science was established in the Nigerian school curriculum in the

UNIVERSITY OF IBADAN LIBRARY

late 1940s. Long before this period, traditional objects and processes were based on scientific knowledge and principles. Indigenous education was in place and Awokoya (1976 in Akinyemi 1987), identified seven areas of knowledge existing in traditional education. These are:

- Traditional technology and production
- Traditional science and speculation
- Traditional language and communication
- Traditional social studies and assessment
- Traditional aesthetics studies
- Traditional arithmetic and calculation
- Traditional physical education and prowess.

In 1843, Nature Study took the place of science in primary schools in the country where each class had a nature corner. In 1920, science teaching was given a boost through a prospect of Phelp-Stoke commission tour of the British West African Colonies such that by1926, Nature Study has become a popular subject in primary schools (Abdullahi.1982). Around late 1950s, when Nigeria was preparing for her independence, the place and importance of science education becomes glaring as Nigerians were about to be called upon to man their affairs towards becoming independent in her quest for technological development. By the 1960s, there was a world-wide review of the philosophy of science teaching in schools. Primary science was identified as the foundation of Science and Technology (Bajah, 1978). In later years, what looked like science was taught in the form of general science or elementary science in primary and secondary school. After independence, African Primary Science Programme (APSP) was

UNIVERSITY OF IBADAN LIBRARY

launched in Kano and this spurred the state governments and interest groups into developing primary curriculum. By 1978, the primary science curriculum programmes were developed for both primary and secondary school. Also, the Primary Reference Committee of the Joint Consultative Committee (JCC) by NERC set up a panel to produce a “core-curriculum” for science education. The panel with the Science Teacher Association of Nigeria (STAN) came up with the Nigerian Integrated Science Project which was published around 1982. In recent years, due to educational reform efforts, Nigeria had a metamorphosis of the science curriculum as the Universal Basic Education Commission (UBEC) changed Integrated Science to Basic Science (NERDC, 2007). This implies that the Integrated Science offered at the primary and Post-primary levels metamorphosed into Basic Science and Technology and Basic Science respectively.

Integrated Science is offered at the various levels of education i.e. primary, secondary and tertiary level including colleges of education. Integrated Science has been defined variously by different authorities. The Federal Ministry of Education (FRN, 2004) operationally defined Integrated Science as that science course which is presented in a way that pupils gain the concepts of the fundamental unit of science as well as the commonality of approach to problems of scientific nature and the understanding of the roles and functions of science in everyday life and the whole world. The subject integrates perspectives from various disciplines including biology, chemistry, physics, earth science and others together.

There are three categories of NCE science teachers at the Nigerian junior secondary school level. They are those who major in Integrated Science (not all colleges of education offer Integrated Science Major). The second categories of teachers are those

UNIVERSITY OF IBADAN LIBRARY

who study integrated science as minor teaching subject. Most colleges of education offer courses in this area. The third are those who study other sciences but were asked to teach basic science in junior secondary schools due to shortage of Basic Science teachers.

Integrated Science study started in Nigerian Colleges of Education in 1990/1991 session as Integrated Science. The curriculum provides for single and double major courses for the pre-service teachers. The single major programme enables the pre-service teacher to offer Integrated Science courses in addition to other single subjects. It is a 34 credit course load in Integrated Science with the remaining load for any other subject whereas the double major programme requires 72-credit course load for the pre-service teachers which is spread over duration of three years. But with effect from 2009/2010 session the double major programme has been scraped, leaving only the single major programme.

Today, Integrated Science is offered in all colleges of education in Nigeria. The programme has helped in producing manpower for the teaching of basic science at the primary and junior secondary school levels of education. However, research reports show that the programme has not been quite successful (Olarewaju, 1996). Some reasons were adduced for this, such as absence of science laboratories in preparing pre –service science teachers in Nigeria Colleges of Education, fear and dislike of the physics aspect of Integrated science as highly mathematical and abstract in nature (Owolabi, Ogunleye & Adeyemo, 2008), lack of adequate supply of expert teachers of Integrated Science at college level, lack of adequate facilities for teaching Integrated Science using activities oriented method and ineffective methods used by the teacher of Integrated Science.

The Federal Government of Nigeria in its quest for scientific inquiry formulated goals in the national policy on education (FRN, 2004) which reflect, amongst others, the

UNIVERSITY OF IBADAN LIBRARY

acquisition of appropriate skills and the development of mental, physical and social abilities and competencies as requirement for the individual to live in and contribute to the development of the society. Educational activities, therefore, are expected to be centered on the learner for maximum self- development and self -fulfillment. In view of these, the junior secondary school is made both pre- vocational and academic. The science teacher at this level is expected to teach science in order to enable the students acquire further knowledge about nature and acquire necessary skills to address life challenges.

The quest for the literacy of future generations led the Federal Government of Nigeria to come up with the National Commission for Colleges of Education (NCCE). This body is saddled with the responsibility of producing teachers with Nigeria Certificate in Education (NCE) to teach in primary and junior secondary schools. This programme with the sole aim of producing teachers to teach these levels of education effectively are mostly confronted with a lot of problems which account for the poor performance as shown in Table 1 and Figure 1 containing the final-year results of Integrated science students from Osun State College of Education, Ila, Federal College of Education, Abeokuta, Emmanuel Alayande College of Education, Oyo and Federal College of Education (Special), Oyo between 2005 and 2011. For the three sessions indicated in the table, a total of 3802 students in the final year took the final examinations, 1266 passed the examination and 2536 failed. This implies that only 33.3% graduated while 66.7% did not graduate. This is not good enough when one considers the importance of the subject to the scientific literacy and technological development of the country.

UNIVERSITY OF IBADAN LIBRARY

Table 1: Integrated Science Final N.C.E. Result for Selected Colleges of Education

Year	College	No examined	No Pass	% Pass	No failed	% failed
2005-2006	School 1	190	42	22.1	148	77.9
	School 2	234	117	50.0	117	50.0
	School 3	206	73	35.4	133	64.6
	School 4	46	18	39.1	28	60.9
2006-2007	School 1	152	34	22.4	118	77.6
	School 2	142	67	47.2	75	52.8
	School 3	229	88	38.4	141	61.6
	School4	56	20	34.7	36	64.3
2007-2008	School 1	174	48	27.6	126	72.4
	School 2	136	67	49.3	69	50.7
	School 3	266	101	37.9	165	62.1
	School 4	48	19	39.6	29	60.4
2008-2009	School 1	181	53	29.3	128	70.7
	School 2	176	59	33.5	117	66.5
	School 3	289	60	20.8	229	79.2
	School 4	58	20	33.5	38	65.5
2009-2010	School 1	194	75	38.7	119	61.3
	School 2	60	26	43.3	34	56.7
	School 3	191	36	18.9	155	81.7
	School 4	60	18	30	42	70
2010-2011	School 1	289	60	20.8	229	79.2
	School 2	79	35	44.3	44	55.7
	School 3	283	106	37.5	177	62.5
	School 4	63	24	38.1	39	61.9
Total		**3802**	**1266**	**33.3**	**2536**	**66.7**

UNIVERSITY OF IBADAN LIBRARY

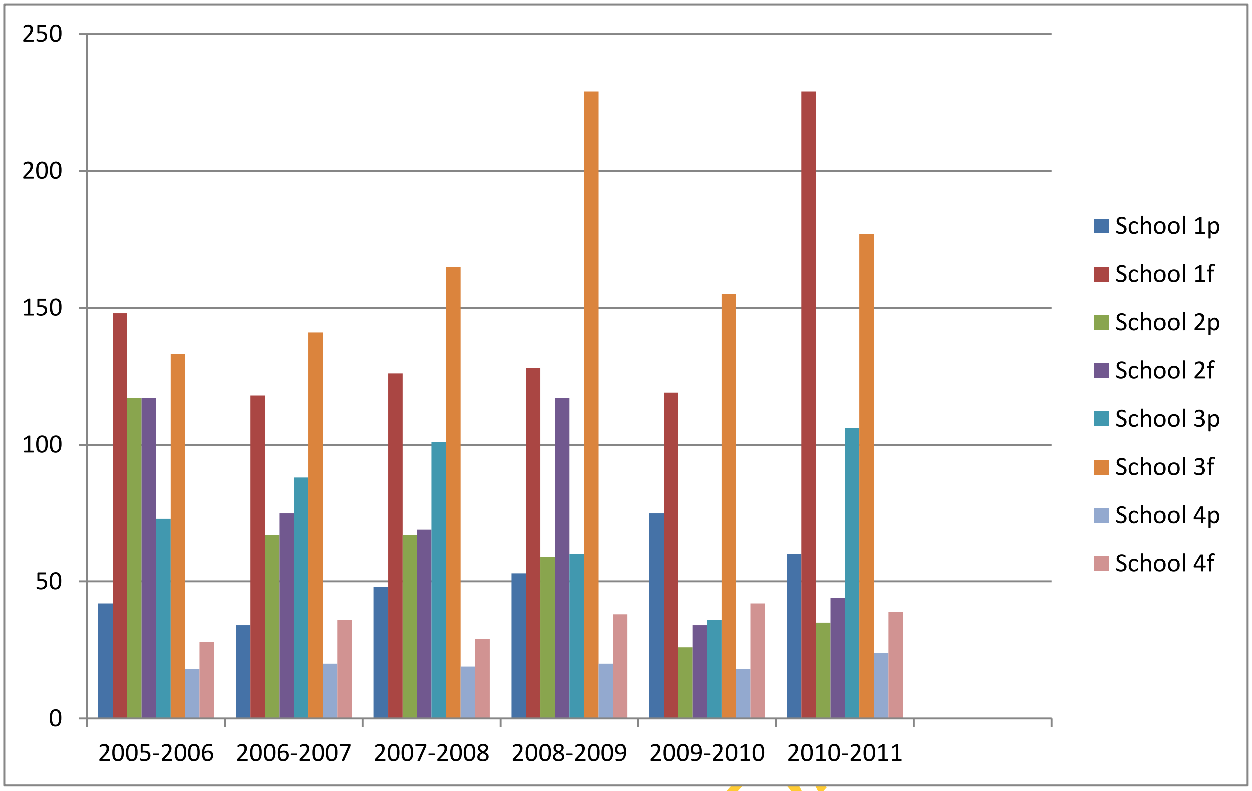


Fig. 1: Integrated Science Final NCE Result for selected Colleges of Education

Sources: Academic Records Section of Osun State College of Education Ila.
Academic Records Section of Federal College of Education, Abeokuta
Academic Records Section of Emmanuel Alayande College of Education, Oyo.
Academic Records Section of Federal College of Education (Special), Oyo.

Key

School 1: Osun State College of Education Ila, Osun State

School 2: Federal College of Education, Abeokuta, Ogun State

School 3: Emmanuel Alayande College of Education, Oyo, Oyo State

School 4: Federal College of Education (Special), Oyo, Oyo State.

Researchers have identified some probable causes of poor performance in the subject. These range from student factors like their poor attitudes to science (Showers & Shrigley, 1995), lack of interest in science (Adepitan, 2003), lack of role models in the

UNIVERSITY OF IBADAN

subject (Ivowi & Oludotun, 2001), poor mathematical background (Ogunleye, 2001). Government factors in the area of policy making, infrastructural provision and teacher welfare (Ogunleye, 2001), teacher factors such as teaching methods employed (Kalijah, 2000, Adepitan, 2003) and unhealthy teacher-student relationship (Aysan, 1996).

There seems to be a general consensus of opinion among science educators concerning the vital role played by teaching methods or instructional strategies adopted by the teacher as these and other variables affect students' achievement and attitude to science (Gbolagade, 2009). He 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 and the society. He called for the adequate training of teachers, which should include the introduction of appropriate methods of teaching the subject-matter. Iroegbu (1998) observed that learners tend to derive maximum benefits in learning cognitive skills when the teaching strategy adopted involves the use of a mixture of different methods, while at the same time, creating opportunity for the learners to practice skills as meaningful whole. Learners must, therefore, be exposed to situations, which demand the knowledge and skills they are required to acquire and use.

Pre-service teachers' science process skills are aspects to be given considerable attention during the training period. This is necessary as they are being trained to teach others later. Integrating the science process skills into the teaching, requires no drastic changes in teaching style but merely involves making the processes of science to be more explicit in lessons, investigation and activities already in use in science curriculum (Wetzel, 2008).

UNIVERSITY OF IBADAN LIBRARY

In 2009, the Oyo State Universal Basic Education Board (SUBEB) undertook monitoring and assessment of all the teachers in the primary school in the state and reported that the primary school teachers are performing poorly in all school subjects and even worse in the sciences (OYO SUBEB News, 2009). The report shows that the primary school teachers are not doing well academically both in pedagogy and in knowledge of the subject- matter. For the situation to be rescued there should be a reformation at the NCE level of education. Indeed, the pre - service teacher training programme in science should be properly looked into. They should be exposed to various teaching strategies that can arouse and sustain student interest, build up self-efficiency and positively change the attitude of pre-service teacher to integrated Science. Many instructional strategies have been developed and found effective in teaching science. Examples are the collaborative group strategies for pre-service teachers by Gbolagade 2009 and Adedigba (2002), problem solving and concept mapping by Orji (1998), reform-based instruction by Barak and Shakhman (2008), meta-cognition strategy by Eldar (2008), self-regulation strategy by Arsal (2010) and Predict-Observe-explain strategies by Babajide (2010) to mention but a few.

In spite of all these efforts towards improved teaching strategies, the performance of pre-service teachers in integrated science is still very low since all these laudable methods do not translate into use by classroom teachers some of who are not ready to change their classroom practices acquired during training. Also, most of these novel strategies are not recommended in the curriculum. So, the researcher is of the opinion that if these improved teaching strategies are emphasized and used in training the pre- service teachers, they would be familiar with these teaching strategies in the course of their

UNIVERSITY OF IBADAN LIBRARY

training and find it more convenient and easy to use when they are in the field practising as teachers.

The National Commission for Colleges of Education (NCCE) recommended various teaching methods that can be used to teach Integrated Science course which includes demonstration, discussion, project, field trip, group discussion and lecture methods. Of all these, lecture method is the most popular, commonest and mostly abused in Nigerian classrooms (Duyilemi, 2005). It is mostly used in tertiary institutions. According to Oludipe (2003), persistent and remarkable expansion in student enrolment at all levels of education as well as shortage of classroom accommodation and other necessary facilities may be responsible for the popularity of lecture method in Nigerian science classes.

Ogunsola- Banidele (1996) has remarked that lecture method is the most abused of all teaching methods and the least effective in many respects. This implies that the aims and objectives of Basic Science cannot be attained with lecture method; hence, there is the need for more involving methods of instruction. That is, if Basic Science at the basic level of education is to achieve its stated objectives, an activity and student oriented approach should be used in line with the role of teacher which has gradually shifted from traditional disseminator to that of mentoring or tutoring. Here, the teacher assists students with sources of information and provides them with guidance. The teacher provides structural, supportive and professional role to the students in analysis, interpretation and reporting of findings (Sampson & Yeoman, 2010). Every educator has ethics and moral obligation to assist all students to realise their full potentials (Orlich, Harder, Callahn, Travisan & Brown, 2010).

UNIVERSITY OF IBADAN LIBRARY

Students need to be given opportunity to be actively involved in the learning process (Duyilemi, 2005). Teaching is not simply standing in front of a class talking, the best teachers contemplate the manner in which they will present a topic and have a wide variety of instruction models at their disposal (Orlich et al, 2010). It is, therefore, imperative to create room for further search for instructional models that could appeal and arouse learners' interest and at the same time help to achieve the objectives of science education.

To achieve desired educational goals, teachers need to reflect on their teaching goals and how these interface with the demographics and abilities of their students. This process will, according to Clarke (2007), allow the teacher to clarify their knowledge base, the content, and their students' learning styles and crystallized the pedagogy to be implemented. In choosing instructional strategies, teachers need to consider the challenges that the students may encounter and strategies to assist the students in overcoming them. Teachers need to evaluate the lesson goals and the action of both themselves and their students as well as define the point at which difficulties emerged. A way of doing this is through constructivism which is learning in an active situation through which new knowledge is acquired by building on prior knowledge and metacognition which involves monitoring students' thinking and behaviors as they regulate what they do and think while having an experience in teaching (Hart, Dixon, Drummond & Mclntyre, 2004).

Reflective Teaching is grounded in constructivism and metacognition where students and teachers are exposed to teaching and learning experience under the scrutiny of their peers and mentor or college supervisor who critiques their ideas (Clarke, 2007).

UNIVERSITY OF IBADAN LIBRARY

Reflection, according to Clarke (2007), refers to thinking about the actual teaching which involves the thought teachers have before, during and after a lesson. This teaching strategy has not been given adequate attention in classrooms, especially in science related subjects but perhaps, could be used to achieve the objectives of basic science curriculum. At the pre-service level, it will be useful to train teachers who would adopt them when they will be practicing later in their career.

Reflective teaching means looking at what you do in the classroom, thinking about why you do it, and thinking about if it works or not. It is a process 'of self - observation and self-evaluation. It is a means of professional development which begins in our classroom. It is paying critical attention to the practical values and theories which inform everyday action, by examining practice reflectively and reflexively (Bolton, 2010). Reflective practice was introduced by Donald Schon in his book: The reflective practitioner in 1983. However, the concepts underlying reflective practice are much older. It focuses on the ways people think about their experiences and formulate responses as the experiences happen. This approach makes a clear distinction between "thinking on action" and "thinking in action". Thinking on action is the way of analyzing experiences as they happen while thinking in action determines how responses are formulated (Krause, 2004). This whole idea is considered as "thinking on your feet".

Reflective practice occurs at all stages of the teaching process, in planning, action (execution) and in evaluation. A reflective practice leads to reflective teaching which refers to the process of the teacher studying his or her own teaching method and determining what works best for the students. It involves the consideration of the ethical consequences of classroom procedure on student (Larrivee, 2000). As teaching and

UNIVERSITY OF IBADAN LIBRARY

learning are complex, and there is not one right approach, reflecting on different versions of teaching and reshaping past and current experience will lead to improvement in teaching practices. Reflective teaching is in three phases which are; the planning, teaching and debriefing phase. During the planning stage the teacher must use strategy(ies) like cooperative learning techniques, hands-on activities etc (Clarke, 2007). Based on these, the researcher use two cooperative teaching strategies with reflective teaching.

Cooperative Learning, according to Orlich et al (2010), is a learning strategy based on small-group approach to teaching that holds students accountable for both individual and group achievement. It takes many forms within the classrooms. Its essential characteristic is that it fosters positive interdependence by teaching students to work and learn together in small group setting (Orlich, et al, 2010). Traditional Cooperative Learning groups consist of four to six students who work on an assignment or a project together in such a way that each group member contributes to the learning process and learns all the basic concepts being taught in the process. It improves students' academic learning and social skills and aids teachers' classroom management and instruction (Evertson, Emmer & Worsham, 2006). It also enhances a student's enthusiasm for learning and their determination to achieve academic success (Mueller & Flaming, 2001; Roman, 2007 in Orlich, et al, 2010). There are different types of cooperative learning models some of which are: brainstorming, role playing, reciprocal teaching, reciprocal peer tutoring, scaffolding, and thinking aloud among others. Two of these cooperative learning strategies: Reciprocal Teaching (RT) and the Reciprocal Peer Tutoring (RPT) was adopted in this study.

UNIVERSITY OF IBADAN LIBRARY

Reciprocal Teaching (RT) is a student-centered instructional strategy in which students and teachers switch roles in a lesson. It is a cooperative learning instructional method in which natural dialogues model reveal learners' thinking processes about a shared learning experience (Foster & Rotoloni, 2005). Teachers foster reciprocal teaching through their belief that collaborative construction of meaning between themselves and students lead to a higher quality of learning (Allen, 2003). Students take ownership of their role in reciprocal teaching as they feel comfortable expressing their ideas and opinions in open dialogue. They take turns articulating with each learning strategy employed. The learning community is able to reinforce understanding and to see, hear and correct misconceptions that otherwise might not have been apparent. All members of the community have shared responsibility for leading and taking part in dialogue during learning experience (Hashey & Connor, 2003).

Furthermore, Reciprocal Teaching increases students' confidence and success in their understanding and use of strategies and in their enjoyment of the lesson. However, there is not enough literature on the use of RT in Science Education. According to Garderen (2004), a modified version of reciprocal teaching can benefit students who struggle to comprehend mathematical word problems. The four major component of this modified approach are clarifying, questioning, summarizing and planning. The RT could be of help in teaching Dynamics which is a physical aspect of Integrated Science and being mathematics oriented course. Reciprocal teaching is an instructional strategy based on modeling and guided practical in which the instructor first models a set of reading comprehension strategies and then gradually cedes responsibility for these strategies to the students (Palincsar & Brown, 1984; Palincsar, 1986).

UNIVERSITY OF IBADAN LIBRARY

Reciprocal Teaching consists of three main components: (a) the teaching and learning of specific concept and the strategies (b) the dialogue between an instructor and students where the instructor models why, when, and where to use the strategies and (c) the appropriating of the role of the instructor by the students, i.e. students begin to model the strategy for other students. Thus, the goals of RT are for students to learn the strategies, learn how and when to use the strategies and become self-regulated in the use of these strategies.

Reciprocal Peer Tutoring (RPT) is also an intervention in which one student provides instruction or academic assistance to another student. RPT is a form of cooperative learning, which has been found to be an effective technique for increasing students' academic achievement (Sharman, 1991; Slavin, 1991). Conceptually, Peer Tutoring is similar to many activities ranging from the informal encounters of play to the most complex activities of cooperation in which people help one another and learn by doing so. This process transforms learning from a private to a social activity by making learners to be responsible for their learning and that of others. Researches have shown that both tutors and tutees gain immensely from participating in reciprocal peer tutoring (Forman, 1994; Slavin, 1996; Griffin & Griffin, 1997). In this process, students function reciprocally as both tutors and tutees. This dual role is beneficial because it enables students to gain from both the preparation and instruction in which tutors are engaged and from the instructions that tutees received (Griffin &Griffin, 1997). Successful peer-tutoring interventions have been carried out in school settings and have typically provided supplementary practice for fundamental skills such as reading, spelling, or mathematics (Mayfield &Vollmer, 2007). In addition, these interventions often involve

UNIVERSITY OF IBADAN LIBRARY

extensive training (4 to 8 hours) prior to implementation, the use of structured formats and predesigned materials to guide instruction and precise methods of delivering feedback (Fuchs &Fuchs, 2005; Saenz, Fuchs & Fuchs, 2005).

The mode of entry of students into the NCE programme is an index of students 'previous knowledge or entry behavior. The Joint Admission and Matriculation Board (JAMB) was established by the Federal Government of Nigeria through Act 2 of 1978 to regularize the intake of students into universities and later polytechnics, monothechnics and colleges of education to solve the problem of multiple admission given to some candidates at the expense of others, (JAMB,1998). The mode of entry into NCE programme is in two forms: the direct entry handled by JAMB and prelimary studies handled by the colleges of education themselves. Daniels and Schouten in Adeyemi (2009) is of the opinion that a prediction of a future examination result could be made with reasonable success on the basis of the result of an earlier examination and that grade may serve as predictive measure and as a criteria measure.

Numerical ability of the Pre-service science teachers is an important factor in effective science teaching. Nunnally (2004) defines Numerical ability as the ability to relatively solve problems in number sequencing, make accurate mathematical deductions through advanced numerical reasoning, interpret complex data presented in various graphical forms, deduce information and draw logical conclusions. According to Gunderson, Ramirez, Beilock and Levine (2011), improving children's spartial skills may have positive impact on their future success in Science Technology and Mathematics (STEM) disciplines not only by improving the spartial skills that are necessary in many sciences and engineering fields but also by enhancing the numerical skills which form the

UNIVERSITY OF IBADAN LIBRARY

backbone of the advanced mathematics critical to all STEM fields. Here in lies the need for this study.

1.2 Statement of the Problem

Pre-service teachers' poor performance in Integrated Science has been an issue attracting the attention of researchers and science educators. This is crucial for a subject as important as Integrated Science and effective teaching and learning of Basic Science in Nigerian schools. Several factors have been adduced to be responsible for this trend. These include the instructional strategy used in teaching the subject at the NCE level which does not make a good level of achievement and science process skills on the part of the pre-service teachers. This is more so as those strategies are not based on self – construction of knowledge, self-assessment and social interaction among learners. Pre-service teachers fear and dislike dynamics and some other allied concept in Integrated Science for being mathematical oriented and abstract in nature. As a result, the teacher needs to be reflective and explored cooperative strategy in teaching it. Previous researchers have focused on various strategies such as Reform-Based Instruction, Self-regulation Strategy Collaborative Learning, and Hands-on activities as means of improving pre-service teacher's achievement in science. However, all these laudable methods do not translate into use by classroom teachers some of who are not ready to change their classroom practices acquired during training. So if these improved teaching strategies are emphasized and used in training the pre- service teachers, they may be familiar with them and find it easier to use when practising as teachers.

This study, therefore determined the effects of reflective-reciprocal teaching and reflective-reciprocal peer tutoring strategies on pre-service teachers' achievement in

UNIVERSITY OF IBADAN LIBRARY

Integrated Science and science process skills in Nigerian Colleges of Education. The study further investigated the moderating effects of mode of entry of pre-service teachers into the college and their numerical ability on the two dependent measures.

1.3 Hypotheses

The following null hypotheses were tested in the course of this study at 0.5 level of significance.

$H_0$1: There is no significant main effect of treatment on pre-service teachers'

(a) Achievement in Integrated Science, and

(b) science process skills

$H_0$2: There is no significant main effect of mode of entry on pre-service teachers'

(a) achievement in Integrated Science, and

(b) science process skills

$H_0$3: There is no significant main effect of numerical ability on Pre-service teachers'

(a) achievement in Integrated Science, and

(b) science process skills

$H_0$4: There is no significant interaction effect of treatment and mode of entry on pre-service teachers'

(a) achievement in Integrated Science, and

(b) science process skills

$H_0$5: There is no significant interaction effect of treatment and numerical ability on pre-service teachers'

(a) achievement in Integrated Science, and

(b) science process skills

UNIVERSITY OF IBADAN LIBRARY

H_06: There is no significant interaction effect of mode of entry and numerical ability on pre-service teachers'

(a) achievement in Integrated Science, and

(b) science process skills

H_07: There is no significant interaction effect of treatment, mode of entry and numerical ability on pre-service teachers'

(a) achievement in Integrated Science, and

(b) science process skills

1.4 Scope of the Study

This study covered six colleges of education in the Southwestern Nigeria. All available NCE II Integrated science students from these colleges were allowed to take part in the programme. Some aspects of Integrated Science with course code ISC 223 was used as contained in the NCE course outline. The course is one of the Physics aspect of Integrated Science and highly numerical in nature.

1.5 Significance of the Study

It is expected that findings from this study would add to the numerous efforts made by educators in Nigeria to make pre-service teachers, science teachers, parent/guardians, school administrators, curriculum planners, researchers and government see the need for a more effective method in the teaching of science. Specifically the findings from this study would be useful to the following stake holders in education

UNIVERSITY OF IBADAN LIBRARY

To Science Educators

The findings from this study would provide lecturers of science courses with relevant information on relevant skills needed as a teacher and how to make teaching more vibrant and flexible. It would also provide them with information on how to have meaningful dialogues with their students and colleague. Findings from the study would enable curriculum planners to include appropriate teaching strategies in the curriculum especially for the NCE programme. The study also provides reference materials on the prospects of these strategies to science teaching for science educators and researchers to be carried out in the area of science teaching strategies. Specifically, model instructional guides developed in this study would be useful to Integrated Science teachers in lesson preparation and instructional delivery using RT and RPT in the teaching of the subject in schools.

To Pre-service Science Teachers

The study would equipped the pre-service teachers with the knowledge of the role of socialization in teaching, and will become aware of different cooperative teaching models especially Reciprocal Teaching and Reciprocal Peer Tutoring that they can use when they are practicing.

To the Government

The government at various levels, concerned with the provision of quality science and technology education to citizens would find this work useful, as it provides information on the ways of giving quality science education to its citizen through effective teaching and learning using strategies which foster reflection and cooperation in learning.

UNIVERSITY OF IBADAN LIBRARY

1.6 Operational Definition of Terms

Achievement in Integrated Science: This is the level of students' knowledge as measured by the Integrated Science Achievement Test. It is the score of the students being exposed to instructional treatment groups. The score of the students on the test is used as a measure of such students' achievement in Integrated Science.

Cooperative Learning: This refers to an instructional strategy in which pre-service teacher works in small group and interacts with one another during teaching and learning.

Mode of Entry: Refers to the manner through which the pre-service teachers were admitted into the NCE programme either through pre-NCE or direct entry.

Numerical Ability: Refers to individual ability of pre-service science teachers to perform tasks requiring knowledge of numbers.

Pre-service Teacher: These are college of education students who are being trained as teachers in the integrated science department.

Reflective Teaching: This is a classroom practice in which a teacher looks at what he does in the classroom, thinking about why he does it, and thinking about if it works, i.e a process of self-observation and self-evaluation. It involved both reflective-in-action and reflective-on-action.

Reflective-Reciprocal Teaching: This is an instructional strategy, which involves a dialogue between a teacher and students in which both the student and teacher shift roles, thereafter, the teacher and pre-service teachers reflects on the lesson as a form of observation and evaluation.

Reflective-Reciprocal Peer Tutoring: This is a strategy in which students function reciprocally as both tutors and tutees with the teacher acting as a facilitator, thereafter, the

UNIVERSITY OF IBADAN LIBRARY

teacher and pre-service teachers reflect on what happen in the classroom as a form of self-observation and self-evaluation.

Science Process Skills: These are per-service science teachers' abilities of observing, classifying, measuring, communicating and predicting in Integrated Science activities measured by pre-service teachers' science process skills rating scale.

UNIVERSITY OF IBADAN LIBRARY

CHAPTER TWO

2.0 REVIEW OF LITERATURE

This chapter provides a review of available literature that are relevant to the subject of this study. It also provides empirical support for the theoretical framework as well as shedding more light on the background and the major concepts involved in the study.

The review focuses on the following subheadings:

2.1 Theoretical framework

2.1.1 John Dewey (1859-1952) Theory of Reflective Thought

2.1.2 Kolb (1984) Theory of Reflective Teaching

2.1.3 Vygosky (1896-1934) Theory of Developmental Learning

2.2 Empirical Studies

2.2.1 Students' Achievement and Science Process skills

2.2.2 Reflective Teaching and the Development of Teaching skills

2.2.3 Cooperative Learning and Students Learning Outcomes in Science

2.2.4 Effects of Reciprocal Teaching on Students' Achievement and Science Process Skills

2.2.5 Effects of Reciprocal Peer Tutoring on Students' Achievement and Science Process Skills.

2.2.6 Mode of Entry and Its Influence on Achievement and Science Process Skills

2.2.7 Numerical ability and its Influence on Achievement and Science Process Skills.

2.3 Appraisal of Literature Review.

UNIVERSITY OF IBADAN LIBRARY

2.1 Theoretical Framework

This study was based on constructivist approach to teaching and learning and the cognitive learning theory. Constructivist theories are concerned with the social nature of learning i.e. how learners create their own conceptual structures in order to make sense of the world. Constructivism is a theory to explain how knowledge is constructed in the human being when information comes into contact with existing knowledge that had been developed by experiences. It is a learning theory based on the idea that knowledge is constructed based on the knower mental activity. According to Dougiamas (1998) the major faces of constructivism are:

- Trivial constructivism
- Radical constructivism
- Social constructivism or socio constructivism
- Cultural constructivism
- Critical constructivism
- constructionism

The cognitive theory which is also referred to as social constructivism (Harrison, 2008) focuses on the cognitive processes that occur as people learn through social interaction, such as listening to and working with others as in reciprocal teaching and reciprocal peer tutoring. The relationship between learners and teacher is a crucial relationship to consider in this regard. The leading constructivist includes:

- John Dewey (1859-1952)
- Maria Montessori (1870-1952)
- Wladyslaw Strzeminski (1893-1952)

UNIVERSITY OF IBADAN LIBRARY

- Lev vygotsky (1896-1934)
- Jean Piaget (1896-1980)
- George Kelly (1905-1967)
- Heinz von Foerster (1911-2002)
- Emst von Glasersfeld (1917-2010)
- Paul Watzlawick (1921-2007)
- Edgar Morin (1921-)
- Humberto Maturana (1928-)
- Laszlo Garai (1935-)
- David A Kolb (1939-)

In this research study, the works of John Dewey, Kolb and Vygosky were considered.

2.1.1 John Dewey's (1859-1952) Theory of Reflective Thought

John Dewey was an educational philosopher and pragmatist who made major contributions to education. This could be seen in his belief in what education and teaching are. John Dewey believes that children are socially active learners who learn by exploring their environment (Eggen & Kenchak, 2006). Dewey (1897) wrote

> *I believe that all education proceed by the participation of the individual in the social consciousness of the race. I believe that the only true education comes through the simulation of the child's powers by the demands of the social situation in which he finds himself, through these demands he is stimulated to act as a member of a unity, to emerge from his original narrowness of action and feeling and to conceive of himself from the standpoint of the welfare of the group to which he belongs.pp.142*

UNIVERSITY OF IBADAN LIBRARY

Schools should take the advantage of this mutual curiosity by bringing the outside world into the classroom making it available and accessible for students. He believes that there should be an integration of theory and practice, the cyclic pattern of experience and the conscious application of that learning experience.

Dewey proposed his concept of reflective thinking in his book, How We Think (1897; 1933). He substituted the word "inquiring" for "reflective thinking" in his later work, Logic: The Theory of inquiring (1933). Inquiring, according to Dewey (1933) is the active, persistent, and careful consideration of any belief of supposed form of knowledge in the light of the grounds that support it and the further conclusion which it intends. Inquiring in this perspective seems to connote something more active and operational than thinking. It refers to the activity engaged in to overcome a situation of doubt to generate knowledge, with provisional and tenuous results, posited in the light of new experience and insight.

To Dewey, reflective activity occurs when a person decides to face a perplexed, troubled or confused situation and prior to a clear-up unified and resolved situations. He listed five phases or aspects of reflective thought which are:

- suggestion
- intellectualization of difficult or perplexity that has been felt (direct experience) into a problem to be solved, a question for which the answer must be sought.
- the use of one suggestion after another as leading idea
- mental elaboration of the idea or suppositions

UNIVERSITY OF IBADAN LIBRARY

- testing the hypothesis by overt or imaginative action to give experimental corroboration or verification of the conceptual idea. (Ross & Hannay, 1986; Dewey, 1933 as edited by Boydston).

Furthermore, Dewey views thinking as a part of a process that culminated in plans, with the objective of altering life conditions to improved ways. It involves a look into the future, a forecast, anticipation or a prediction (Dewey, 1933). He also advocated flexibility in his approach to problem solving:

> *The five phases, terminals, or functions of thought that we have noted do not follow one another in a set order. On the contrary, each step in genuine thinking does something to perfect the formation of a suggestion and promote its change into a leading idea or directive hypothesis. It does something to promote the location and definition of problem. Each improvement in the idea leads to new observation that yield new facts or data and help the mind judge more accurately the relevancy of facts already at hand pp. 206*

Dewey believes that the teacher's place and work in the school is not to impose certain ideas or to form certain habits in the child, but is there as a member of the community to select the influences which shall affect the child and to assist him in properly responding to these influences.

2.1.2 Kolb's Theory of Reflective Teaching

Kolb reflective model highlights the concept of experimental learning and is centered on the transformation of information into knowledge. This takes place after the situation has occurred and entails a practitioner reflecting on the experience, gaining a general understanding of the concepts encountered during the experience and then testing these general understandings on a new situation. In this way the knowledge that is gained

UNIVERSITY OF IBADAN LIBRARY

from a situation is continuously applied and reapplied building on a practitioner's prior experience and knowledge (Kolb & Kolb, 2005).

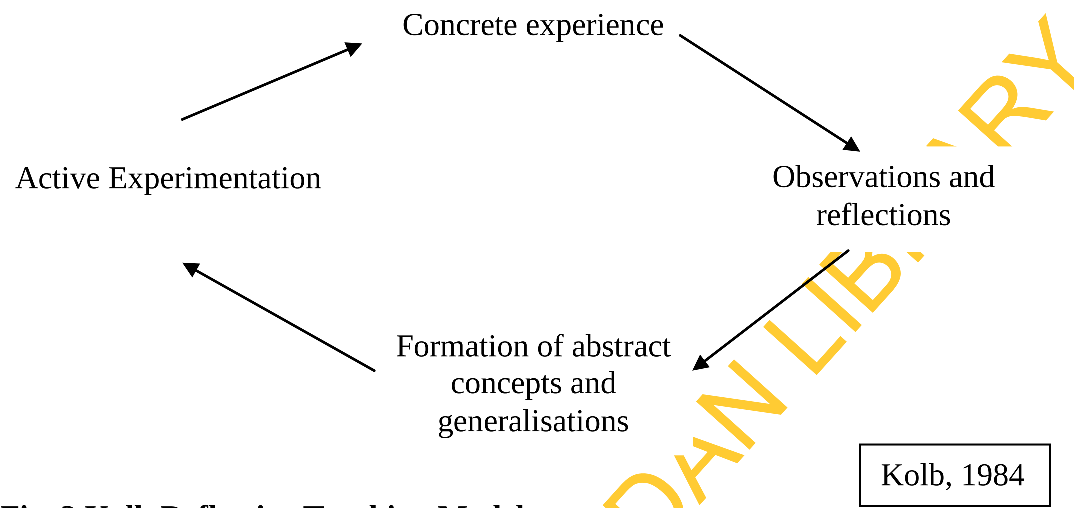


Fig. 2 Kolb Reflective Teaching Model

In Kolb's framework for reflection, the Concrete Experience refers to the teaching situation in-the-moment, and the teacher is focusing on and noticing in terms of her teaching, the students, and the learning process. The Reflection and Observation stage, refers to the ability to think back to a teaching situation and describe in detail what happened during the lesson. At this stage, the teacher tries to answer the question "What happened"? In the Abstract Conceptualization stage, a teacher tries to understand what happened in the classroom and investigates reasons for it. At this point, he/she tries to answer the question "Why did it happen"? Based on emotion, teaching experience, and personal and theoretical knowledge in the final stage, Active Experimentation, the reflective practitioner decides on what her next step will be, given the information gathered in the description and analysis of the situation. "What will I do next? What will I do about this situation"? Is what the teacher plans. This cyclical step of Kolb's

UNIVERSITY OF IBADAN LIBRARY

reflection is applicable to reflective teaching and it's the one adapted in this research work.

2.1.3 Vygosky's Theory of Developmental Learning

Vygosky's theory of learning is basically on cognitive development (Vygosky, 1978). Two processes are involved in cognitive development, namely, the biological and physiological processes. According to him, children's behaviour emerges at the intersection of these two processes. The theory states that biological processes are quantitatively transformed into higher psychological functioning in developmental processes. According to him, all the physical changes are series of transformation, which were brought about by developmental processes. Children's development is as a result of the social and cultural processes. He also emphasis the social genesis of knowledge. To him every function in the (student's) cultural development appears twice: first, on the social level, and later, on the individual level. This social genesis of knowledge construction is comprised of three primary assumptions: (a) knowledge and meaning are active creations of socialization; (b) knowledge and meaning are social creations and as such reflect social negotiation and consensus; and (c) knowledge and meaning are constructed for the purposes of social adaptation, discourse, and goal achievement (Doolittle, Hicks, Triplett, Nichols, & Young; 2006). These three assumptions are evident in Cooperative Teaching. Specifically Reciprocal Teaching and Reciprocal Peer Tutoring are based on active socialization with both instructor- student and student- student interaction.

Vygosky believes that development is as a result of combination of speech and practical activities. His ideas also led to the notion of scaffolding which is a process of

UNIVERSITY OF IBADAN LIBRARY

helping learners to move from a point of his initial difficulties on a topic, to a point where he received "help" they are able to perform. The theory also states that children are ready to learn a concept when their cognitive structures are able to incorporate some aspects of that concept. For example, different learners who are ready to learn a concept may learn different things about the concept from the same experience. He also conceptualized learning and development as a social and collaborative activity that cannot be "taught" to anyone. Rather, the learner constructs his own understanding in his own mind while the teacher acts as a facilitator just as in Reciprocal Teaching and Reciprocal Peer Tutoring, which designs appropriate situations and support for learners to learn meaningfully from one another. This includes incorporating classroom activities in which students work in group and providing learners with a sense of oneness between their community and learning.

2.2 Empirical Studies.

2.2.1 Students' Achievement and Science Process Skills

The science process skills are the foundation of problem solving in science and the scientific method. Padilla (1990) in Aktamis & Ergin, (2008) defines science process skills as transferable skills that are applicable to many sciences and that reflect the behaviors of scientists. They are the skills that facilitate learning in physical sciences, ensure active students' participation, have students develop the sense of undertaking responsibility in their own learning, increase the permanence of learning, and also have students acquire research ways and methods, that is, they ensure thinking and behaving like a scientist (Ergul; Simsekli. Calis. Ozdilek Gocmencelebi & Sanli, 2011). They are inseparable in practice from the conceptual understanding that is involved in learning and

UNIVERSITY OF IBADAN LIBRARY

applying science. While the process skills are viewed as central to elementary school science education and important enough to be taught in their own right, they are often combined with science content, enabling children to learn both science process and content at the same time-in a seamless learning experience (Menchling et al. 1994). For instance children may practice the skill of observation while identifying the properties of rock. Learning science goes beyond scientific knowledge acquisition since it includes the acquisition of cognitive skills such as the science process skills. They are an important method in teaching science lessons and also the building-blocks of critical thinking and inquiry in science. Learning science lessons by apprehending requires using science process skills. Having science process skills acquired, at the same time, means preparing future scientists, having scientific literacy acquired, that is, enabling students to use science information in daily life (personal, social and global) (Harlen, 1999 in Ergul et al 2011).

Science process skills are based on scientific inquiry and teaching science by inquiry involves teaching students science process skills as well as critical thinking and scientific reasoning skills used by scientist. They are acquired through training and direct experiences (Njoku, 2002). They are intellectual skills with learned capabilities which scientists used as self-management procedure in carrying out their scientific activities (Shaibu & Mari, 1997). They are also acquired during practical teaching of science in the laboratory (Oginni, 2009). Njoku (2002) explained that these science process skills are cognitive and psychomotor skills which scientists use in problem identification, objective inquiring, data collection and analysis. These skills are retained after the cognitive knowledge of science has been forgotten.

UNIVERSITY OF IBADAN LIBRARY

Integrating the science process skills as one of teaching strategies requires no drastic changes in one's teaching style (Wetzel, 2010). It merely involves making the processes of science more explicit in lessons, investigations and activities you are already using in your science curriculum. The science process skills, according to Wetzel (2010), are the methods used by students to conduct investigations and understand how we know about the world in which we go beyond the textbook and supplementary the core-content within textbooks with hands-on mind-on activities. It also means using your course content as a means for exposing students to the real processes of science.

The science process skills are separated into two categories-Basic Science Process Skills (BSPS) and Integrated Science Process Skills (ISPS) (Wetzel, 2008).The skills listed under the basic science process skills are:

- Observing – using the 5 senses to find out information about objects: an objects' characteristics, properties, similarities and other identification features
- Classifying – the process of grouping and ordering objects
- Measuring – Comparing unknown quantities with known quantities, such as: Standard of unit of measuring and estimation of errors. This information is considered quantitative data. Measurements are to be recorded in an orderly and systematic fashion with labeled units of measure.
- communicating – using multimedia, written, graphs, images, or other means to share findings. This is needed to reflect the true nature of science.
- Inferring – forming ideas to explain observations i.e. interpreting or explaining observation. More than one inference may be presented to explain an observation.

UNIVERSITY OF IBADAN LIBRARY

- Predicting – forecast a future event based on prior experience, i.e. observation, interference, or experiments. It is forming an idea of an expected result-not a guess-but a belief of what will occur based upon present knowledge and understandings, observations, inferences. A prediction is to clarify ideas and reveal any misconception or missing information.

Basic science process skills provide the intellectual groundwork in scientific inquiry (Beaumont-Walters & Soyibo, 2001). These skills are those which must be acquired and fundamental to the teaching and learning of science.

For integrated science process skills, the skills are:

- evaluating information
- controlling of variables
- defining operationally
- hypothesizing, and
- experimenting (Ong & Kenneth, 2005).

The integrated science process skills are structured on basic skills. They are the terminal skills for solving problems or doing science experiments (Karamustafaoglu, 2011). The ability to carry out integrated science process skills is attributed to hypothetico-deductive reasoning (Huppert, Lomask and Lasarowitz, 2002).

The Curriculum Development Centre (CDC) of the Malaysian Ministry of Education also listed seven (7) and five (5) skills respectively for BSPS and ISPS in all its science syllabuses for primary, secondary and post secondary levels. The twelve (12) skills and their precise definition according to Ong and Kenneth (2005) were listed in table II below. Students are expected to be familiarised with the language of science process

UNIVERSITY OF IBADAN LIBRARY

skills right from the start as they experience the practical and the theoretical aspects of science.

Table 2.1: Definition of Science Process Skills as stipulated in all the Malaysian science syllabuses

No	Skill	Explanation
1	Observing	Process of gathering information about an object or phenomenon using all or some of the senses. Instruments could be used to assist the senses. The observation could be quantitative, qualitative or change.
2	Classifying	Observing and identifying similarities and differences between objects or phenomena, and gather them in terms of similar characteristics.
3	Measuring and using numbers	Observing quantitatively using instruments with standardized units. Ability to use numbers is central to the ability to measure.
4	Inferring	Giving explanation to an observation of event or object. Usually, past experiences and previously collected data are used as a basis for the explanation, and it could be correct or otherwise.
5	Predicting	Process of conjecturing a coming event based on observation and previous experience or availability of valid data.
6	Communicating	Presenting idea or information in varied modes such as orally, in written form, using graphs, diagrams, models, tables, and symbols. It also involves ability to listen to other's idea and respond to the idea.
7	Using space and time relation	Describing changes in parameter with time. Examples of parameters are location, direction, shape, size, volume, and mass.
8	Interpreting data	Process of giving rational explanation of an object, event or patterns from the gathered information. The gathered information may come in different forms.

UNIVERSITY OF IBADAN LIBRARY

9	Defining operationally	Making definition of a concept or variable by stating what it is, and how it could be carried out and measured.
10	Controlling of variables	Identifying the fixed constant variable, manipulated variable and responding variable in an investigation. The manipulated variable is changed to observe its relationship with the responding variable. At the same time, the fixed variables are kept constant.
11	Hypothesising	Ability to make general statement that explains a matter or event. This statement must be testable to prove its validity.
12	Experimenting	This is an investigation that tests a hypothesie. The process of experimenting involves all or combination of the other processes.

Source: Ong & Kenneth (2005)

These methods (i.e. science process skills) involve making explicit references to the science and allowing students time to reflect on how they participated in the process. It also helps ensure students make the connection between science processes involved within an investigation and science content (Karen, 2009). Science process skills are special skills that simplify learning science, activate students, develop students' sense of responsibility in their own learning, increase the permanency of learning, as well as teach them the research methods (Karamustafaoglu, 2003 in Karamustafaoglu, 2011). They are the thinking skills that we use to get information, think on the problems and formulate the results. Scientist use them in their studies. These skills are appropriate for all fields of science, and they reflect on the correct behaviors of scientists while they are solving a problem and planning an experiment. They constitute the essence of the thinking and research within science. It is more important for the students to learn how to apply science than learning reality, concepts, generalizations, theories and laws in science lessons. Therefore, it is necessary for them to pick up the habit of science process skills.

UNIVERSITY OF IBADAN LIBRARY

These skills according to Preece & Brotherton, 1997 in Karamustafaoglu, 2011 are considered to be efficient in learning and teaching, engage a significant place in various countries' teaching programs. Such as 'Science-A Process Approach' (SAPA) developed by the American Association for the Advancement of Science between 1963 and 1974. In this approach the teaching of science process skills was specifically focused on in elementary and high school science curricula. For in the nature of many children is already the curiosity for searching and this curiosity leads them to search. That is to say, the skills and processes students use and develop are the same as those that scientists use while studying. This implies that the ways of thinking in science are called science process skills. When we are doing science we ask questions and find answers to questions, these are actually the same skills that we all use in our daily lives as we try to solve everyday questions. When we teach students to use these skills in science, we are also teaching them skills that they will use in the future in every area of their lives (Ergul, et al, 2011). The American Association for the Advancement of Science (AAAS) classified the science process skills into fifteen (Bybee et al., 1989). These are: observing, measuring, classifying, communicating, predicting, inferring, using number, using space/time relationship, questioning, controlling variables, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. The skills (both basic and integrated) were listed in the table below:

UNIVERSITY OF IBADAN LIBRARY

Table 2.2: The American Association for the Advancement of Science (AAAS) Science Process Skills

Process Skills	Definition
Observing	Using all five senses
Classifying	Grouping object and event according to their properties
Space/time relation	Vitualising and manipulating object
Using Numbers	Using quantitative relationship
Measuring	Expressing the amount of an object in quantitative terms
Inferring	Giving an explanation for a particular object or event
Predicting	Forecasting a future occurrence
Integrated skills	
Defining operationally	Concrete description
Formulating models	Constructing images, objects or mathematical formulars
Controlling Variables	Manipulating and controlling properties in order to make comparison
Interpreting Data	Arriving at explanations, inferences or hypotheses from data
Hypothesising	Stating a tentative generalization of observations or inference
Experimenting	Testing a hypothesis

UNIVERSITY OF IBADAN LIBRARY

The use of science process skills by students increases the permanence of learning. For learning by doing according to Minner, Levy and Century (2010), student uses almost all of his or her senses and learning becomes more permanent and hands-on activities get them to acquire experience. Research skills not only get students to learn some information about science, but also learning these skills helps them to think logically, ask reasonable questions and seek answers, and solve the problems they encounter in their daily life.

Literatures suggests that there are various factors that influence the acquisition of cognitive skills such as science process skills which is one of the variable of interest in this study. Teachers play an important role in learning, including acquisition of science process skills. Marzano, Pickering and Pollock (2001) asserts that although schools make little difference, that is approximately 10% in students' achievement, the most important factor affecting students learning is the teacher. According to them, teachers can have a profound influence on students' learning even in schools that are relatively ineffective. Also, Harlen (2000) identifies three main aspects of the teacher's role: (1) setting up the learning environment, (2) organizing classroom activities, and (3) interacting with students. Among these three aspects, the most important aspect is teachers' interaction with students during their teaching. Apart from teachers' factors readiness is another factor that influences the acquisition of science process skills. Driscoll (2000) opined that students' readiness is perceived as learner's developmental level of cognitive functioning. It is the cognitive maturity that is assumed to determine the extent to which learners are capable of learning. This therefore implies that students' cognitive level should be taken under consideration in teaching students.

UNIVERSITY OF IBADAN LIBRARY

Research studies done in the 70s and 80s tends to support the link between active student involvement and the development of science process skills (Wideen, 1975 in Ong & Kenneth, 2005). Shaw, (1983) in Ong and Kenneth, (2005) studied 83 sixth grade students randomly assigned to four science classes (2 classes in experimental group and 2 in control group). The experimental group received science instruction with an emphasis on process skills while the control group emphasized strictly science content. Two teachers taught the four classes alternating between the control and experimental to reduced teacher effect. Using t-test to determine the significant difference between the two groups, it was found that the experimental group had a significantly higher mean score on the process skill test compared to the control group. Also, Beaumont-Walters and Soyibo (2001) determined the level of performance on science process skills among Jamaican ninth and tenth-graders who participated in the Reform of Secondary Education as compare to those that did not. He found that the mean of those participated in the reform was slightly higher than those that did not. Jusoh (2001) in Ong and Kenneth (2005) in his own study investigated Form 2 and 4 students' performance on science process skills test using the translated version of the instrument developed by Burns, Okey, and Wise (1985). Comparing the performance on science process skills level by level, it was found that there was a statistically significant difference between forms 2 and forms 4 students with the form 4 students performing better than the form 2 students.

2.2.2 Reflective Teaching and the Development of Teaching Skills

Over the years, Dewey's theories of reflective thought and the principles of pedagogy it inspired were stated again and again by educators and have taken a revered place in theories of learning and teaching. By the middle of the 1980s researchers

UNIVERSITY OF IBADAN LIBRARY

confidently claim that reflection (inquiring or crucial thinking) is again in "Vogue" in teacher education as a useful teaching strategy. It was emphasized that perhaps never before in the history of education practice has there been a greater push to teach children to think critically (Poblete Sr., 1999). Yet, in spite of this, it was difficult even to achieve definitional clarity to the construct due to a variety of perspectives and current conceptualization offered by different authors on what it means to be reflective about teaching (Lesley, 1989; Tanner, 1988; Ross & Hanny, 1986)

Corollary to this, reflective teaching as an inquiring-oriented approach in teacher education is considered an ambiguous term signifying a wide variety of meanings (Tom, 1985; Henderson, 1989). This could be attributed mainly to three reasons.

- The varying perspective authors assume in examining reflection (Lesley, 1989)
- The teacher's education rationales designed to help habits of inquiring are grounded in diverse images of the teacher, with little consensus's on the meaning of particular images, e.g., teachers as innovators, teachers as participant observers, teachers as continuous experimenters, adaptive teachers, teachers as action researchers, teachers as problem solvers, teachers as political craftsmen, etc. (Tom, 1985).
- Comparing inquiring-oriented approach to teacher education to alternative views in order to generate a definition of the paradigm limits inquiring as a function of other perspectives which in themselves are not fully developed frameworks (Feiman-Nemser, 1990).

UNIVERSITY OF IBADAN LIBRARY

Reflective practice was introduced by Donald Schon in his book: The reflective practitioner in 1983. However, the concepts underlying reflective practice are much older. It focuses on the ways people think about their experiences and formulate responses as the experiences happen. This approach makes a clear distinction between “thinking on action” and “thinking in action”. Thinking on action is the way of analyzing experiences as they happen while thinking in action determines how responses are formulated (Krause, 2004). This whole idea is considered as “thinking on your feet”

Griffiths and Tam (1992) in Problete (1999) categorised reflection into two: reflection –in –action and reflection –on –action. Reflection –in –action refers to what happens when ones is presented with novel puzzles, the resolving of these puzzles in the context of action, according to Schon (1983) unites means and ends, research and practice, and know and doing. This type of reflection is personal and private. It occurs as an action is going on and the reaction is rapid i.e act and reacts. Reflection – on –action on the other hand is seen as a procedure for studying immediate, at-hand events in order to understand them and develop a conceptual framework for useful practice. It involves recalling one’s teaching after the class. This is interpersonal and occurs after an event might have taken place. Reflection on action includes:

- Involvement in a scenario (an action);
- Recording of the scenario (for getting stable idea);
- Determinations, interpretations and evaluation;
- Formation of educational construal; and
- Confirmation to determine whether the construal has meaning to other practitioner Garman (1989) in Problete (1999).

UNIVERSITY OF IBADAN LIBRARY

Another type of reflection is reflection –for- action which occurs before an event is taken place. All is embedded under reflective practice

Reflective teaching stems from John Dewey's concept of "reflective inquiry" (Dewey, 1938). He viewed the students as an inquirer and an active participant in learning. He assumed that the interaction of subject-matters and method of inquiry could not be ignored in schooling. Following this line of thinking, the reflective teacher makes decision based on a problem-solving paradigm (Orlich, et al, 2010). Problems are not viewed as obstacles to overcome but as opportunities to be met. Teachers reflect on problems, and as part of a learning community, they call on others (i.e. their peer and senior colleagues) to reflect on identified problems. In such cases, they collectively list a series of alternatives that they can take. Ultimately, such list is narrowed down to a set of actions that are ethical, just and educationally sound. Reflective teaching can be thought about in terms of asking searching questions about experience and conceptualized as both a state of mind and an on-going type of behavior. Being a reflective practitioner at any stage in teacher development involves constant, critical look at teaching and learning and at the work of the teacher (Harrison, 2008). Reflective Teaching deals with active research, critical thinking and professional enquiry. It also deals with thinking deeply to solve a given problem and in doing this you ask a lot of thought provoking questions. A reflective teacher, according to Dewey (1933) is willing to engage in constant self appraisal and development. Among other things, it implies flexibility, rigorous analysis and social awareness. Also, Orlich, et al (2010) reported that with reflective teaching, student can work harmoniously together, foster their own learning strategies and create an atmosphere in which information sharing can take place .With reflective teaching, students will be good thinkers thereby making them a responsible citizens and good learners. For an effective teaching session, it is necessary both to stimulate pupil's

UNIVERSITY OF IBADAN LIBRARY

interest and provide structure for the subsequent activities (Pollard, 2008) as reflective teaching according to Strouse (2001) is ideally the more efficient way to reach every student in the classroom.

In spite of the confusion about what is meant by the use of the term reflective teaching, “the slogan of reflective teaching has been embraced by teachers, teacher educators, and researchers all over the world” (Zeichner & Liston, 1996). Reflective teaching means looking at what you do in the classroom, thinking about why you do it, and thinking about if it works, a process of self-observation and self-evaluation. It is a conscious attempt to think before, during and after instruction for the betterment of the end product on the part of the students (Taghilou, 2007). Reflective teaching is therefore a means of professional development which begins in our classroom. In practical terms, this means giving careful consideration or thought to teaching and students’ learning to make it dynamics. It is adopting an analytical approach to teaching, which involves examining, framing, attempting to solve dilemmas of classroom and questioning assumptions, values and beliefs about teaching (Minott, 2009). It also involves taking part in curriculum development, being involved in changes occurring in the college and, taking responsibility for own professional development. Bailey (1997) defined reflective teaching as signifying a movement in teacher education, in which student teachers or working teachers analyze their own practice and its underlying basis, and then consider alternative means for achieving their ends. It involves recognizing, examining, ruminating over the way an individual teaches. Teachers think metacognitively about what works for them and what needs improvement. Through reflection, teachers gain the personal and professional knowledge (Grossman, et al, 2001).

Reflection or “critical reflection” refers to an activity or process in which an experience is recalled, considered, and evaluated, usually in relation to a broader purpose.

UNIVERSITY OF IBADAN LIBRARY

It is a response to past experience and involves conscious recall and examination of the experience as a basis for evaluation and decision making and as a source for planning and action (Jack, 1990).

The term "reflective practice" coined by Schon (1987), focuses on the ways people think about their experiences and formulate responses as the experience happen. This approach makes a clear distinction between "thinking on action" and "thinking in action". (Clarke, 2007) Thinking on action is the way of analyzing experiences as they happen while thinking in action determine how responses are formulated (Krause, 2004). Reflective practice leads to reflective teaching.

The concept of reflective practice centers on the idea of life-long learning where a practitioner analyses experiences in order to learn from them. Reflective practice is used to promote independent professionals who are continuously engaged in the reflection of situations they encounter in their professional worlds.

Models of Reflective Practice

There are several models of reflection used to draw lesson out of experiences some of which are presented below:

Argyris and Schon Model of Reflective Teaching

Argyris and Schon pioneered the idea of single loop and double loop learning in 1978. The theory was building around the recognition and amendment of a perceived fault or error. Single loop learning is when a practitioner or organization, even after an error has occurred and a correction is made, continues to rely on current strategies, technique or policies when a situation again comes to light. Double loop learning

UNIVERSITY OF IBADAN LIBRARY

involves the modification of personal objectives, strategies or policies so that when a similar situation arises a new framing system is employed (Argyris &Schon, 1978)

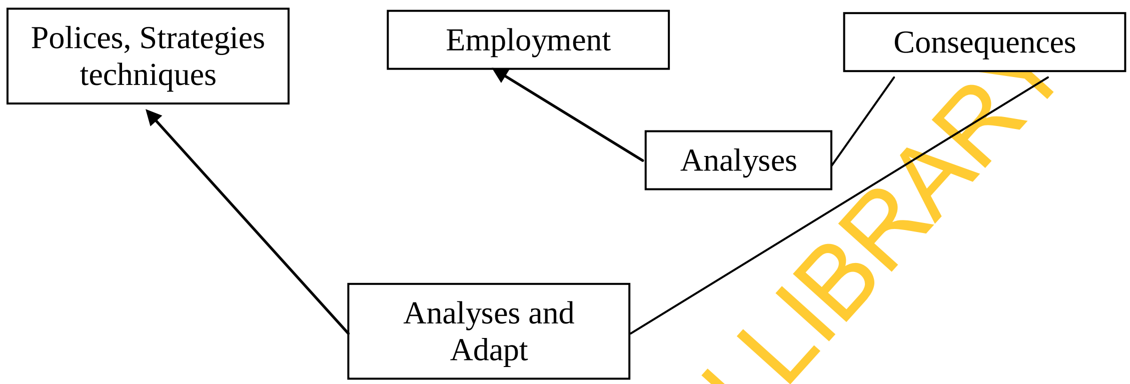


Fig. 3 Adaptation of the Argyris and Schon Double loop Learning Model

Schon himself introduced some years later the concept of Reflection-in-action and Reflection-on-action the summary of which was presented in the figure below:

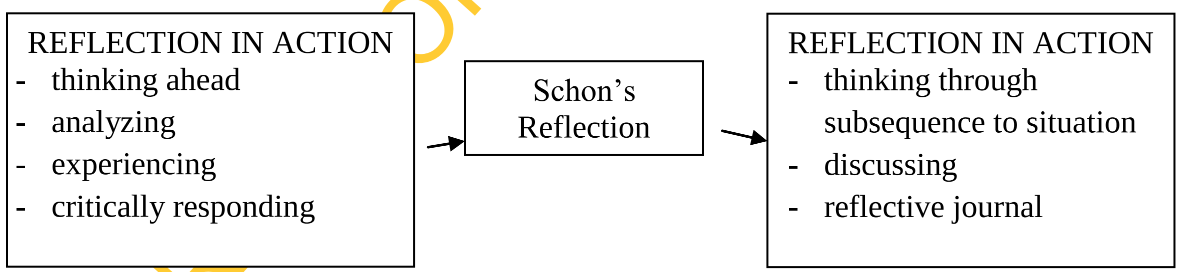


Fig. 4 Schon concept of reflection-in-action and Reflection-on-action

Gibbs Model of Reflective Teaching

Its own model is a circular process of reflection where practitioners must not only describe the experience but include an evaluation and analysis of how they were feeling during the experience. This examination of the emotion associated with the situation allows a practitioner to make sense of the situation and come to a conclusion of what also could be done, or what other options could have been taken. The important aspect of

UNIVERSITY OF IBADAN LIBRARY

Gibbs' model is the final stage whereby Action Plan is formulated to examine what actions would be employed if the situation arose again (Gibbs, 1988)

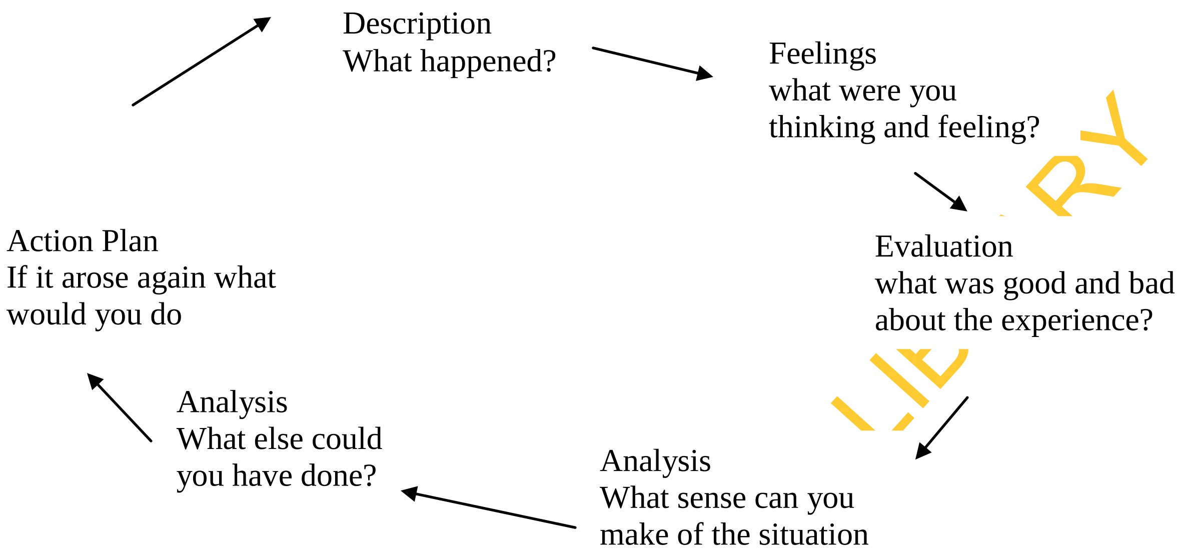


Fig. 5 ***Adaptation of the Gibbs Reflection model.***

(Source: Gibbs, 1988)

Rolfe Model of Reflective Teaching

Rolfe's reflection model is based around Bolton's (1970) developmental model (Bolton, 1970). A simplistic cycle composed of 3 questions which asks the practitioner, what, so what and now what. Through this analysis, a description of the situation is given which leads into the scrutiny of the situation and the constitution of knowledge that has been learnt through the experience. Subsequent to this, ways in which to personally improve and consequence of one's response to the experience are reflected on.

UNIVERSITY OF IBADAN LIBRARY

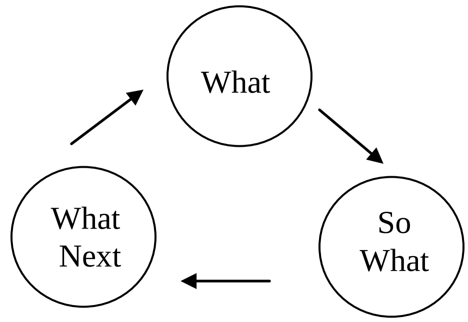


Fig. 6 Rolfe's reflection model

(Source: Rolfe, G., Freshwater, D. & Jasper, M. (2001)

Kolb's Reflective Model.

Kolbs' reflective model highlights the concept of experimental learning and is centered on the transformation of information into knowledge. This takes place after the situation has occurred and entails a practitioner reflecting on the experience, gaining a general understanding of the concepts encountered during the experience and then testing these general understandings on a new situation. In this way the knowledge that is gained from a situation is continuously applied and reapplied building on a practitioner's prior experience and knowledge (Kolb & Kolb, 2005).

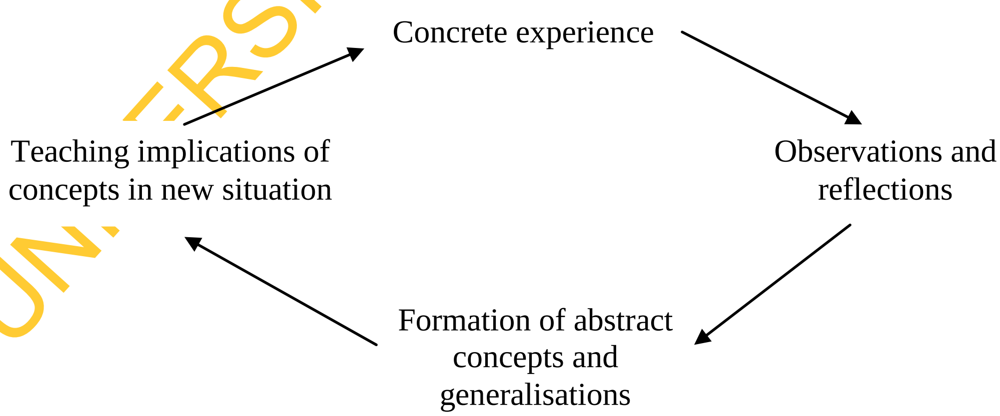


Figure 7. Kolb's reflective model

Kolb, 1984

(Source: Kolb, 2005)

UNIVERSITY OF IBADAN LIBRARY

This study adopts the Kolb (1984) reflective model. Reflective practice occurs at all stages of the teaching process, planning, action (execution), and evaluation (Clark, 2007). That is, the thinking about teaching, which involves the thoughts teachers have before, during, and after the actual enactment of a lesson. This construct is parallel to the thinking processes identified by Polya (1945). In his concept of mathematical problem solving, there are three phases: (a) Understanding, (b) Planning, and (c) Looking back.

According to Clarke (2007), teachers should engage in similar types of thinking before they teach a lesson. To achieve desired results, teachers should reflect on their teaching goals and method and how these interface with the demographics and abilities of their students. This process would allow them to clarify their knowledge base, the mathematics content, and their students' learning styles and to crystallize the pedagogy to be implemented (Clark, 2007). Teachers must consider the challenges that students may encounter and strategies to assist students in overcoming them. Polya's "looking back" phase is the reflective thinking that teachers engage in after they teach a lesson (Artzt & Armour-Thomas, 2002). At the end of the lessons, teachers evaluate the lesson goals and the actions of both themselves and their students as well as define the points at which difficulties emerged. Methods of reflection include the following:

- Reflective journal
- Videotaped lesson / peer conference
- Students input and lesson evaluations
- Student can provide structural evaluations of a lesson

They must consider the strategies employed and when necessary make modifications. The self-assessment helps identify what was not addressed and the unexpected

UNIVERSITY OF IBADAN LIBRARY

challenged of the lesson. Failure to acknowledge these challenges could impede teachers' self-improvement and their students' achievement (Harrison, 2008). The stages of the reflective teaching adopted are a model-experience-reflect format which is as follows:

- Facilitators model an exercise, such as planning, teaching, or problem solving – plan
- Next, the facilitator (i.e. the teacher) experience the activity – teaching
- Finally, at the close of each activity, everyone reflect – debrief (Hart, et, al, 2004)

Orlich, et al (2010) lists the following as characteristic of a reflective teacher:

- Cares about students
- Understands the social context of schooling
- Questions assumptions
- Knows content
- Identifies Problems or issues
- Collects relevant data
- Constructs a plan of operation
- Uses many instructional strategies
- Practices problem-solving strategies
- Thinks prospectively and retrospectively
- Realizes that reflection is cyclical
- Evaluates the results and process used.

Leitch and Day (2000) submitted that the appeal of the use of reflective teaching by teachers is that as teaching and learning is complex, and there is not one right approach,

UNIVERSITY OF IBADAN LIBRARY

reflecting on different versions of teaching, and reshaping past and current experiences will lead to improvement in teaching. As larrivee, (2000) argues, Reflective practice moves teachers from their knowledge base of distinct skills to a stage in their careers where they are able to modify their skills to suit specific contexts and situations, and eventually to invent new strategies. In implementing a process of reflective practice teachers will be able to move themselves, and their schools, beyond existing theories in practice (Leitch & Day, 2000).

Clarke, (2007) use the reflective teaching model with student teachers pairmate as part of a microteaching experience and found out that as they continue to use the Reflective Teaching model, student teachers discovered that it provides them with a structural approach that enabled them to add ideas and details to their lesson. The student teachers also found out that it engaged their students in activity that required cooperative learning and group interaction

Reflective teaching involves asking oneself questions like the following:

- why do I teach the way I do?
- What principle and beliefs inform my teaching?
- Should I do it differently?
- What is the greatest single challenge I face in my teaching?
- Why does a particular teaching method work well for one student but not for another?
- What are my unconscious teaching routines?
- What am I doing right in my classroom?
- What am I doing that is not right?

UNIVERSITY OF IBADAN LIBRARY

- How can I do it better if given second chance?
- What made my lesson seem so successful/not successful?

The following are the advantages of reflective teaching:

- It develops the quality of teaching through continuous improvements.
- It gives educators new opportunities to reflect on and assess their teaching.
- It enables teachers to explore and test new ideas, methods, approaches, and materials.
- It provides opportunity to assess how effective the new approaches were.
- Teachers share feedback with fellow team members.
- They make decisions about which new approaches to include in the school's curriculum, instruction, and assessment plans.
- It significantly increases student motivation for learning
- It recognises individual progress
- It enhance and develop forms of collaborative learning
- It increase learner independence
- It enhance confidence Donald, (1985).

Taghilou, (2007) also listed the following as part of benefit a teacher stand to enjoy from being a reflective teacher:

- It provides time for calm review of the days happening.
- Self-reinforcement of things that worked,
- Space for devising strategies for improvement,
- Put teachers in control and allows them to grow professionally from their own expertise, daily experience and understanding of what student's needs.

2.2.3 Cooperative Learning and Students Learning Outcomes in Science

Though, there are a lot of articles written about cooperative learning in recent years, busy secondary school teachers contending with heavy curricular and teaching demands might not know much about the instructional method. Equipped with only a partial understanding of cooperative learning, some teachers may view it as a series of forced artificial constructs. It is simply separating students into groups for an activity (Lin, 2006). Cooperative learning is an instructional method in which students work in small groups to accomplish a common learning goal under the guidance of a teacher. The method is characterized by the following features, which are distinct from other forms of group work:

- Learners positively depend on one another in a team to achieve a mutual learning goal.
- Learners engage in face-to-face interactions.
- Learners are assessed individually and held accountable for equally sharing and contributing to the mastery of learning goals.
- Learners reflect and assess the effectiveness of group functioning for future learning (Johnson, Johnson & Smith, 1991; Bonwell & Eison, 1991). Johnson, Johnson, and Smith defined cooperative learning as "the instructional use of small groups so that students work together to maximize their own and each other's learning. Learners use and develop appropriate collaborative and interpersonal skills to teach and encourage one another to learn. Prince (2004) list five essential components that must be present for small-group learning to be truly cooperative:

1. clear positive interdependence between students
2. face to face interaction
3. individual accountability
4. emphasize interpersonal and small-group skill
5. processes must be in place for group review to improve effectiveness.

UNIVERSITY OF IBADAN LIBRARY

Cooperative learning processes lessen individual competitiveness and foster cooperative small problem-solving group behavior (Johnson, Johnson, & Smith, 1991; Slavin 1991). By having learners treat one another as resources and requiring learners to go beyond only superficial engagement with learning materials, cooperative learning provides the social context for students to actively learn and make deeper connections among facts, concepts, and ideas.

Three primary purposes of using cooperative learning are to develop students' social and communication skills, increase tolerance and acceptance of diversity, and improve academic achievement. Researchers found that students who participated in cooperative learning exhibited less competitive behavior and more cross-ethnic cooperation than those who participated in whole-class teaching (Slavin, 1991). Researchers also found that cooperative learning promotes better relationships among students (Slavin, 1991).

2.2.4 Effects of Reciprocal Teaching on Students' Achievement and Science Process Skills

Reciprocal Teaching refers to an instructional activity that takes place in the form of a dialogue or conversation among students regarding a concept. According to Palinscar (1984), during reciprocal teaching, the teacher and students take turns assuming the role of teacher in leading this dialogue, which leads to an interacting group learning experience. Reciprocal teaching stems from the concern for content interacting which have been given educators greater insight into how to help student read for meaning and monitor their comprehension. This approach was successfully developed by Palinscer

UNIVERSITY OF IBADAN LIBRARY

and Brown. It is a cooperative process that infuses cognitive and metacognitive skills with schema activation in the context of shared dialogues among teachers and student. Foster and Rotoloni (2005) also defines reciprocal teaching as a cooperative learning instructional method in which natural dialogue models reveals learners' thinking processes about a shared learning experience. Teacher foster reciprocal teaching through their belief that collaborative construction of meaning between themselves and students leads to a higher quality of learning (Allen, 2003). Students take ownership of their roles on reciprocal teaching when they feel comfortable expressing their ideas and opinion in open dialogue. They take turns articulating and talking through their thought. The learning community is able to reinforce understanding and to see, hear, and correct misconceptions that otherwise might not have been apparent (Foster & Rotoloni, 2005). All members of the community have shared responsibility for leading and taking part in dialogue during learning experience, (Hashey & Connors, 2003).

Reciprocal teaching is based on Vygotsky's theory of fundamental role of social interaction (dialogue) in the development of cognition. Palincsar, Brown, and Comprone (1989) in Foster and Rotoloni (2005) defined reciprocal teaching as a dialogue between teacher and student. This dialogue is described as reciprocal because each learner acts in response to another. This interaction may occur between teacher and student or between students.

RT has been used successfully with middle level students. As reported by Foster and Rolotoni, 2005 RT strategy was used by Mrs Clark with her third grade class to teach reading comprehension with her class which has several students who are reading well below grade level. The students see themselves as poor reader but after exposing them to reciprocal teaching they feel comfortable to take part in discussions and engaging with

UNIVERSITY OF IBADAN LIBRARY

both fiction and non-fiction grade level texts. Palincsar & Brown (1986), as cited in Oczkus (2003), observed that reciprocal teaching used with a group of student for 15-20 days unproved reading comprehension on assessments by 30 to 80 percent.

As earlier stated, reciprocal teaching is based on Vygotsky's theory of the fundamental role of social interaction (dialogue) in the development of cognition. Vygotsky's theory of Zone of Proximal Development (ZPD) is critical to identify appropriate text and scaffolding activities to support student success (Vygotsky, 1978). Text must be at a level that can be effectively shared, not too difficult. Appropriate support and feedback must be given to facilitate learning during reciprocal teaching activities (Oczkus, 2003). The procedures are first modeled by the teacher then they are practiced and coached with peer and teacher feedback.

Finally, the leadership of the group work strategy is handed over to the students (Allen, 2003). The teacher monitors and evaluates to determine where scaffolding is needed to help students to be successful in using strategies. Students become aware of their own learning process and think critically about them.

The dialogue is structured by the use of four strategies, sometime known as the "Fabulous four" (Oszkus, 2003), which are predicting, questioning, clarifying and summarizing. See figure bellow:

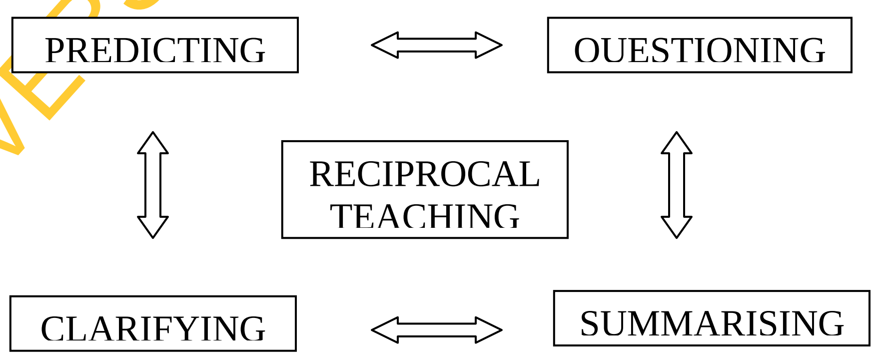


Figure 8. Oszkus' Fabulous four
(Source: Oszkus, 2003)

UNIVERSITY OF IBADAN LIBRARY

Basically the reciprocal teaching is in two phases which are as follows:

Phase One: Teacher Instruction of Strategies

Step One: Here teacher provides students with instruction and practice of four comprehension strategies are:

1. Predicting: students are encouraged to make a guess on what the text is going to be about e.g. what kind of problems can we solve with equation of motion?
2. Questioning: what, why and how questions should be asked about the section to build a shared understanding. What do you think about the motion of an object in a straight line?
3. Clarifying: clear up any misunderstandings or misconceptions unclear vocabulary or concepts.
4. Summarizing: help students get the main idea of the section, text or concept by summarizing it e.g. what did we learn? What are the important concepts or ideas we learned in this

Step Two: Students practice these strategies in small group of not less than six and through whole class discussion. The teacher monitors these discussions and provides feedback.

Phase Two: Students ownership and use of strategies

Step Three: After students have become comfortable with the strategies, there is a shift in roles with the students working in pairs and small groups and exchanging the role of teacher. The teacher still monitors the discussion but takes a less active role in the learning.

UNIVERSITY OF IBADAN LIBRARY

According to Rosenshine & Meister (1994), there are four important instructional practices embedded in reciprocal teaching:

- Direct teaching of strategies, rather than reliance solely on teacher questioning
- Student practice of reading strategies with real reading, not with worksheets or contrived exercises
- Scaffolding of instruction: students as cognitive apprentices
- Peer support for learning

Instructional techniques involved in it according to Palincsar, Ransom and Derber, (1988) are: demonstrate, or model and explain, practice with feedback, dialogue or "simple conversation with a purpose" (scaffold or provide students with temporary support and take turns leading text dialogues.

Reciprocal teaching involves a high degree of social interaction and collaboration, as students gradually learn to assume the role of teacher in helping their peers construct meaning from the text.

The procedure of reciprocal teaching, according to Palinscar (1984), is as follows:

- A dialogue between students and teacher, each taking a turn in the role of dialogue leader;
- "Reciprocal" interactions where one person acts in response to the other;
- Structured dialogue using four strategies: questioning, summarizing clarifying, predicting:

  They also state how the four strategies should be introduced as follow:

- During the initial phase of instruction, the teacher assumes the strategies

UNIVERSITY OF IBADAN LIBRARY

- Through modeling the teacher demonstrate how to use the strategies while reading text.
- During guided practice the teacher supports students by adjusting the elements of the task based on each student's level of proficiency.
- Eventually the students learn to conduct the dialogue with little or no teacher assistance

The teacher assumes the role of a coach\facilitator by providing students with evaluative information regarding their performance and prompting them to higher levels of participating.

Advantages of reciprocal teaching are: students are actively engaged in learning; reading strategies are used in an integrated, coordinated way in a meaningful context; students enjoy working together and being "teacher"; students are able to learn with the benefit of repeated tutor modeling and learn to take responsibility for their own and each other's learning.

Following are research-based guidelines for effective reciprocal teaching:

1. **Shift gradually**. The shift from teacher control to student responsibility must be gradual.
2. **Match demands to abilities**. The difficulty of the material and the responsibility given to students` must match the competencies of each student and grow as these competencies develop.
3. **Diagnose thinking.** Instructors should carefully observe the "teaching" of each student for clues about how the student is progressing in mastering the strategies and whether or what kind of follow up instruction is needed.

UNIVERSITY OF IBADAN LIBRARY

The review of research on the relationship between reciprocal teaching and student's ability to construct meaning from text has shown a variety of positive results. For instance, over time reciprocal teaching instruction has produced positive changes in students' reading comprehension, as measured by experimental – designed and standardized texts (Brady, 1990; Carter, 1997, Taylor & Frye, 1992). Reciprocal teaching also helps to improve the quality of student-generated questions (Palinscar, 1984) and enables students to write summaries consisting of mostly main ideas (Taylor & Frye, 1992, Dermody, 1988, Paliscar, 1987).

Most importantly, these results have been documented with a wide range of students including those considered low readers, those with learning disabilities, and those for whom English is not their first language (Brady, 1990, Klingner & Vaughn, 1996).

A significant body of research (Carter, 1997; Palinscar, 1984, Palinscar & Klenk, 1991) has shown that students who have been struggling with reading and are taught how to think about text in this way are able to feel comfortable taking part in discussions and engaging with both fiction and non-fiction grade level texts. They begin to understand how to make sense of what they are reading whether it is in the context of pleasure reading, classroom reading, social studies text, science text, or even in Mathematics word. Paliscar and Brown (1986, as cited in Oczkus, 2003), observed that reciprocal teaching used with a group of students for 15-20 days improved reading comprehension on assessments by 30 to 80 percent. Paliscar and Klenk (1991) concluded that students improved reading skills immediately and also exhibit that they had maintained these skills on texts performed a year later. Also, in a study by Hashey, and Connors, (2003), the

UNIVERSITY OF IBADAN LIBRARY

teachers saw increase in students' confidence and success, in their understanding and use of strategies, and in their enjoyment of the lesson.

Also, Garderen (2004) opined that a modified version of reciprocal teaching (i.e. clarifying, questioning, summarizing and planning) can benefit students who struggle to comprehend mathematical word problems. In a reciprocal teaching mathematics lesson, one student is assigned to be group leader. The student leads the other students through each of the four steps as follows

- the group first clarifies any words or phrases that are not understood
- then the leader uses questions to guide the group into identifying the key parts of the problem
- next, the leader summarizes the purpose of the word problem and
- finally guides the group in creating a plan to solve the problem
- each person in the group takes turn being the leader.

While positive effects of reciprocal teaching are well document ted, limitations in past research exist, for example, most reciprocal teaching studies were conducted using experimental designs involving statistically comparable groups of students and controlled variables. Yet this does not reflect typical classroom situations. Even when more naturalistic designs were used, most studies were conducted during a time when practice was influenced by more traditional models of learning emphasizing transmission of knowledge rather than construction of knowledge. However, very few studies have analyzed the dialogue of reciprocal teaching to determine how well the intervention was taught and what effect, if any; it had on students' abilities to construct meaning (Rosenshine & Meister, 1994). Also, most research works on reciprocal teaching was based on reading comprehension, its effect on science related course are not

UNIVERSITY OF IBADAN LIBRARY

documented and this, the present research intends to do. It would also examine reciprocal teaching in typical classroom, where teachers had previous exposure to constructivist thinking.

2.2.5 Effects of Reciprocal Peer Tutoring on Students' Achievement and Science Process Skills

Peer tutoring is an interaction in which one student provides instruction or academic assistance to another student. It is a form of cooperative learning which has been found to be an effective technique for increasing students' academic achievement (Bargh & Schul, 1980; Sherman, 1991; Slavin, 1991). Peer tutoring can take many forms in the classroom setting. The most effective form of the peer tutoring was a reciprocal method where the students reverse roles of tutor and tutee regularly. When students are required to explain their thought process in such a way that the other students will understand, they get a deeper understanding of the concept themselves (Spencer, 2006). Reciprocal Peer Tutoring has a structured format where "students prompt, teach, monitor, evaluate and encourage each other" (Fantuzzo, King & Heller, 1992).

Research on tutoring has also demonstrated educational benefits for tutors and tutees of various ages and abilities, ranging from kindergarten to secondary (e.g. Fuchs & Fuchs, 2003 etc.). Tutors, however, usually benefit most from peer tutoring, perhaps because they engage in rehearsal of course content while preparing to teach tutees (Bargh & Schul, 1980). Studies have shown that peer tutoring can improve performance in a variety of subjects including spelling, mathematics but there is not much evidence to show its effect on science related subjects, hence, this research work.

UNIVERSITY OF IBADAN LIBRARY

Noting the benefits students derived from acting as a tutors, Fantuzzo and his associates (Pigott, Fantuzzo, & Clement, 1986; Wolfe, Fautuzzo & Wolfe, 1986) developed a procedure that enable both members of a peer tutoring pair to participate in the tutoring role. In this technique, known as Reciprocal Peer Tutoring (RPT), students function reciprocally as both tutor and tutee. This dual role is beneficial because it enables students to gain from both the preparation and instruction in which tutors engage,, and from the instruction that tutee receive.

Previous research on PRT has tested its effectiveness for elementary students (Frantuzzo, King & Heller, 1992) and undergraduates' psychology students (Frantuzzo,Riggo, Conmelly,& Dimeff, 1989). These studies demonstrated that PRT improved the academic achievement of both groups. In addition, the findings of three experiments with both undergraduates suggest that RPT reduce their level of stress and anxiety (Griffin & Griffin, 1997). Walker (2007), Mesler (2009), and Spencer (2006) observed different types of children and they all discovered that pairing students in the form of peer tutors increased the achievement of both students

RPT has a structured format where students prompt, teach, monitor, evaluate and encourage each other (Fantuzzo, King & Heller, 1992). Students are part of the educational process and are able to prepare instructional materials and receive feedback from peers. The alternating structure is designed to utilize group reward and interdependence to maximize learning and motivation. In the context of peer tutoring, the role of the teacher is to facilitate, observe, question, and guide the learning of their students. However, it is still necessary to include some whole group instruction so the students have a base of knowledge. As according to Fernandez-Santander, (2008),

UNIVERSITY OF IBADAN LIBRARY

"Maintaining short periods of lecturing in every session was very helpful in the development of the pupil's trust in the new learning methodology and in the success of it" After the content has been given, then the teacher can roam the room to listen to discussions that students are having about the material. This will help them begin to understand the thought processes that their students are following and may intervene if they feel it is necessary.

Format for a PRT lesson

- Peer tutors present tutees with a problem to solve using a flashing card with the answer at back, the student computes the problem in writing on a worksheet.
- Tutee responds correctly or incorrectly
- After ten minutes, the pairs switch role and continue for another 10 minutes
- Once the tutoring is completed a 16-problem quiz covering what was practiced is given.
- Individual goals are combined with group goals and are rewarded if they met or surpassed the predetermined goals (Fantuzzo, Davis & Ginsburg, 1995).

2.2.6 Mode of Entry and its Influence on Achievement and Science Process Skills

Pre-service teacher can be admitted into a college of education either through direct entry (when all the requirement are met) or through preliminary study (when there is a deficit in the admission requirement and such deficit must be available before the end of the programme). Mode of entry into NCE programme depends on the student performance in General Certificate in Education and/or Secondary School Certificate Examination result and their performance in UTME scores. The academic success of a

UNIVERSITY OF IBADAN LIBRARY

student at a given moment refers to how an individual is able to demonstrate his or her intellectual abilities .Daniel and Schouten (1970) in Adeyemi (2009) argued that a prediction of a future examination result could be made with reasonable success on the basis of the results of an earlier examination and that grades may serve as prediction measures and as criterion measures. Findings made by Peers and Johnson (1994) confirmed the validity of the number and grades of passes in the Scottish Certificate of Education in predicting first year and final year university performance. Also, in a study carried out by Gay (1996) in USA, it was confirmed that high school grades are good predictors of college grades.

Previous studies on the effect of mode of entry on performance of students in Medical School have reported no difference between concessional and Direct Entry students, better performance by UME/JAMB students, against Direct Entry and Remedial (Pre-degree) science student (Olaleye & Salami, 1997). The study carried out by Afolabi, et al. (2007) on 200 level medical students of Ladoke Akintola University of Technology shows that the students admitted through JAMB performed better in 200 level Physiology examinations but that there was no correlation between the University Matriculation Examination (UME) scores and the O-Level aggregate. Houltram, (1996) carried out a study into the relationship between entry age, entry qualification and academics performance on the common foundation programme which lasted for 18 month found out that performance of most matured students, whether qualified or not, was above average, with the qualified group higher.

Simeon, Irtwanger and Nancy (2010) also carried out a comparative analysis of academic achievement of UME and ex-Remedial students with University of Agriculture,

UNIVERSITY OF IBADAN LIBRARY

Markudi. The result of their research work shows those ex-Remedial students were found to have higher consistent and predictable achievement than UME. In a similar way Keith (1989), in its research on influence of mode of entry, sex and secondary science background on the attitude and knowledge score reported that mature age students(especially women), despite lower science entry scores on the measure used, appear to develop more positive attitude toward science.

2.2.7 Numerical Ability and its Influence on Achievement and Science Process Skills.

Studies have shown that numerical skills are necessary factors that support mathematics and science achievement. Nunnally (2004) defines Numerical ability as the ability to relatively solve problems in number sequencing, make accurate mathematical deductions through advanced numerical reasoning, interpret complex data presented in various graphical forms, deduce information and draw logical conclusions. It is design to measure the students ability to use numbers to correctly solve problems. Such test according to Olatoye and Aderogba (2011) signify basic arithmetic prowess in an individual. He went further that numerical ability test can be given directly to candidates or administered as subsets of other test. Numerical ability has been shown to influence students' achievement. Adu (2002) tested the influence of quantitative ability among other independent variables on students' academic achievement in Economics. The study found a significant influence of quantitative ability on student's academic achievement. Also Emeka and Adegoke (2001) examined the effect of students' numerical ability on the cognitive achievement of senior secondary school Physics student. The study revealed

UNIVERSITY OF IBADAN LIBRARY

that the higher the numerical ability of students, the better their performance in the physics achievement test. This may be expected in the sense that physics is quantitative in nature therefore students with high numerical skills are likely to record higher performance in physics achievement tests than their counterparts with low numerical ability. Falaye (2006) on the other hand carried out a research on final year Senior Secondary School Students in Nigeria to investigate the influence of gender, course study and numerical ability on the student's achievement in practical Geography. The study revealed that the impact of student's numerical ability on their achievement is not significant. Also Ursos and Bauyot (2006) carried out a study on Mathematical Modeling of Numerical Ability test and achievement test in college algebra. The result of the study showed that a moderate correlation exists between numerical ability test and achievement test.

2.3 Appraisal of Literature Review.

Studies on reflective practice to teaching and learning were examined in the review. It has been observed that majority of the studies were conducted in disciplines other than those of science. Most literature on reflective teaching, focused mainly on it's used by pre-service teachers during teaching practice exercise. Also, literature on both reciprocal teaching and reciprocal peer tutoring are mainly on reading comprehension, social studies text, spelling, and so on, its effects on mathematics and science related courses are not documented. Also there is no enough literature on the use of reciprocal teaching and reciprocal peer tutoring strategies with the pre-service teachers. The review was devoid of an empirical base for using reflective teaching in teaching and learning of

UNIVERSITY OF IBADAN LIBRARY

science. This necessitates the need to adapt the model to focus primarily on the effectiveness of reflective teaching with reciprocal teaching and reciprocal peer tutoring on the teaching of science concepts. This is why, in this present study, it is intended to make an empirical investigation on the effect of reflective teaching coupled with reciprocal teaching and reciprocal peer tutoring on pre-service teachers achievement in selected science concepts and science process skills.

UNIVERSITY OF IBADAN LIBRARY

CHAPTER THREE

METHODOLOGY

This chapter presents the research design, variables in the study, selection of participants, instrumentation, research procedure as well as method of data analysis

3.1 Research Design

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

Experimental group I 0_1 X_1 0_4

Experimental group II 0_2 X_2 0_5

Control group 0_3 0_6

where 0_1, 0_2 and 0_3 represent the pretest observations of experimental I, II and control groups respectively.

0_4, 0_5 and 0_6 represent the posttest observations for experimental groups I, II and control group respectively.

X_1 is experimental treatment of Reflective-Reciprocal Teaching

X_2 is experimental treatment of Reflective-Reciprocal Peer Tutoring

This design employed the use of 3x3x2 factorial matrix presented on Table 2

UNIVERSITY OF IBADAN LIBRARY

Table 3.1 Schematic Diagram of the Factorial Matrix

Treatment	Numerical ability	Mode of entry	
		Prelim	Direct
Reflective-Reciprocal Teaching	Low		
	Medium		
	High		
Reflective-Reciprocal peer tutoring	Low		
	Medium		
	High		
Conventional Teaching	Low		
	Medium		
	High		

3.2 Variables in the study

The **independent variable** is the teaching strategy manipulated at three levels:

1. Reflective- Reciprocal Teaching,
2. Reflective -Reciprocal Peer Tutoring,
3. Conventional Teaching.

The **Moderator variables** are two:

a. Pre-service teachers' numerical ability at 3 levels

1. Low
2. Medium
3. High

UNIVERSITY OF IBADAN LIBRARY

b. Pre-service teacher's mode of entry

1. Preliminary Study
2. Direct Entry

Dependent Variables: These are:

i. Pre-service teacher's achievement in Integrated Science.

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

These are summarized in the figure below:

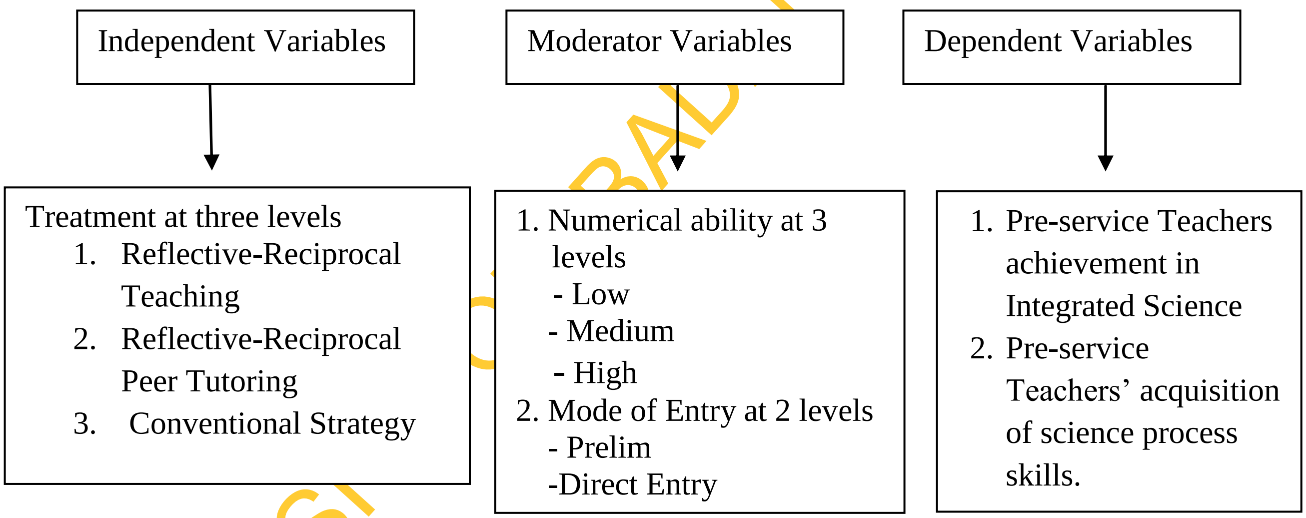


Figure 9i: Schematic diagram of Variables in the Study

3.3 Selection of Participants

The participants for this study was taken from N.C.E II Pre-service teachers studying Integrated Science as teaching subject in the government owned eleven (11) colleges of education (four owned by the Federal government while the remaining seven by the State government) in Southwestern Nigeria. From these Colleges, Six (three federal and three state) was purposively selected based on their relative distance from one

UNIVERSITY OF IBADAN LIBRARY

another. The colleges were randomly assigned to treatment and the control group. Two colleges were exposed to Reflective-Reciprocal teaching another two to Reflective-Reciprocal Peer Tutoring and the remaining two to the Conventional Teaching.

From the selected colleges, intact classes of N.C.E II Integrated Science were used for the study.

3.4 Selection of topic/concept

N.C.E II Integrated Science students offer five courses in their second semesters. Of the entire five courses, Dynamics which is the only physics related course among them was chosen for this study. The code is ISC 223. This is because the students have done the Pre-requisite to this course in their first year as Man and Energy 1, which gives the course a very good background. The content of the course includes:

i. Speed and acceleration
ii. Linear momentum
iii. Work, energy and power

3.5 Instrumentation

Six instruments were used in the study. These include:

1. Operational Guide for Reflective-Reciprocal Teaching Strategy (OGRRTS)
2. Operational Guide for Reflective-Reciprocal Peer Tutoring Strategy (OGRRPTS)
3. Operational Guide for Conventional Teaching Strategy (OGCTS)
4. Pre-service Teachers' Numerical Ability Test (PTNAT)
5. Pre-service Teachers' Achievement Test in Integrated Science (PTATIS)
6. Science Process Skills Rating Scale (SPSRS)

UNIVERSITY OF IBADAN LIBRARY

3.5.1 Operational Guide for Reflective-Reciprocal Teaching Strategy (OGRRTS)

This operational guide was used for teaching experimental group 1. It is an instructional guide based on the philosophy of cooperative work among learners and reflection on the part of the research assistance and the pre-service teachers. This operating guide is made up of four RT strategies of 'Predicting' 'Questioning' 'Clarifying' and 'Summarising.

The research assistance models the four RT strategies, and then provides examples of meaningful dialogue in which text ideas were elaborately connected to previous knowledge and applied in new ways. Next, the research assistance provides guided practice for their students; gives them feedback on their use of RT strategies and allows them to take ownership of the strategy.

Validation of OGRRTS

The Reflective- Reciprocal Teaching Guide was given to three experience Integrated Science lecturers in a College of Education to rate and examine its content and face validity. The recommendations given were used to reconstruct some of the guide. The inter-rater reliability was then estimated using Scott's π. The inter rater reliability index obtained was 0.75.

3.5.2 Operational Guide for Reflective-Reciprocal Peer Tutoring Strategies (OGRRPTS)

This operational guide consists of five lessons that were used for treatment group II. The lesson plan was based on the steps listed by Utley and Mortweet (1997) as well as Fuchs and Fuchs, (2001). The main features of the guide are; general information,

UNIVERSITY OF IBADAN LIBRARY

procedure, general objective, tutor training, peer tutoring, peers shifting of roles and the content of the subject-matters.

Validation of OGRRPTS

The guide was given to three experienced Integrated Science lecturers in a College of Education to rate and examine its content and face validity. The recommendations given were used to reconstruct some of the guide. The inter-rater reliability was then estimated using Scott's π. The interrater reliability index obtained was 0.72.

3.5.3 Operational Guide for Conventional Teaching Strategy (OGCTS)

The instructional guide consists of six lessons that were used to teach pre-service teacher in the control group. The lessons were based on normal ways of writing lesson note. The main feature of the guide is: general information, the procedure, the teacher, general objectives, content for each lesson, summary and conclusion.

Validation of OGCTS

The operational guide was given to three experience Integrated Science lecturers in a College of Education to rate and examine its content and face validity. The recommendations given were used to reconstruct some of the guide. The inter-rater reliability was then estimated using Scott's π. The inter rater reliability index obtained was 0.77.

3.5.4 Pre-service Teachers' Numerical Ability Test (PTNAT)

This instrument was administered to the pre-service teachers before exposing them to treatment. The instrument developed by the researcher consists of two sections. The section A seeks for demographic information of the respondents such as name,

UNIVERSITY OF IBADAN LIBRARY

college, sex and mode of entry while section B consists of 30 items which the pre-service teachers will solve on the space provided on the question paper to test their numerical ability level.

Validation of PTNAT

To validate PTNAT, the instrument was given to two experts in Science Education. Their advice was incorporated into the items. The modified test items was administered to thirty five pre-service teachers not involved in the main study to determine the reliability and internal consistency of the scores using Split-half method. The reliability index obtained was 0.79.

3.5.5 Pre-service Teachers' Achievement Test in Integrated Science (PTATIS)

This instrument tests the Pre-service teachers' intellectual achievement in speed and acceleration, linear momentum work, energy and power. The test contains fifty multiple-choice objective test items. It has two sections with Section A containing demographic information such as name, college, sex and mode of entry while section B containing the test items constructed as presented in Table 3. The alternatives for the questions range from A to D. One mark goes for each corrects option and zero for wrong option. This means that the total marks obtainable is 50. The test items were generated to cover the cognitive domain of knowledge, Understanding and Thinking in accordance with Okpala; Onocha and Oyedeji(1998).

UNIVERSITY OF IBADAN LIBRARY

Table 3b: Table of Specification for PTATIS

Topic	Knowledge	Understanding	Thinking	Total
Speed and Acceleration	3 (1, 11, 15)	11 (2,5, 7, 9,12, 14, 16, 19, 21, 51, 58)	6 (3, 4, 8, 10 17, 18)	20
Linear momentum	1 (48)	11 (35, 37, 38, 40,41, 42,43, 47, 49, 61, 63)	5 (44, 45, 46, 51, 64)	17
Work, Energy and Power	2 (24, 25)	7 (6, 23, 26, 29, 30, 32,,55)	4 (27, 33, 52, 67)	13
Total	**6**	**29**	**15**	**50**

Validation of PTATIS

To determine the face validity of the instrument, copies of the initial draft of sixty eight multiple choice items were given to three research students in science education who are teaching Integrated Science in Colleges of Education for necessary comments, as regard to suitability and language used. Based on their comments, some items were reworded and ten items were dropped. The draft of the test was also given to two experts in Science Education who went through it and made necessary corrections and suggested that five items be reframed. The test was further administered to thirty-five pre-service teachers from a College of Education which is not part of those chosen for the study. The discriminating indices for each of the items and difficulty levels were also computed by the researcher. The items with moderate difficulty indices of 0.4 to 0.6 were retained while ensuring that such items had positive correlation with the entire test. The responses were used to determine the reliability using Kuder-Richardson formular 20 (KR-20). The KR-20 value of 0.85 was obtained.

UNIVERSITY OF IBADAN LIBRARY

3.5.6 Pre-service Teachers Science Process Skills Rating Scale (PTSPSRS)

This is made up of thirty two items on a 5-point rating scale to measure pre-service teachers' science process skills. The thirty two items were distributed among the six basic science process skills which are observing, classifying, measuring, communicating, inferring and predicting. The rating scales used are: Very Good=5, Good=4, Very Fair=3, Fair=2 and Poor=1.

Validation of PTSPSRS

To validate this, the instrument was given to two lecturers in Science Education for review. Their opinions and advice were used to either discard or rework the items. The instrument was used by three independent raters to observe and rate the pre-service teachers during the activity session. The inter-rater reliability was then estimated using Scott's π. The inter-rater reliability index obtained was 0.82.

3.6 Research Procedure

The following time schedule was used for the study

1^{st} -2^{nd} weeks: Training of Research Assistant

3^{rd} week: Visitation to the Colleges used as control

4^{th} week: Administration of Pretest and numerical ability test

5^{th} -9^{th} weeks: Application of treatment on experimental and control group

10^{th} week: Administration of Posttest and process skill rating scale

1. Training of Lecturers (3 weeks)
2. The researcher personally visit the participating lecturers who are the lecturers handling the course in their respective colleges and train them on how to implement the steps involved in the guides designed. Two lecturers were trained

UNIVERSITY OF IBADAN LIBRARY

for each experimental group 1and experimental group II. The training covers one week each for each of the groups. One week was use to visit the colleges used as control group.

3. The fourth week was used for pretest administration for all pre-service teachers participating in the study using the achievement test and numerical ability test.
4. The fifth to tenth week was used for the implementation of the treatment (including pre-service teachers 'science process skills rating scale) for each of the two experimental and control groups. The pre-service teachers were rated during the first and the last activities class using the Pre-service Teachers' Science Process Skills rating scale with the activities recorded using video recorder.

Procedure for Experimental Group I: Reflective-Reciprocal Teaching Strategy (RRT)

Phase One: Preliminary Plan (Teacher dominates)

Step 1: Pre-Service Teachers are paired into heterogeneous small groups.

Step 2: The research assistance provides Pre-Service Teachers with instructions on the content of the topic.

Step 3: He teaches them how to use the four RT strategies:

i. Predicting: Here the pre-service teachers are encouraged by the research assistance to make guesses on what the text or topic is going to be about e.g. what problems can we solve with equations of motion? What is the role of climate in an ecosystem? What do you think will happen next?

ii. Questioning: 'What', 'why' and 'how' questions will be asked by the research assistance about the section or text to build a shared understanding.

UNIVERSITY OF IBADAN LIBRARY

iii. Clarifying: Misunderstandings, misconceptions, vague vocabularies and concepts are cleared by the research assistance.

iv. Summarizing: At this stage the research assistance help the pre-service teachers to get the main idea of the section, text or concept by summarizing it. e.g. what did we learn? What are the most important concepts or idea we learned in this topic?, predicting, questioning, clarifying and summarizing strategies of reciprocal teaching.

Step 4: Pre-Service Teachers practise the usage of the strategies in small groups while research assistance facilitates or monitors their discussions and make necessary corrections where applicable.

Phase Two: Students dominate i.e. Pre-Service Teachers claim ownership of the usage of the strategies while the research assistance takes less active role and monitors discussion.

Phase Three: Briefing / Reflection

Step 1: The research assistance reflects on the teaching immediately after the class, write reflective notes on any areas that needed improvement. Changes were then made to the next lesson plan based on the reflective note.

Step 2: the pre-service teachers also discuss their self assessment of the lesson with their mate immediately after the lesson, write reflective notes on any areas that needed improvement.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

UNIVERSITY OF IBADAN LIBRARY

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

Procedure for experimental group II: Reflective-Reciprocal Peer Tutoring Teaching Strategy (RRPT).

Phase one: Pre-experimental skills assessment and instruction

Step1: Here the research assistance assesses the pre-service teacher by administering a ten minutes quiz.

Step 2 He tells the pre-service teachers that they will be learning to work in teams to help each other do well in the course.

Step3: He gives them instruction and explanations of how to solve problems and modeled correct solutions. He also explains the content of the subject matter to the pre-service teacher

Phase two: Tutoring stage.

Step1: Pair the pre-service teachers into group of mixed ability based on the result of the quiz in phase one.

Step 2 Gives the materials needed to each group (that is sheets of paper divided into four sections: “try 1”, “try 2”, “help”, “try 3”; problem drill sheets with 10 problems; flash cards and answer sheets.

Step 3 Tell the pre-service teacher to choose who will act as tutor first.

Step4: Tutor training session.

Step5: Peer tutoring which consists of the following steps:

UNIVERSITY OF IBADAN LIBRARY

1. Peer tutors present tutees with a problem to solve using a flash card or writing such problem on the chalkboard with the answer on the back of the flash card. The pre-service teacher computes the problem in writing on the Worksheet.
2. If the problem is solved correctly, the tutors praise the tutees and present the next problem. If the solution is incorrect, the tutors reads the question again and tell the tutees to try again in the worksheet section marked "try 2"
3. If the tutees do not solve the problem correctly on the second try, tutors help them by computing or solving the problem in the "help" section of the worksheet. As the tutors work the problem, they explain what they are doing at each step and answer tutee's questions. Then the tutors tell the tutees to work the problem again in the "try 3" section.
4. If tutors have trouble answering tutees' questions, they can ask the research assistance for help.
5. After ten minutes the pairs switch roles and continue for another ten minutes.
6. During tutoring sessions, the research assistance work around the room supervising and identifying strategies tutors can use to help their tutees.
7. Once the tutoring is completed, a ten-problem quiz covering what was practiced is given and the pre-service teachers work on their own for 20 minutes.
8. The pre-service teachers switch papers with their partner within the group. They use an answer sheet to correct their partners work.
9. Individual goals are combined with group goals and are rewarded if they met or surpassed the predetermined goals.
10. The research assistance then gives them the next topic and instructs them to prepare against next lesson.

UNIVERSITY OF IBADAN LIBRARY

Phase Three: Briefing / Reflection

Step1; The research assistance reflects on the teaching immediately after the class, write reflective notes on any areas that needed improvement. Changes were then made to the next lesson plan based on the reflective note.

Step 2: the pre-service teachers also discuss their self assessment of the lesson with their mate immediately after the lesson, write reflective notes on any areas that needed improvement

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

Procedure for conventional teaching strategy

The procedure is as follow:

Step1: The research assistant introduces the lesson

Step 2: The research assistant explains theoretical bases on the topic

Step 3: The research assistant solves problems if any with example and application

Step 4: The research assistant solicits questions from the class and give class work

Step 5: The research assistant marks students' work

Step 6: The research assistant concludes the lesson with corrections to students work.

5. The eleventh week: A post-test of one hour Integrated Science Achievement Test was administered to the pre-service teacher with the assistance of the research assistance who is the facilitator in their respective schools. The study lasted for eleven working weeks.

UNIVERSITY OF IBADAN LIBRARY

Method of Data Analysis

Data collected were analyzed using Analysis of Covariance (ANCOVA). The Multiple Classification Analysis (MCA) aspect of ANCOVA was used to determine the magnitude of the performance of the various groups. Where there were significant main effects, the Scheffé Post-hoc Analysis was used to determine the sources of such significant differences. For significant interaction effects, graphical illustrations were used to explain such effects.

UNIVERSITY OF IBADAN LIBRARY

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 This chapter is on the results of this study. These were presented in line with the seven hypotheses formulated for the study. Also the summary of findings was presented.

4.1 Pre- and Posttest Achievement and Science Process Skills of the Participants.

The descriptive report on the performance of the pre-service teachers along the divides of treatment, mode of entry and numerical ability are presented in this section.

Table 4.1 Descriptive Statistics of Pre- and Posttest Achievement and Science Process Skills across Treatment Groups

TREATMT	STATISTICS	PRE-ACHVT	POST-ACHVT	PRE-SKIL	POST-SKIL	Mean Gain	
						Achievement	Skills
Reflective-Reciprocal Teaching	Mean Std.Dev.	17.54 5.03	23.09 5.74	50.49 6.95	65.95 8.01	5.55	15.46
Reflective-Reciprocal Peer Tutoring	Mean Std.Dev.	12.64 5.82	23.15 5.92	30.28 3.49	43.22 3.97	10.51	12.94
Control	Mean Std. Dev.	14.05 3.79	17.88 3.52	30.43 3.26	41.43 3.02	3.83	11.05

From Table 4.1, participants exposed to the reflective- reciprocal peer tutoring had the highest mean gain (10.51) in achievement having obtained 12.64 and 23.15 respectively

UNIVERSITY OF IBADAN LIBRARY

at pre- and posttests. This group was followed by those exposed to the reflective-reciprocal teaching (mean gain =5.55) while the control group had a mean gain of 3.83.

This table also reveals that the mean gains in science process skills is in favour of pre-service teachers in the reflective-reciprocal teaching group (mean gain =15.46) followed by those in the reflective-reciprocal peer-tutoring group (mean gain =12.94) while the control group obtained the lowest mean gain (11.05). These relative mean gains are represented on figure 4.1

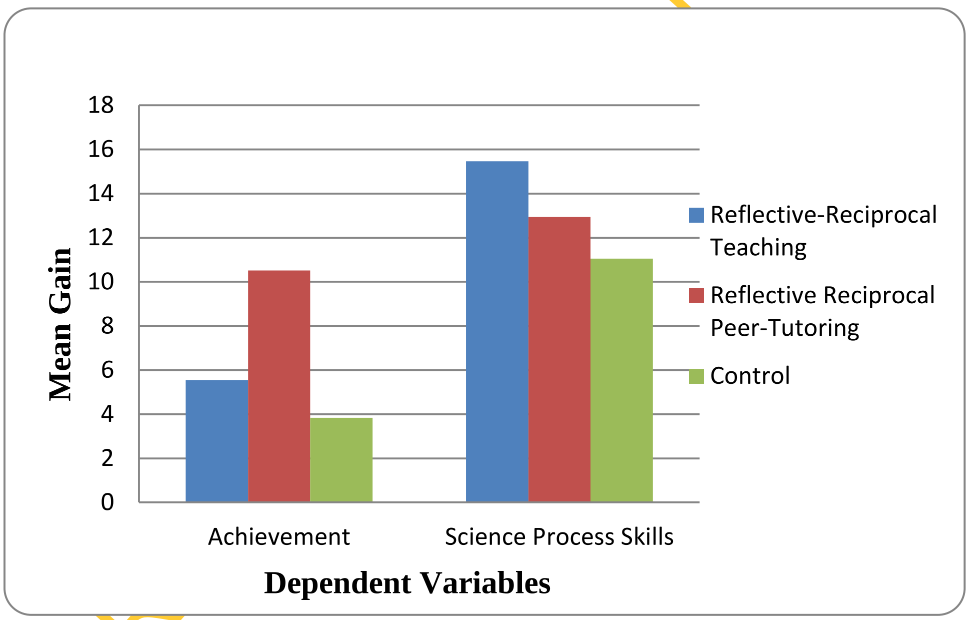


Figure 10: Mean Gains in the Two Experimental and Control Groups

UNIVERSITY OF IBADAN LIBRARY

Table 4.2 Descriptive Statistics of Pre- and Posttest Achievement and Science Process Skills by Mode of Entry.

MODE	STATISTICS	PRE-ACHVT	POST-ACHVT	PRE-SKIL	POST-SKIL	Mean Gains	
						Achievement	Skills
Direct	Mean	14.58	22.11	38.07	51.60	7.53	13.53
	Std. Dev.	5.67	5.86	11.11	12.42		
Prelim	Mean	16.50	21.38	40.79	54.43	4.88	13.64
	Std. Dev.	4.80	5.63	11.33	14.73		

Table 4.2 shows that the mean gain in achievement score was higher for pre-service teachers who had direct entry into the program (7.53) compared to those through the prelim (mean gain =4.88). The trend is however, different for science process skills where the prelim group slightly performed better (mean gain= 13.64) than their direct counterparts (mean gain =13.53).

Figure 4.2 presents the findings pictorially.

UNIVERSITY OF IBADAN LIBRARY

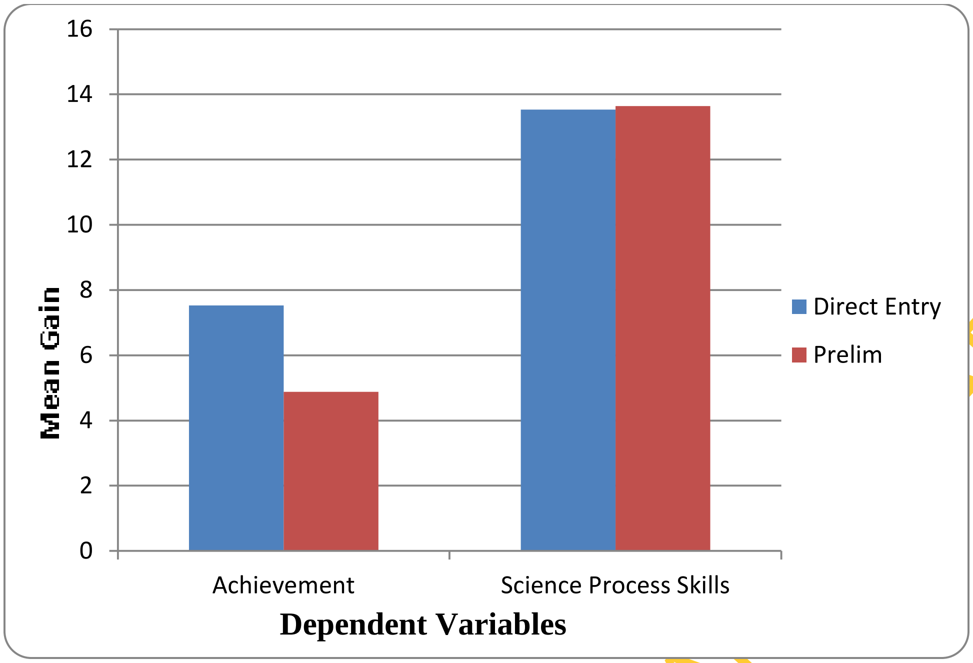


Figure 11: Mean Gains in Achievement and Science process skills by Direct and Prelim Entry Modes

Table 4.3 Descriptive Statistics of Pre-and Posttest Achievement and Science Process Skills Based on Numerical Ability

NUMERICAL ABILITY	STATIS-TICS	PRE-ACHVT	POST-ACHVT	PRE-SKIL	POST-SKIL	Mean Gain	
						Achievement	skills
Low	Mean	14.10	20.22	34.53	47.74	6.12	13.21
	Std. Dev.	4.09	5.15	9.00	11.71		
Medium	Mean	14.17	21.81	38.13	51.95	7.64	13.82
	Std. Dev.	5.69	6.19	10.54	12.37		
High	Mean	16.53	23.77	42.93	56.56	7.24	13.63
	Std. Dev.	6.27	5.54	12.18	13.20		

UNIVERSITY OF IBADAN LIBRARY

Table 4.3 shows that on achievement, the pretest and posttest mean scores for the low numerical ability group of pre-service teachers are 14.10 and 20.22 respectively with a mean gain of 6.12. This represents the lowest mean gain. This was followed by the high numerical ability group with a mean gain of 7.24 while the medium numerical ability group had the highest mean gain (7.64).

On science process skills, the mean gains had the medium ability group on the highest point (13.82) with the high ability (mean gain =13.82) and the low ability group (mean gain =13.21) following in that order.

Figure 4.3 represents the relative standing of the ability groupings on achievement and science process skills.

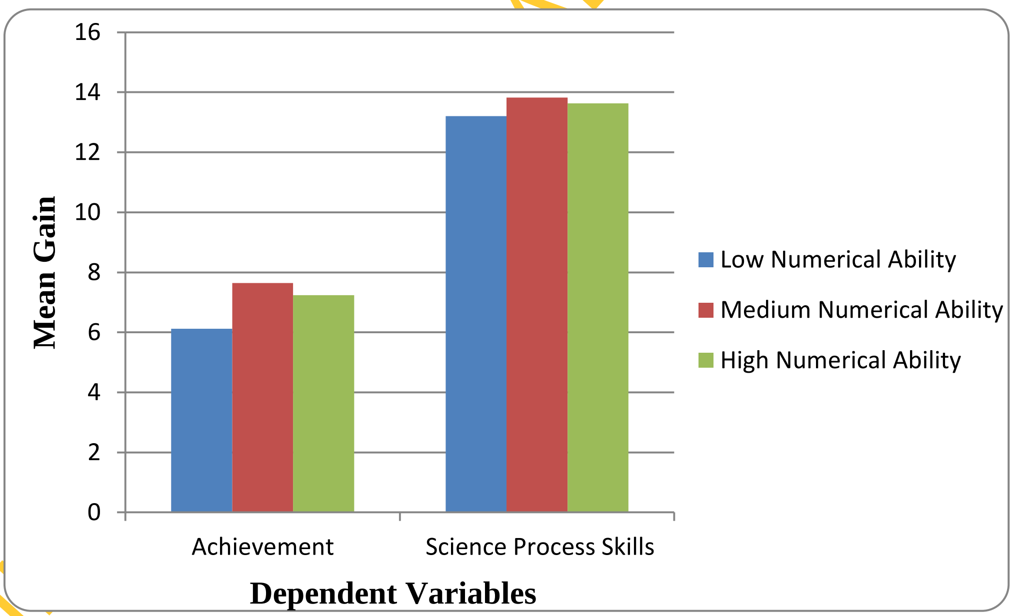


Figure 12: Mean Gains in Achievement and Science Process Skills by Different Numerical Ability Groupings

UNIVERSITY OF IBADAN LIBRARY

4.2 Test of Hypotheses

H_O 1_a: There is no significant main effect of treatment on pre-service teachers' achievement in Integrated Science

Table 4.4: Summary of ANCOVA of Post Test Achievement by Treatment, Numerical Ability and Mode of Entry

Source of varicose		Sum of square	df	Mean square	F	Sig
Covariates	PRE-ACHVT	3939.219	1	3939.219	262.297	.000
Main effects	(combined)	1751.708	5	350.342	23.328	.000
	TREATMENT	1686.517	2	843.258	56.149	.000
	MODE	1.735	1	1.735	.115	.123
	NUMUMERICAL ABILIT	63.456	2	31.728	2.113	.734
2-way interactions	(Combined)	75.086	8	9.386	.625	.757
	TREATMENT× MODE	5.232	2	2.616	.174	.840
	TREATMENT× NUMERICAL ABILITY	41.233	4	10.308	.686	.602
ABILITY	MODE× NUMERICAL	37.853	2	18.296	1.260	.285
3-Way Interaction	TREATMENT×MODE× NUMERICAL ABILITY	11.566	4	2.892	.193	.942
Model		5777.579	18	320.977	21.373	.000
Residual		4145.011	276	15.018		
Total		9922.590	294	33.750		

* Significant at p<.05

UNIVERSITY OF IBADAN LIBRARY

Table 4.4 shows that there is significant effect of treatment on pre-service teachers achievement in integrated science ($F_{(2, 276)}$= 56.149; p<.05). This means that there is significant difference in the posttest achievement scores of those in the Reflective-Reciprocal Teaching, Reflective-Reciprocal Peer Tutoring and those in the control group. The null hypothesis la is, therefore, rejected.

Table 4.5 presents the respective performance of the treatment and control groups.

Table 4.5: Multiple Classifications Analysis of Achievement Mean Scores by Tteatment, Numerical Ability and Mode of Entry

Variable + category		N	Predicted Mean		Deviation		Eta	Beta
			Unadjusted	Adjusted for factors and covariates	Unadjusted	Adjusted for factors and covariates		
TREATMT	REF REC TEACHG	121	23.09	21.02	1.13	-94	.375	.406
	REF REC PEER	109	23.15	24.84	1.18	2.88		
	CONTROL	65	17.8	18.89	-4.09	-3.07		
NUMABILI	Low	96	20.22	21.31	-1.74	-.65	.251	.086
	Med	98	21.81	22.02	-16	5.43		
	High	101	23.77	22.53	1.81	.57		
MODE	Direct	237	22.11	22.00	.14	4.03	.050	.014
	Prelim	58	21.38	21.79	-.58	-.16		
R= .757								
R^2 = .574								

UNIVERSITY OF IBADAN LIBRARY

From table 4.5 pre-service teachers in the Reflective-Reciprocal Peer Tutoring had higher adjusted achievement mean score ($\bar{x}$ =24.8; Dev. =2.88) than those in the Reflective-Reciprocal Teaching group ($\bar{x}$ =21.02; Dev. = -.94) and the control group ($\bar{x}$ =18.89l; Dev.= -3.07). The treatment has therefore impacted more on the experimental groups than the control in terms of achievement in Integrated Science.

In order to trace the actual sources of the significant effect of treatment on achievement, Table 4.6 presents the summary of Scheffé post hoc tests.

Table 4.6: Scheffé Post hoc Tests of Achievement by Treatment

Treatment	N	$\bar{x}$	Treatment		
			1. Reflective-Reciprocal Teaching.	2. Reflective-Reciprocal. Peer. Tutoring	3 control
Reflective- Reciprocal Teaching	121	21.02			*
Reflective-Reciprocal Peer Tutoring	109	24.84			*
Control	65	18.89	*	*	

* Pairs of groups significantly different at p<.05

Table 4.6 shows that the Reflective-Reciprocal Teaching ($\bar{x}$=21.02) significantly differs from the control group ($\bar{x}$= 18.89). Also, the Reflective-Reciprocal Peer Tutoring group ($\bar{x}$=24.84) differs significantly from the control group. These significantly pair wise differences were therefore, responsible for the significant effect of treatment on achievement in Integrated. Science

UNIVERSITY OF IBADAN LIBRARY

H_O 1_b: There is no significant main effect of treatment on pre-service teachers' science process skills.

Table 4.7: ANCOVA of Posttest Science Process Skill Score of Pre-service Teachers by Treatment, Numerical Ability and Mode of Entry

Source of varicose		Sum of square	Df	Mean square	F	Sig
Covariates	PRE-SKIL	41773.420	1	41773.420	2058.886	.000
Main effects	(combined)	1416.579	5	283.316	13.964	.000
	TREATMENT	1360.388	2	680.194	33.525	.000*
	MODE	20.898	1	20.898	1.030	.311
	NUMUMERICAL ABILIT	35.294	2	17.647	.870	.420
2-way interactions	(Combined)	218.994	8	27.374	1.349	.219
	TREATMENT× MODE	71.418	2	35.709	1.760	.174
	TREATMENT× NUMERICAL ABILITY	112.159	4	28.040	1.382	.240
ABILITY	MODE × NUMERICAL	20.366	2	10.183	.502	.606
3-Way Interaction	TREATMENT×MODE× NUMERICAL ABILITY	120.664	4	30.166	1.487	.206
Model		43529.656	18	2418.314	119.191	.000
Residual		5599.856	276	20.289		
Total		49129.512	294	167.107		

Significant of $p<.05$

UNIVERSITY OF IBADAN LIBRARY

Table 4.7 shows that there is significant effect of treatment on pre-service teachers science process skills ($F_{(2, 276)}$= 33.525, $p<.05$). This implies that the difference in the science process skills of pre-service teachers exposed to Reflective-Reciprocal Teaching, Reflective-Reciprocal Peer Tutoring and control are significant. Hypothesis 1b is hereby rejected.

Table 4.8: MCA OF Science Process Skills by Treatment, Numerical Ability and Mode of Entry

Variable + Category		N	Predicted Mean		Deviation		Eta	Beta
			Unadjusted	Adjusted For Factors and Covariates	Unadjusted	Adjusted For Factors and Covariates		
TREATMENT	REF REC TEACH	121	65.95	57.50	13.79	5.34		
	REF REC PEER	109	43.22	49.28	-8.94	-2.88	.893	.351
	CONTROL	65	41.48	47.04	-10.68	-5.12		
NUMERICALABILITY	Low	96	47.74	52.47	-4.42	.31		
	Med	98	51.95	52.38	-.21	.22	-.280	.029
	High	101	56.56	51.65	4.41	-.51		
MODE	Direct	237	51.60	52.02	-.56	-.14	.087	.022
	Prelim	58	54.43	52.73	2.27	.57		
R= .938								
R^2 =.879								

UNIVERSITY OF IBADAN LIBRARY

From Table 4.8, the Reflective-Reciprocal Teaching group had higher adjusted posttest science process skills mean score ($\bar{x}$=57.50; Dev =5.34) than their counterpart exposed to the Reflective-Reciprocal Peer Tutoring ($\bar{x}$=49.28; Dev. = -2.88) and those in the control group ($\bar{x}$=47.04; Dev. 5.12). To this end, the Reflective-Reciprocal Teaching proved more effective than the Reflective-Reciprocal Peer Tutoring and the control.

Table 4.9 tests the pairs of groups for significance so as to trace the control source(s) of significance.

Table 4.9: Scheffé Post hoc Tests of Science Process Skills by Treatment

Treatment	N	$\bar{x}$	Treatment		
			1.Reflective-Reciprocal Teaching	2.Reflective-Reciprocal Peer Tutoring	3 Control
1.Reflective-Reciprocal Teaching	121	57.50		*	*
2.Reflective-Reciprocal Peer Tutoring	109	49.28	*		
3.Control	65	47.04	*		

* Pair of groups significantly different at p<.05

Table 4.9 shows that the significant effect of treatment on the pre-service teachers science process skills is due to the significant pair wise difference between RRT ($\bar{x}$=57.50) and RRPT ($\bar{x}$=67.04) as well as between RRT ($\bar{x}$=57.50) and the control group ($\bar{x}$=47.04).

Ho2a: There is no significant main effect of mode of entry on pre-service teachers' achievement in Integrated Science.

UNIVERSITY OF IBADAN LIBRARY

Table 4.4 shows that mode of entry has no significant effect on the pre-service teachers achievement in Integrated. Science ($F_{(1, 276)}$= .115; p>.05). Based on this, hypothesis 2a is not rejected.

Table 4.5 has also shown that the adjusted posttest mean achievement score is slightly higher for the pre-service teachers admitted through direct entry ($\bar{x}$=22.00; Dev= 4.03 E-02) than the mean score of those through the prelim ($\bar{x}$=21.79; Dev. =-.16).

Ho2b: There is no significant main effect of mode of entry on pre-service teachers science process skills.

Table 4.4 shows that there is no significant effect of mode of entry on pre-service teachers' science process skills ($F_{(1, 276)}$ =1.030; p>.05). Hypothesis 2b is therefore, not rejected.

From Table 4.5, the MCA shows that the adjusted posttest science process skills mean scores place the pre-service teachers through prelim at an edge ($\bar{x}$= 52.73; Dev.=.57) over those through direct ($\bar{x}$=52.02; Dev.= -.14).

Ho3a: There is no significant main effect of numerical ability on Pre-service teachers' achievement in Integrated Science.

From Table 4.4, there is no significant effect of numerical ability on the achievement of the pre-service teachers ($F_{(2, 276)}$ =2.113; p>.05). The null hypothesis 3a is therefore not rejected.

Table 4.5 also shows that the high numerical ability group had higher adjusted posttest mean achievement score ($\bar{x}$=22.53; Dev. =.57) than the medium ability ($\bar{x}$=22.02, Dev. =5.43E-02) and the low numerical ability group ($\bar{x}$=21.31; Dev.= -65) respectively.

UNIVERSITY OF IBADAN LIBRARY

Ho3b: There is no significant main effect of numerical ability on Pre-service teachers' Science Process skills.

Table 4.7 shows that numerical ability has no significant effect on pre-service teachers science process skills ($F_{(2, 276)}$= 870; p<.05). On this basis, hypothesis 3b is not rejected.

From Table 4.8 pre-service teachers with low numerical ability had higher adjusted posttest achievement mean score ($\bar{x}$=52.47; Dev. =.31) than their contempt's with medium ability ($\bar{x}$=52.38; Dev.=.22) and high ability ($\bar{x}$= 51.65; Dev. =-51) respectively.

Ho4$_a$: There is no significant interaction effect of treatment and mode of entry on pre-service teachers' achievement in Integrated Science.

From Table 4.4, there is no significant interaction effects of treatment and mode of entry on pre-service teachers achievement in integrated science ($F_{(2,276)}$= .174; P>.05). hypothesis 4a is, therefore, not rejected.

Ho4b: There is no significant interaction effect of treatment and mode of entry on pre-service teachers' science process skills.

Table 4.7 shows that the 2-way interaction effect of treatment and mode of entry on science process skills is not significant ($F_{(2,276)}$= 1.760; p>.05). Hence, hypothesis 4b is not rejected.

Ho5a: There is no significant interaction effect of treatment and numerical ability on pre-service teachers' achievement in Integrated Science.

From Table 4.4, treatment and numerical ability has no significant interaction effect on pre-service teachers in integrated science ($F_{(4,276)}$= .686; p>.05). Hypothesis 5a is therefore, not rejected.

UNIVERSITY OF IBADAN LIBRARY

Ho5b: There is no significant interaction effect of treatment and numerical ability on pre-service teachers' science process skills.

Table 4.7 shows that there is no significant 2 way interaction effect of treatment and numerical ability on pre-service teachers science process skills ($F_{(4, 276)}$= 1.382; p>.05). On this basic, hypothesis 5b is not rejected.

Ho6a: There is no significant interaction effect of mode of entry and numerical ability on pre-service teachers' achievement in Integrated Science.

Table 4.4 shows that mode of entry and numerical ability has no significant interaction effect on pre- service teachers' achievement in integrated science ($F_{(2,276)}$= 1.260, p>.05). Hence, hypothesis 6a is not rejected.

Ho6b: There is no significant interaction effect of mode of entry and numerical ability on pre-service teachers' science process skills.

From Table 4.7 the interaction effects on mode of entry and numerical ability on pre-service teachers science process skills is not significant ($F_{(2,276)}$=. 502; p>.05). Hypothesis 6b is therefore, not rejected.

Ho7a: There is no significant interaction effect of treatment, mode of entry and numerical ability on pre-service teachers' achievement in Integrated Science.

Table 4.4 shows that the 3-way interaction effect of treatment, mode of entry and numerical ability on pre-service teachers' achievement in integrated science is not significant ($F_{(4, 276)}$=. 193; p>.05). Hypothesis 7a is therefore not rejected.

Ho7b: There is no significant interaction effect of treatment, mode of entry and numerical ability on pre-service teachers' science process skills.

UNIVERSITY OF IBADAN LIBRARY

From Table 4.7, it was obtained that the 3-way interaction effect of treatment, mode of entry and numerical ability on pre-service teachers, science process skills is not significant ($F_{(4, 276)}$= 1.487; P> .05). Hypothesis 7b is therefore not rejected.

4.3 Discussion of findings

4.3.1 Effect of Treatment on Pre-service Teacher's Achievement

The major finding of this study is that there is a significant difference in the achievement of pre-service teachers exposed to Reflective-Reciprocal Peer Tutoring, Reflective-Reciprocal Teaching and the Conventional Teaching strategies. The Reflective-Reciprocal Peer Tutoring was the most effective strategy followed by the Reflective-Reciprocal Teaching with the Conventional strategy been the least effective. The superiority of Reflective-Reciprocal Peer Tutoring may be due to the fact that it had a structured format where pre-service teachers taught, monitored, and evaluated one another. That is, pre-service teachers were part of the educational process and were able to prepare instructional materials, plan the lesson, deliver the lesson receive feedback from peers and reflect after the lesson to identify where problems arose with probable solutions provided against other classes. They functioned both as tutor and as tutee while the teacher acted as a facilitator.

Also the pre-service teachers monitored their academic progress in a group context, setting team goal and managing their own group reward. These assist the pre-service teachers to improve their perceptions of their own academic competence and self-control. It also made the pre-service teachers to be responsible for their actions in the class, monitoring their academic progress rather than being passive learners. The pre-service teachers were at the center of the teaching and learning process. The bulk of the

UNIVERSITY OF IBADAN LIBRARY

responsibility lied on them with the classroom teacher only monitoring and providing help when the "teacher" had trouble answering students' questions. The pre-service teachers played the major and important roles in the classroom setting. These roles developed their self-confidence and made them to possess sense of self-direction and self-control in teaching. It also empowered them to take responsibility for their own action and that of their group.

Pre-service teacher's better performance in Reflective-Reciprocal Peer Tutoring may also be due to the fact that they worked cooperatively with their peers thereby providing the social context for the pre-service teachers to actively learn and make deeper connections among facts, concepts and ideas. This developed their social and communication skills, increased cooperation and tolerance of one another as pre-service teachers were from diverse background working together to achieve group goal and aspiration. This made learning to be more permanent. The improvement in achievement with the use of Reflective-Reciprocal Peer Tutoring over the two other strategies may also be due to the fact that it utilized group reward system and interdependence that maximized learning and motivation. The pre-service teachers were active learners in the classroom. They took active part in the planning and delivering of a lesson thereby acquitting them with the role of a teacher. This finding is in agreement with the earlier research results obtained by Fantuzzo, King and Heller (1992), Slavin (1991) Griffin and Giffin (1997), Fuchs and Fuchs (2003) and Mayfield and Vollmer (2007).

The Reflective-Reciprocal Teaching was more effective than the Conventional Strategy. This may be as a result of its shift from the instructor-centered to student-centered style where there was a construction of meaning between the Lecturer and the

UNIVERSITY OF IBADAN LIBRARY

pre-service teachers which consequently led to high quality learning. The Pre-service teacher swapped roles with the Lecturer thereby increasing their confidence and level of understanding. This strategy encouraged the pre-service teachers to feel comfortable expressing their ideas and opinion in open dialogue. This dialogue included discussions, questions and answers, with feedback after which both the lecturer and the pre-service teachers reflected on what happened in the classroom. They identified common problems, thought about possible solutions and attempted an action plan to use against the forthcoming class.

Also, in Reflective-Reciprocal Teaching the pre-service teachers thought before, during and after the lessons and this made them to consult different texts before the lesson and this in turn widened their horizon on the topic. This also helped the pre-service teachers to forge connections between theory and practice. The improvement on pre-service teachers' performance in the strategy over the Conventional strategy may also be as a result of pre-service teachers checking their understanding of materials they encountered by generating questions, clarifying concepts, summmarising important information from text and ruminating over all these after the class. This gave the pre-service teachers opportunity to monitor their learning and thinking processes. The Reflective-Reciprocal Teaching required the pre-service teachers to interact and participate actively in the class. This fostered healthy relationships and helped to create an ideal learning and social environment. The superiority of this strategy over the conventional strategy may also be as a result of the topic used being mostly in text with minimal mathematical operations as Reflective-Reciprocal Teaching strategy was most effective with text. This result is in agreement with the findings obtained by Lavariee

UNIVERSITY OF IBADAN LIBRARY

(2000), Rosenshine and Meister (2003), Oczkus (2003), Hashey and Connors (2003) , Foster and Rotoloni (2005), Peter, David, Cheri, William and Carl (2006) and Clarke (2007) who all found Reflective-Reciprocal Teaching as effective in the teaching of science.

4.3.2. Effects of Treatment on Science Process Skills in Integrated Science

The result obtained showed that there was a significant main effect of treatment on pre-service teachers' science process skills. The Reflective-Reciprocal Teaching was more effective than the Reflective-Reciprocal Peer Tutoring and the Conventional teaching strategy. The superiority of the Reflective-Reciprocal Teaching at improving science process skills may be as a result of the nature of the strategy which involved a little input by the lecturer since both the lecturer and the pre-service teacher shifted role during the lessons. The lecturer in this group brought their expertise to bear based on the training that the researcher gives them which took to. Hence, the science process skills acquired by the pre-service teachers in this group were higher than those acquired by pre-service teachers in the two other groups. This finding is in agreement with the results obtained by Harlen (2000) as well as Marzano, Pickering and Pollock (2001) that teachers' role have positive influence on the science process skills.

The Reflective-Reciprocal Peer Tutoring was more effective than the Conventional Teaching Strategy probably because pre-service teacher in this group were in full control of the activities involved in the practical class. Pre-service teachers in this group therefore acquired some skills and still retained those skills. This accounted for their higher adjusted posttest science process skills mean score and hence, the effectiveness of the Reflective-Reciprocal Peer Tutoring strategy over the Conventional Teaching Strategy. This finding is in line with the finding of Driscoll, (2000), Ong and

UNIVERSITY OF IBADAN LIBRARY

Kenneth, (2005) who found that learners readiness, their interaction with others and active participation and involvement were major factor in development of science process skills.

4.3.3 Effect of Mode of Entry on Achievement and Science Process Skills

The result obtained in this study showed that there was no significant effect of mode of entry on both achievements in integrated science and science process skills in integrated science. However, there is still a difference in adjusted posttest mean achievement score of the direct entry group of pre-service teachers. The direct entry group performed better than their prelim counterpart in achievement but the prelim group performed better than direct entry group in science process skills. On achievement, increase in the performance of the direct entry student over their prelim counterpart might be as a result of their possessing more entry requirement than the prelim student. That is they possess the minimum entry requirement needed for them to be admitted directly for the 3-year course. The increase in performance of prelim group in science process skills may be as a result of their spending one year ahead of the direct entry group in the college. Also, they might have been exposed to some skills during their first year in the college as a preliminary student. That is, the duration of their stay in the college might have contributed to their improved performance in science process skills. This is also in agreement with the finding of Simeon and Nancy (2010).

4.3.4 Effects of Numerical Ability on Achievement and Science Process Skills

The result of the study showed that there was no significant effect of numerical ability on pre-service teachers' achievement in integrated science and science process

UNIVERSITY OF IBADAN LIBRARY

skills. Although on achievement, the pre-service teachers with high numerical ability performed better than those with medium numerical ability and those with low numerical ability (that is high >medium> low), on science process skills those with low numerical ability perform better followed by those with medium numerical ability and those with high numerical ability (that is low> medium > high). This may be as a result of the fact that the topic and the practical activities and problems in the study did not involve much mathematical calculation such that if the student missed the few that involved calculation, this might not have significant impact on their performance. This is in agreement with the finding of Falaye (2006) that the impact of student's numerical ability on students' achievement is not significant.

4.3.5 Two-Way Interaction Effects of Treatment and Mode of Entry on Achievement and Science Process Skills

The result obtained showed that the two-way interaction effects of treatment and mode of entry in integrated science achievement and science process skills were not significant. This implied that irrespective of pre-service teachers' mode of entry into the programme the Reflective-Reciprocal Peer Tutoring is still the most effective strategy in terms of achievement, followed by Reflective-Reciprocal Teaching and the Conventional Teaching Strategy. While the Reflective-Reciprocal Teaching is still the most effective strategy in terms of science process skills, followed by Reflective-Reciprocal Peer Tutoring and the Conventional Teaching Strategy. Pre-service teachers that entered through prelim perform better than those that entered through direct entry in science process skills but this difference is not significant. While on achievement the pre-service

UNIVERSITY OF IBADAN LIBRARY

teachers admitted through direct entry performed better than those admitted though the preliminary study

4.3.6 Two-Way Interaction Effects of Treatment and Numerical Ability on Pre-service Teachers' Achievement in Integrated Science and Science Process Skills

The two-way interaction effects of treatment and numerical ability on pre-service teachers' achievement in integrated science and science process skills were not significant. The implication of this non-significant interaction effect showed that being of high, medium or low numerical ability does not affect the pre-service teachers' achievement and science process skills. That is irrespective of the level of numerical ability, the Reflective-Reciprocal Peer Tutoring is still the best followed by the Reflective-Reciprocal Teaching and the Conventional Teaching Strategy in terms of pre-service teachers' achievement. While the Reflective-Reciprocal Teaching is the best in terms of science process skills followed by the Reflective-Reciprocal Peer Tutoring and then the Conventional Teaching Strategy.

4.3.7 Two-way Interaction Effects of Mode of Entry and Numerical Ability on Integrated Science Achievement and Science Process Skills.

The result obtained showed that the two-way interaction effect of pre-service teachers' mode of entry into the programme and their numerical ability on achievement and science process skills were not significant. This result implies that if effective teaching strategies such as the Reflective-Reciprocal Peer Tutoring and Reflective-Reciprocal Teaching were used, the pre-service teachers either direct or prelim of high, medium or low levels of numerical ability would perform better in Integrated Science

UNIVERSITY OF IBADAN LIBRARY

achievement and science process skills. Although there may be some differences in the achievement and science process skills of prelim and direct entry pre-service teachers of high, medium and low levels of numerical ability, these differences would not be high enough to attract serious consideration.

4.3.8 Three-Way Interaction Effects of Treatment, Mode of Entry and Numerical Ability on Integrated Science Achievement and Science Process Skills

The result obtained in the three-way interaction effects of treatment, mode of entry and numerical ability were not significant on both Integrated Science achievement and science process skills. This implies that if the same treatment is given to pre-service teachers with high, medium and low levels of numerical ability that are admitted into the college through either prelim or direct programme similar result would be achieved in Integrated Science achievement and science process skills as have found in this study. That is irrespective of the mode of entry of pre-service with high, medium or low numerical ability level the reflective-reciprocal peer tutoring is still the most effective follow by the reflective-reciprocal teaching and the conventional teaching strategy. Whereas on science process skills the reflective-reciprocal teaching is the most effective followed by the reflective-reciprocal peer tutoring with the conventional teaching strategy been the least irrespective of their mode of entry and numerical ability level.

UNIVERSITY OF IBADAN LIBRARY

CHARPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 This chapter discusses the summary for the study. It also presents relevant recommendations and conclusion.

5.1 Summary of Findings

The findings of this study could be summarized as follows:

1 There were significant main effects of treatment on pre-service teachers' achievement and science process skills. On achievement the Reflective-Reciprocal Peer Tutoring was more effective than the Reflective-Reciprocal Teaching and control while on science process skills, the Reflective-Reciprocal Teaching was more effective than the Reflective-Reciprocal Peer Tutoring and control.

2 There was no significant main effect of mode of entry on both achievement and process skills in integrated science. However, direct entry group of pre-service teachers perform better than their prelim counterpart in achievement but the reverse is the case for process skills.

3 Numerical ability had no significant effect on pre-service teacher's achievement and science process skills in integrated science. The trend on achievement is high >medium> low while on science process skills it is low> medium > high.

4 There was no significant interaction effect of treatment and mode of entry on achievement in integrated science and science process skills.

5 There was no significant interaction effect of treatment and numerical ability on pre-service teachers' achievement in integrated science and science process skills.

UNIVERSITY OF IBADAN LIBRARY

6 There was no significant interaction effect of mode of entry and numerical ability on pre- service teachers' achievement in integrated science and science process skills.

7 There was no significant interaction effect of treatment, mode of entry and numerical ability on pre- service teachers' achievement in integrated science and science process skills.

5.2 Implications of the Findings

Based on the findings of this study, the effectiveness of Reflective-Reciprocal peer Tutoring strategy on pre-service teachers' achievement in Integrated Science has been established. This study also established that Reflective-Reciprocal Teaching was more effective than the Reflective-Reciprocal Peer Tutoring and the Conventional teaching at improving pre-service teachers' acquisition of science process skills. The use of the two strategies will help to improve social interaction among the pre-service teachers. It will also help in shifting the role of teacher in the classroom to that of a facilitator. The strategy could be used to empower the pre-service teachers to take responsibility for their own action. It will also help the pre-service teachers to see Integrated Science as one of the best teaching subject as well as allowed the pre-service teachers to have good grade and reduced the level of failure in the course.

The use of Reflective-Reciprocal Peer Tutoring and Reflective-Reciprocal Teaching could help improving the professional development of pre-service teachers thereby making them better teachers when they are in the field practicing as teachers. It will also reduce the effort of lecturers in training the pre-service teachers.

UNIVERSITY OF IBADAN LIBRARY

5.3 Conclusion

The study has established that the Reflective-Reciprocal Peer Tutoring and Reflective-Reciprocal Teaching Strategies are both effective at improving pre-service teachers' achievement in Integrated Science and science process skills at the College of Education level. This is due to the fact that both strategies allowed the pre-service teachers to meet their classroom needs, made teaching and learning to be more flexible allowing room for change and growth, allow social interaction among the lecturer and pre-service teachers and within the pre-service teachers, encouraged self-regulation, provided both lecturer and pre-service teachers feedback and empowered pre-service teachers in self-confidence in terms of their abilities and efforts.

5.4 Recommendations

Based on the results obtained and discussed in this study, the following recommendations are hereby made:

1. The use of Reflective-Reciprocal Peer Tutoring Strategy and Reflective-Reciprocal Teaching were recommended to lecturers for the teaching of Integrated Science in the colleges of education for better achievement of pre-service teachers in integrated science.
2. The pre-service teachers should be encouraged by the lecturers by using the strategies to teach them so that the pre-service teachers will be familiar with both strategies and find it convenient and easy to use when practicing as a teacher.
3. The use of Reflective-Reciprocal Teaching is recommended to be used by the lecturers in practical class for pre-service teachers' better acquisition of science process skills

UNIVERSITY OF IBADAN LIBRARY

4. The pre-service teachers should be made to use both strategies by the lecturers and supervisors when on teaching practice to improve the achievement of their students.
5. The lecturer and pre-service teachers should be encouraged by their college management to be a reflective teacher as this would be a form of professional development.
6. Government should organize a form of in-service and re-training programme for teachers in the effective use of the Reflective-Reciprocal Peer Tutoring and Reflective-Reciprocal Teaching Strategies through organization of seminars, workshop, and conferences for science teachers to improve their teaching skills as well as improving the achievement and acquisition of science process skills of their student.

5.5 Contribution of the Study to Knowledge

This study has contributed to knowledge in the following ways:

- It has been established that the Reflective-Reciprocal Peer Tutoring followed by the Reflective-Reciprocal Teaching is effective in improving pre-service teachers' achievement in Integrated Science. The result has provided a basis for curriculum innovation in training the lecturers through in-service programmes to expose them to these teaching strategies. Also the curriculum planners can also include the strategies in training pre-service teachers so that they can be familiar with the strategies and find them easier to use when practicing as teachers.
- Also both strategies encourage social interaction among pre-service teachers as they participated actively in planning and teaching, and also encourage group

UNIVERSITY OF IBADAN LIBRARY

work as the pre-service teachers received help from their pair mate. This will help all categories of pre-service teachers to participate actively during the lesson thereby turning the learning of Integrated Science to be fun.

- By learning with one another both strategies improve the pre-service teachers' acquisition of science process skills as they have the opportunity of learning from one another. This also improves their level of confidence at facing the class and their communication skills.
- The Reflective-Reciprocal Peer Tutoring and the Reflective-Reciprocal Teaching gives the pre-service teachers opportunity to teach, monitor, evaluate one another and reflect after the lesson to identify where problems arise with probable solutions provided against other classes. This serves as a form of professional development to the pre-service teachers.

5.6 Suggestions for Further Studies

Future research should focus on the use of Reflective Teaching Strategies by the pre-service teachers in Colleges of Education in Nigeria during teaching practice exercise. The study should also be replicated in other regions of the Federal Republic of Nigeria and in other science subject areas such as Chemistry, Biology and Agricultural Science. Other moderator variables such as students' cognitive style, self-efficacy and attitude should also be investigated.

UNIVERSITY OF IBADAN LIBRARY

REFERENCES

Abdullahi, A.1982. *Science Teaching in Nigeria* Ilorin: Atoto Press Limited.

Adedigba, A. T. 2002. Two collaborative group strategies and achievement in Mathematics in colleges of Education. An unpublished Ph. D Thesis University of Ibadan.

Adenekan, J. A. 1994. Problem solving ability as a factor of students' achievement in secondary Physics. *Lagos Journal of science education* 2 (2), 94-97 Lagos.

Adeniyi, A. G. 2005. Science and technology education in secondary schools: Need for manpower development. *Journal of the Science Teachers Association of Nigeria*, 40 (1&2), 63-67.

Adepitan, J. O. 2003. Pattern of enrolment on Physics and students evaluation of the contributory factors on Nigeria Colleges of Education; *African Journal of Education Research* (2), 136-146.

Adesoji, F.A (2002).Modern strategies in the teaching of integrated science. In S.O Ayodele (Ed.), *Teaching strategies for Nigeria secondary school*. Ibadan: Power House Press Publishers p.205-212.

Adeyemi, T. O. 2009. Mode of Entry as a Predictor of Success in Final Year University. *Middle East Journal of Scientific Research* 4(1), 10-19

Adu, E. O. 2002. Two problem-based Learning Strategies: Quantitative ability and gender as determinants of students' academic Achievement in Economics. Unpublished Ph.D Thesis, University of Ibadan.

UNIVERSITY OF IBADAN LIBRARY

Afolabi, A. O; Mabayoje, V.O; Togun, V.A; Oyadeyi, A.S and Raji, Y. 2007. The Effect of Mode of Entry into Medical School on Performance in the First Two Years. *Journal of Medical Science*. 7 (6), 1021-1026.

Akinyemi, K. 1987. Aligning Practice with Policy in Vocational-technical Education. *Journal of Vocational Education and Training*, 39(102), 15-18.

Aktamis, H. and Ergin. O. 2008. The effect of Scientific Process Skills Education on Students' Scientific Creativity, Science Attitude and Academic Achievements *Asia-Pacific Forum on Science Learning and Teaching*, 9(1).

Allen, S. 2003. An analytical comparison of three models of reading strategy instruction. IRAL: *International Review of Applied Linguistics in Language Teaching*. 41 (4), 319-339

Allen, T, Vandekeerre,K. Topping, K. J Kosack, W. Gatt, S. Marchal, J.Mestdagh, N. Schmeinck,N. Sidor, W Donnert, K. 2007. Peer Learning on Primary School Science: Theoretical Perspective and Implication for Classroom Practice. *Electronics Journal of Research in Educational Psychology* 5(3), 471-496

American Association for the Advancement of Science.(1989). *Science for all Americans: Project 2061*. New York: Oxford University Press.

Annis, V. L.1983. The processes and effects of peer tutoring. *Human Learning* 2, 39-47.

Argyris, C. A. and Schon, D. 1978. *Organization Learning*: *A theory of Action perspective, Reading, Mass:* Aderson Wesley

UNIVERSITY OF IBADAN LIBRARY

Arsal, Zeki. 2010. The Effect of diaries on Self-Regulation Strategies of Pre-service Science Teachers. *International Journal of Environmental and Science Education* 5(1), 85-103

Artzt, A. F. and Armour – Thomas, E. 2002. *Becoming a reflective mathematics teacher, A guide for observations and self-assessment*. N. J. Lawrence Erlbaum Associates

Ayeni,O. 1972. A Comparative Study of the performance of direct and concessional entrance into the University of Ibadan Medical School. Br. *Journal of Medical Education*, 6, 277-285.

Aysan, F. I. 1996. Perceived causes of Academic failure among the students at the faculty of Education at Buca, Turkey.

Babajide,V. F. T. 2010. Generative and Predict-Observe-Explain Instructional Strategies as determinants of Secondary School Students Achievement and Practical Skills in Physics. An unpublished Ph. D Thesis university of Ibadan.

Bailey, K. M. 1997. The use of diary studies in teacher education programmes in S.C. Richard and D. Nunan (Edu.*) Second Language Teacher Education* New York: Cambridge University Press. 215-226.

Bajah, S. T. 1978. Meaning and Philosophy of Integrated Science. Journal *of the Science Teachers' Association of Nigeria.* 16(2), 26-32

Barak, M. & Shakhman, L. (2008**).** Fostering higher-order thinking in science class: Teachers' reflections, *Teachers and Teaching, Theory and Practice***,** 14(3), 191-208**.**

UNIVERSITY OF IBADAN LIBRARY

Bargh, J. A. and Schul Y. 1980. On the cognitive Benefits of teaching, *Journal of Education Psychology,* 72, 593 – 604

Beaumont-Walters, Y. and Soyibo, K. 2001. An analysis of high school students' performance on five integrated science process skills, *Research in Science and Technological Education,* 19(2), 133-145.

Bolton, T. 1970. *Reach, Touch and Teach* Hutchinson, London, U 22, 169-177.

Bolton, G. (2010). *Reflective practice: writing and professional development*. London: Sage.

Bonwell, C. and Eison, J. (1991) "*Active Learning: Creating Excitement in the Classroom,"* ASHE-ERIC Higher Education Report No. 1.

Bordet M., De Brocket, P., Read, C., Harris, S. and Zhang, Y. 2001. Determinants of science and Technology. Skills; Overview of the study *Education quarterly review, statistics canads* 1 (8), 8-11

Brady, P. L. 1990. Improving the reading comprehension of middle Students through reciprocal teaching and semantic mapping strategies unpublished doctoral dissertation, University of Oregon, Eugene.

Burns, J. C., Okey, J.R. and Wise, K.C. 1985. Development of an integrated process skills test: tips II. *Journal of Research in Science Teaching*, 22(2) ,169-177.

Bybee, R.W., Buchwald, C.E., Crissman, S., Heil, D., Kuerbis, P.J., Matsumoto, C. & McLnerney. J.D. (1989). *Science and technology for the elementary years: Frameworks for curriculum and instruction.* Washington: NCISE.

UNIVERSITY OF IBADAN LIBRARY

Cartel, C. 1997. Why reciprocal teaching? *Educational Leadership,* 64-68.

Chickering, A., and Gamson, Z. 1987. "Seven Principles for Good Practice," *AAHE Bulletin*, 39:3–7, ED 282 491, 6pp, MF-01; PC-01.

Clarke, P.A.J. 2007. *Reflective Teaching Model: A Tool for motivation, collaboration, self-reflection and Innovation in Learning*. Georgia State University. Retrieved Oct. 2010 –coefaculty. valdoste.edu

Department of Education and Science, 1989. Aspects of Primary Education: *The teaching of Mathematics.* London: HMSD

Dermody, M. 1998. Metacognitive Strategies for development of reading comprehension for young children. *Paper presented at the annual meeting of the America Association of Colleges for Teacher Education*, New Orleans, L.A.

Dewey, J. 1933. *How We Think*: A Restatement of the relation of Reflection Thinking to the Educative Process. Chicago: Henry Regnery.

-------- 1897: *How We Think*: New York: Dover Publications

Dickers, J. and Delater, J. 2001. Enrolment trends in school science Education in Australia. *International Journal of Science Education* (2315), 487-500

Donald R. Cruickshank, 1985. Uses and Benefits of Reflective Teaching. *The Phi Delta Kappan.* 66 (10), 704-706.

Doolittle, P., Hicks, D., Triplett, C., Nicholas, W. and Young, C. 2006. Reciprocal Teaching for Reading Comprehension in Higher Education: A Strategy for Fostering the Deeper Understanding of Texts. *International Journal of Teaching and Learning in Higher Education* 17(2) 106-118

UNIVERSITY OF IBADAN LIBRARY

Dougiamas, M. 1998, A journey into Constructivism, http//dougiamas,com/ writing/constructivism.html

Driscoll, M. P. 2000. *Psychology of learning for instruction*. MA: Allyn and Bacon.

Duyilemi A. N, 2005. The Jets Programme and the attitude of girls to science and technology in Nigeria. *Educational Thought* 4 (1), 32-38.

Edward, A. and Knight, 1994. *Effective Early Years Education*, Open university Press. Buckingham.

Eggen, P. D. and Kenchak, P.P. 2006. Strategies and Models for teacher. *Teaching content and theory skills.*

Elder, Osnat, 2008. A metacognition strategy for training Pre-service teachers: Collaborative diagnosis of conceptual understanding in Science. Proceedings of the *8th International Conference on International conference for the learning science.* 3

Emeka, E. A. and Adegoke, B. A. 2001. The interaction effects of test response mode, students' numerical ability and gender on cognitive achievement in senior secondary school Physics in Y. Awosika et al (eds), *Tropical issues in Education*: Papers in honuor of Professor C. O, Udoh.

Ergul, R., Simsekli,Y., Calis,S., Ozdilek,Z., Gocmencelebi, S., and Sanli, M. 2011. The Effect of Inquiry-Based Science Teaching on Elementary School Students' Science Process Skills and Science Attitudes. *Bulgarian Journal of Science and Education Policy*, 5 (1)

UNIVERSITY OF IBADAN LIBRARY

Esan, A. O. 2002. Effects of cooperative and individualistic problem solving strategies on students learning outcomes in Secondary School Mathematics unpublished Ph. D Thesis, University of Ibadan.

Evertson, C. M., Emmer, E. T., & Worsham, M. E. (2006). *Classroom management for elementary teachers* (7th ed.). Boston: Allyn and Bacon

Falaye, F. V. 2006. Numerical ability, course of study and gender differences in student's achievement in Practical Geography Research in Education 76, 33

Fantuzzo, J. W, Riggio, Ronald, E., Conmelly, Sharm, Dimeff, Linda A.1989.Effects of Reciprocal Peer Tutoring on Academics Achievement and Psychological adjustment: A Component Analysis, *Journal of Educational Psychology* 81(2), 173-177

Fantuzzo, J.W.,King,,J.A. and Heller, L.R. 1992. Effects of Reciprocal Peer Tutoring on Mathematics and School Adjustment: A Component Analysis. *Journal of Educational Psychology* 84(3), 331-339

Fantuzzo, J.W. 1995. Effects of Parent involvement in isolation or in combination with Peer Tutoring on Student Self Concept and Mathematical Achievement. *Journal of Educational Psychology*, 87(2), 172-281

Federal Republic of Nigeria. 2004. *National policy on education (Revised)*. Lagos. Federal Government Press

Feiman-Nemser, S. 1990. "Teacher Preparation: Structural and conceptual Alternative, *In Handbook of Research on Teacher Education*, Ed. W. Robert Houston, New York: Macmillan Publishing Company, Inc."

UNIVERSITY OF IBADAN LIBRARY

Fernandez-Santander, A. (2008). Cooperative learning combined with short periods of lecturing: a good alternative in teaching biochemistry. *Biochemistry and Molecular Biology Education*, *36*(1), 34-38.

Forman, F. 1994. Peer Collaboration as Situated Activity: Examples from Research on Scientific Problem Solving. In :H.C. Foote, C.J. Howe, A. Anderson, A.K. Tolmie , D.A. Warden (Eds) Group and Interactive Learning . pp 3-8 Southampton, Computational Publications

Foster, E., and Rotoloni, R.. (2005). Reciprocal Teaching: General overview of theories.. In M. Orey (Ed.), Emerging perspectives on learning, teaching, and technology. Retrieved <1/6/2011>, from http://projects.coe.uga.edu/epltt/

Fuchs, D., and Fuchs, L.S. 2005. Peer-Assisted Learning Strategies: Promoting word recognition, fluency, and reading comprehension in young children. *The Journal of Special Education*, 39(1), 34-44

Garderen, D. 2004. *Reciprocal teaching as a comprehension strategy for understanding mathematical word problems*. Boston: Houghton-Miffim.

Garg, K. and Cupa, B. 2003. Decline in Science Education in India. *A case study of undergraduate lend current science* 84 (9), 1198-1201

Gay, L, R. 1996. *Educational research: competencies for analysis and application*; Upper Saddle River, New Jersey: Merrill, Prentice-Hall Inc, 249-305.

Gbolagade, R. O. 2009. The impact of constructivist model based training programmes on pre services' teacher knowledge, attitude, classroom practice and students' teaching outcome in Junior Secondary School Mathematics. An unpublished Ph.D Thesis of University of Ibadan.

Gibbs, G. 1988. *Learning by doing: A guide to teaching and learning methods*, Oxford further education unit, Oxford, Polytechnic.

UNIVERSITY OF IBADAN LIBRARY

Goto, M, 2001. *Japan International Bureau for education (IBF).* Science Education for contemporary Society: Problem Issue and Dilemma Geneos UNESCO 31-38.

Griffin, B. W. and Griffin, M. M. 1997. The Effects of Reciprocal Peer Tutoring on Graduate Student's Achievement, Test Anxiety and Academic Self-Efficacy. *Journal of Experimental Education* 65 (3).

Grossman, Sue, Williston and Judy, 2001. Strategies for teaching early childhood students to connect reflective thinking to practice. Teaching Strategies. Childhood Education 77(4), 236-240

Gunderson, E. A; Ramirez, G; Beilock, S.l. and Levine, S.C. 2011. The relation between spartial skills and early number knowledge: The role of the linear number line. *Spatial Intelligence and Learning Center NSF Science of Learning Center*, Chicago.

Harlen, W. 2000. *Teaching, learning and assessing science* 5-12 (3rd ed.). London: Paul Chapman Publishing.

Harrison, 2008. *Professional Development and the reflective Practitioner in* *<u>Reflective Teaching and learning</u>* Edited by Sue Dymoke and Jennifer Hanson. SAGE publication London.

Hashey, J. M. and Connors, D.J. 2003. Learning from our Journal: Reciprocal teaching action research. *Reading Teacher*, 57 (3), 224-233

Harts, Dixon, A., Drummond, M, and Mclntyre, D. 2004. Learning without limits. Maidenhead Open University press. Reciprocal teaching goes to college: Effects for postsecondary students at risk for academic failure. *Journal of Educational Psychology,* 90 (4), 670-681.

UNIVERSITY OF IBADAN LIBRARY

Henderson, J. G. 1989. "'positioned Reflective Practice: A curriculum Discussion", *Journal of Teaching Education*, (March-April 1989), 10-14

Hoffmann, A. M et al 1999: Science Technology and Vocational Education of Girls in Africa. *Summary of 21 National Reports for UNESCO*.

Houltram, B. 1996. Entry age, entry mode and academic performance on a project 2000 common foundation program. *Journal of Advance Nursing*. 23, 1089-1097.

Huppert, J, Lomask, S. and Lazarowitz, R. 2002. Computer simulations in High school: students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education*, 24(8), 803-821.

Iroegbu, T. O 1998. Problem based learning, numerical ability and gender and line graphic skills at Senior Secondary Physics in Ibadan. An unpublished Ph.D. Thesis of University of Ibadan.

Ivowi, U. M. O and Oludotun J. S, 2001. The student's women in Physics in Nigeria. *42nd Annual Conference proceeding science Teacher Association of Nigeria*

Jack C., 1990: Towards Reflection Teaching: The Teacher Trainer Back Articles. *http://www.tttjournal.co.uk.*

Johnson, D. W., Johnson, R.T., and Smith, K. 1991. *Active Learning: Cooperation in the College Classroom,* Edina, MN: Interaction Book Company.

Joint Admission and Matriculation Board. 2005. U.M.E Bronchure Guidelines for Admission to 1st degree courses in Nigerian Universities 2006/2007 session. Abuja.

UNIVERSITY OF IBADAN LIBRARY

Jones, M. A. and Brader – Araye, L. 2009. The impact of construction on Education: Language, Discoursed meaning, http://acjournal.org/holding/vol.15/iss3/ speakjenes . pdf retrieved Dec. 2008

Kalijah, T. 2000. Education Training and career in Physics for woman in Malaysia ln PAP *International conference on women in Physics* UNESCO Paris France.

Karamustafaoglu, S. 2011. Improving the Science Process Skills Ability of Science Student Teachers Using I Diagram. *Eurasian Journal of Physics and Chemical Education* 3(1), 26-38.

Karen, L.L. 2009. Process Skills for Life Science: Training Guide http://soinc.org\tguides.htm.Download on10/19/2010

Keith Skamp, 1989. General science Knowledge and attitudes towards Science and science Teaching of Pre-service Primary Teachers: Implications for Pre-service science unit. *Research in Science Education* 19. 257-267.

Klingner, J. K. and Vaughn, S. 1996. Reciprocal teaching of reading comprehension strategies for students with learning disabilities who use English as Second language. *Elementary School Journal*, 96 (3), 275-293.

Kolb, A. 1984. 'Experimental Learning: experience as the Source of Learning and Development'. Englewood Cliffs, New Jesey

Kolb, A. Y, Kolb, D. A. 2005. Learning style and Learning speaker, enhancing experimental Learning in higher education. *Interactive learning environments*, 18, 245-261

Krause, K. L. 2004. Reflective teaching, *Educational Psychology for learning and Teaching*, 13, 1-44, Nelson Australia press ltd. Retrieved on November, 27, 2010.

UNIVERSITY OF IBADAN LIBRARY

http://66.102.1.104/-scholars hl=x9=cache:OWs50pgkaisj:www.thouson learning. com.au/higher/-education/krauwe/media/krause-chapter-13.pdftrekated:owsso pgkaisJ:scholar.google.com

Larrivee, B. 2000. Transforming Teaching Practice: Becoming the critical reflective teacher: *Reflective Practice,* 1(3), 293-307

Leitch, R. and Day, C, 2000. Action Research and Reflective Practice: towards a holistic view' *Educational Action Research*, 8 (1), 179 -193.

Lesley, T. S. 1989. "Editorial", *Journal of Teaching Education*, (March-April, 1989) xxxx (2)

Lin, E. 2006. Cooperative Learning in the Science Classroom *Science Teacher* 73(5), 35-39

Marzano, R. J., Pickering, D.J., and Pollock, J.E. 2002. *Classroom instruction that works: Research- based strategies for increasing student achievement*. Virginia: ASCD.

Mayfield, K. H. and Vollmer, T. R. 2007. Teaching Maths Skills to At-risk Students Using Home-based Peer Tutoring. *Journal of Applied Behavior Analysis.* 40(2)

Mechling, K. et al 1994. *A recommended science competency continuum for Grades K-6 for Pennsylvania schools*. Harrisburg, P.A. PennsyIvme Department of Education

Mesler, L. (2009). Making retention count: The power of becoming a peer tutor.*Teachers College Record*, *111*(8), 1894-1915.

Miller, E, 2000. Education for all in the Caribbean in the 1990s: *EFA in Caribbean assessment 2000*: Monograph series Kingston Jamaica, UNESCO

Minner, D. O., Levy, A. J. and Century, J. 2010. Inquiry-based Science Instruction- What is it and does it matter? Results from a research synthesis years 1984-2000 *Journal of Research in Science Teaching,* 4(7), 474-496

UNIVERSITY OF IBADAN LIBRARY

Minott M. A. 2009. Reflective Teaching: A form of Professional Development *html:file:llc:\Documents and settings\my documents\Reflective Teaching A form … 9/5/2010*.

Moshe-Barak and Larisa Shakhman, 2008. Reform-Based Science Teaching: Teachers' Instructional Practice and Conceptions. *Eurasia Journal of Mathematics Science and Technology Education*. 4(1), 11-20.

Mueller, A. and Flaming, T. 2001. Cooperative Learning: Listen to how Children work at School. *Journal of Education Research*, 94 259-265.

Murphy, P. 2010. Gendered learning and achievement in Poland A. Ed., *Readings for reflective teaching* New York. Continuum.

National Research Council. 2000. Inquiry and the National Science Education Standard. Washington, DC. National Academy Press.

NCCE, 2009: National Commission College of Education for Colleges of Education (NCCE) *Statistical Digest for Colleges of Education In Nigeria* 1998-2002

Nigerian Education Research and Development Council (NERDC). 2007. Teachers handbook for the implementation of the 9 years Basic Science and Technology Curriculum. Abuja. NERDC Press.

Njoku, Z. C 1999. A scale for the assessment of students' chemistry practical skills in secondary schools. *Journal of the Science Teacher Association of Nigeria* 34(1&2), 83 – 89.

---------- 2002. Enhancing girls' acquisition of science process skills in co-educational schools. An experience with sex grouping for practical chemistry. *Journal of the Science Teacher Association of Nigeria* 37(1&2).

UNIVERSITY OF IBADAN LIBRARY

Nunnally, J. O. 2004. Memory, New York: Macmillan Press.

Nwagbo, C. 2003. Level of scientific literacy of secondary school science students' implications for sustainable development in Nigeria. *Proceedings of the 43rd Annual Conference and Inaugural Conference of CASTME Africa*; :73-77.

Oczkus, L. D. 2003. Reciprocal Teaching at work: Strategies for improving reading comprehension, Network, DE: *International Reading Association*.

Oginni, A. M. 2009. Selected Students' Aptitude Indices and School Factors as Predictors of Senior Secondary School Students' Learning Outcomes in Chemistry in Lagos State-An unpublished Ph.D Thesis University of Ibadan.

Ogunleye , B. O.2001, Circle Perception of strategies for improving low enrolment, under achievement and attitude of girls in Physics at the Senior Secondary School level. *Proceeding of STAN 42nd annual conference*.

Ogunsola-Bamidele, M. F, 1996. Mathematics in Physics which way forward: attitude toward the teaching of physics. *Paper presented at the Annual meeting of the National Science Teachers Association of Nigeria*.

Okebukola, P. O. A. 2002. A review of state of science in developing countries. *Science Education Review*. 46 (6), 23-45

Okpala, PN., Onocha, C.O. and Ayodeji O.A. 1998. Measurement and evaluation in education. Ibadan Stirring Horden publisher Nig Ltd.

Olagunju, A. M, Adesoji. F .A. Iroegbu, T. O and Ige, T .A. 2003. Innovations in science teaching for the new millennium. In Oluremi Bamisaiye (Ed). *Innovations in Theory and Practice* Macmillan publisher Nigeria.

UNIVERSITY OF IBADAN LIBRARY

Olaleye, S.B. and Salami, H.A. 1997. Predictors of Academics Performance in the pre-clinical Sciences: Effects of age, sex and mode of admission at the Maiduguri Medical School. *Africa Journal of Medicine and Medical Sciences* 26(3-4), 189-190.

Olanrewaju, A. O. 1996. Using Nigerian Languages as media of instruction to enhance science and technological development. An action Delarged. Fafunwa Foundation *Internet Journal of Education using Nigeria Language retrieved 23 Nov, 2010*.

Olatoye R. A. and Aderogba A. A. 2011. Performance of Senior Secondary School Science Students in Aptitude Test: The Role of Students Verbal and Numerical Abilities. Journal of Emerging Trends in Educational Research and Policy Studies 2(6), 431-435

Oludipe, B. 2009. Impact of Reciprocal Peer Tutoring on Secondary School Student's Achievement in Large Physics Classroom in Nigeria

Oludipe, B. D. 2003. Peer Tutoring-assisted instruction. An intervention for increasing senior secondary school students' achievement in Physics. *African Journal of Educational research* 9(1&2). June/Dec. Published by the Department of Teacher Education, University of Ibadan, Nigeria.

Ong, E. K. and Kenneth, R. 2005. Acquisition of Science Process Skills amongst Form 3 Students in Malaysian Smart and Mainstream Schools. *Journal of Science and Mathematics Education in S.E. Asia* 28(1).

Orji, A. B. 1998. Effects of problem solving and concept wrapping instructional strategies on students learning outcomes in Physics in Ibadan. An unpublished Ph. D Thesis university of Ibadan, Nigeria.

UNIVERSITY OF IBADAN LIBRARY

Orlich, D. C Harder, R. J., Callahan, R. C, Travisan, M. S and Brown, A. H. 2010. *Teaching strategies. A guide to Effective instruction.* Ninth Edition Wads worth CEN GAGE learning U.S.A

Osborne, R. J. & Wittrock, M. C. 1983. Learning science in generative process. *Science Education*. 67(4), 489-508.

Owolabi, T, Ogunleye A. O. and Adeyemo, S. A. 2007. Assessing students' acquisition of skills in Physics. *Proceedings of the 50th Anniversary Conference of STAN: 216-221.*

OYO SUBEB, 2009. Oyo SUBEB Success Stories. *OYO SUBEB NEWS* Vol. 2 no 8

Padilla, M. J. 1990. Science Process Skills. *National Association of Research in Science Teaching Publication: Research Matters- to the Science Teacher*

Palincsar, A. S. 1984. Reciprocal teaching comprehension – fostering and comprehension-monitoring activities. *Cognition and introduction*. 1 (2), 117-175.

--------------------- 1986. The role of dialogue in providing scaffolded instruction. *Educational Psychologist*, 21, 73-98

---------------------- 1986. Interactive teaching to promote Independent learning from text. *The Reading Teacher*, 39 (8), 771-777

---------------------- 1987. Collaborating for collaborative learning of text comprehension paper presented at the annual meeting of the *American Educational Research Association*, Washington, DC

Palinscar, A. S. and Klenk, L. 1991. Learning dialogues to promoting text comprehension. (PHS Grant 059). Bethesda, MD: *National Institute of Health and Human Development*

UNIVERSITY OF IBADAN LIBRARY

Palincsar, A. S. and Brown, A .L. and Campione, J, 1989. Structured dialogue among communities of first-grade learners. Paper presented at the annual meeting of the *American Educational Research Association*, San Francisco, California

Peers, I. S. and M. Johnson, 1994. Influence of learning context on the relationship between A-Level attainments and final degree performance: A meta-analytical review , *British Journal of Education Psychology*, 64, 1-15

Peter E. D., David, H., Cheri, F. T, William, D. N. and Carl, A. Y. 2006. Reciprocal Teaching for Reading Comprehension in Higher Education: A Strategy for Fostering the Deeper Understanding of texts. *International Journal of Teaching and Learning in Higher Education* 17 (2)

Pigott, H .E, Fantuzzo, J. W. and Clement, P. 1986. The effect of reciprocal peer tutoring and group contingencies on the academic performance of elementary school children. *Journal of Applied behaviour Analysis* 19, 93-98.

Poblete, D. Sr. 1999. A Reflective Teaching Model: An Adventist Assessment. 24th International Faith and Learning Seminar Held at Andrews University, Berrien Springs, Michigan, U.S A. June 20=July2, 1999

Pollard, A. 2008. *Reflective Teaching* 3rd Edition, Continuum International Publishing group. Great Britain

Polya, G. 1945. *How to solve it?* Garden City, NJ: Doubleday.

Prince, M. 2004. "Does Active Learning Work? A Review of the Research," *Journal of Engineering Education*, 93(3), 223-231

UNIVERSITY OF IBADAN LIBRARY

Qualification and Curriculum Authority 2000. *Standard at key stage 2, English, Mathematics and science*. London: QCA

Rolfe, G., Freshwater, D. & Jasper, M. (2001) *Critical Reflection in Nursing and the Helping Professions: A User's Guide.* Basingstoke. Palgrave Macmillan.

Rosenshine, B. and Meister, C. 1994. Reciprocal teaching: a review of the research. *Review of educational research* 64 (4), 479 – 530.

Ross, W. E. and Hannnay, L.M 1986. "Toward a critical Theory of Reflective inquiring" *Journal of Teacher Education,* (July-August 1986), 9-15.

Saenz, L., Fuchs, L.S., & Fuchs, D. 2005. Peer-Assisted Learning Strategies for English language learners with learning disabilities. *Exceptional Children*, 71(3), 231-247.

Sampson, and Yeomans R. 2010. Analysing the role of mentors: in Andrew Pollard, (Ed.) *Reading for reflective teaching*. New York Continuum.

Schon D.A. 1983. *The Reflective Practitioner, How Professionals Think in Action*, Basic Books. New York.

---------------- 1987. Educating the Reflective Practitioner. Sanfransisco: Jossey-Bass.

Shaibu, A. A. M. and Mari, J. S. 1997. Gender-related difference in understanding of science process skills amongst junior secondary schools. *Journal of Science Teachers Association of Nigeria* 32, (1&2), 21-27.

Sharman, L. W. 1991. Cooperative Learning in Post-secondary Education: implication from social Psychology for active learning experiences. *Paper presented at the annual meeting of the America educational Research*

Showers, D. E. and Shrighary, R. I. 1995. Effects of Knowledge and Persuasion on High School Students Attitude toward Nuclear Power Plants. *Journal of Research in Science Teaching* 8(1), 23-43

UNIVERSITY OF IBADAN LIBRARY

Simon, V. Irtwange and Nancy N. Agbe. 2010. Comparative analysis of academic achievement of UME and ex-Remedial students Case study of University of Agriculture, Markudi, Nigeria. *International Journal of Educational Administration and Policy Studies.* 2(1), 009-030.

Slavin , R. E. 1996. Synthesis of research on cooperative learning. *Educational leadership*, 48, 71 -82.101 (5), 495 – 510.

Spencer, V. G. (2006). Peer tutoring and students with emotional or behavioral disorders: A review of the literature. *Behavioral Disorders*, 31(2), 204-222

Staub, D., and Hunt, P. 1993. The Effects of Social Interaction Training on High School Peer Tutor of Schoolmate with Severe Disabilities, *Exceptional Children* 60(1), 41-57

Strouse, J. H, 2001. *Exploring Socio-Cultural Themes in Education.* Upper Saddle River, NJ.

Taghilou M. R. 2007. From reflective teaching to effective learning: A new class order. *Iranian Journal of Language Studies.* 1 (2) 89-102

Tanner, L. N. 1988. "Observation The Path, Not Taken: Dewey's model of inquiring", *Curriculum inquiring*, 8(4)

Taylor, B. M. and Frye, B. 1992. Comprehensive Strategies instruction in the intermediate grades. *Reading Research and instruction*, 92, 39-48.

Tom, A. R., 1985. "Knowledge Resources for improving the content of Pre-service Teacher Education" *Journal of Teacher Education*, Sept., Oct., 1985.

Ursos, M. E. and Bauyot, M. Mathematical Modeling of Numerical Ability Test and Achievement Test in College Algebra as Basis for the Construction of Module for

UNIVERSITY OF IBADAN LIBRARY

Bridging Program. In C. Crawford et al. (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2006 (3685-3686). Chesapeake, VA: AACE.

Vygotsky, L. S. 1978. *Mind in society: The development of higher psychological process*, (M. Cole, V. John Steiner, S. Scribner, E Souberman, Eds, and trains) Cambridge, Massachusetts. Harvard University Press

Walker, E. N. (2007). The Structure and culture of developing a mathematics tutoring collaborative in an urban high school. *The High School Journal*, *91*(1), 57-67

Welch, A. R. 1993: Class, Culture and the state in comparative education: Problems, perspectives an d prospects; *comparative education*, 29(1), 7-27.

Wells, S. E. 1990. *At youth Identification, Programmes, and Recommendations* Eagle word.co Teacher idea press.

Wetzel, D. 2008. Science Investigation Skills is Important for Problem Based learning. *Source; htlp: llEzine Articles.com/?expert=David Wetzel Diewn Loard 10/19/2010*

Wetzel, D, 2010. Tips for Integrated science Process skills in Lesson retrieve for *http://ezinearticle.com*

Wolfe, J .A. Fantuzzo, J. W. and Wolfe J. A. 1984. Student–administered group-oriented contingencies: A method of combining group. Oriented contingencies and self-directed behavior and increase academic productivity. *Child and family Bahaviour Therapy*, 6, 45 - 60.

Zeicher, K. M. and Liston, D. P. 1996. *Reflective Teaching: An Introduction*, Mahwah, New Jersey: Lawrence Erlbaum Associates, Published.

UNIVERSITY OF IBADAN LIBRARY

APPENDIX 1

Operational guide for Experimental group 1

Reflective-Reciprocal Teaching

Duration: 2hours

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

1. Understand predicting, questioning, clarifying and summarizing strategies of reflecting teaching
2. Apply the strategies in teaching the concept of speed, velocity and acceleration.
3. Predict the concept of speed, velocity and acceleration
4. Perform simple calculations on them
5. Derive the three equations of motion
6. State the differences between speed, velocity and acceleration
7. Clarify some misunderstanding and misconceptions on the concept.
8. Summarise the content of speed, velocity and acceleration.

Teaching Procedure

Phase One: Research assistant model this section

Pre-service teachers are grouped into heterogeneous small groups. The research assistant provides instruction / teaches pre-service teachers on how to use the strategies.

(a) *Predicting:* pre-service teachers are encouraged to make the guess on the topic of the lesson.

(i) predict what you think average speed is all about

UNIVERSITY OF IBADAN LIBRARY

(ii) what will happen when a car moving at a top speed suddenly saw a school boys crossing

(iii) what makes a stationary object to move

(b) *Questioning*

(i) what is average speed?

(ii) how would you determine the distance travelled from average speed?

(iii) what are the differences between speed and displacement?

(iv) what happen to a body whose velocity increases?

(v) when does a body has uniform acceleration?

(vi) given initial velocity (u) acceleration (a) and distance travelled(s) calculate the final velocity (v)

(c) *Clarifying:*

(i) Speed is the rate of change of distance moved with time while velocity is the rate of change of displacement moved with time.

(ii) displacement is the distance covered by a body in a specified direction.

(iii) average speed = $\frac{\text{distance travelled}}{\text{Time taken}}$

Unit = m/s

Distance = average speed x time taken

S.I unit of distance is *m*

S.I unit of time is *sec*

(iv) Velocity = $\frac{\text{distance moved in a specified direct}}{\text{Time taken}}$

UNIVERSITY OF IBADAN LIBRARY

$$\text{Velocity} = \frac{\text{Displacement (x)}}{\text{Time taken}}$$

$$\text{Displacement } x = vt$$

$$\text{Average velocity} = \frac{v + u}{2} = \frac{\text{final velocity + initial velocity}}{2}$$

(4) *Summarizing*

(i) Speed, velocity and acceleration are used in motion.

(ii) Speed is a scalar quantity while velocity and acceleration are vector quantities.

(iii)Increase in velocity given rise to acceleration while decrease in velocity gives rise to deceleration. If the velocity of a body does not change the body is said to move with uniform or constant velocity.

(iv) A body that starts from rest has zero initial velocity and body that comes to rest has a final velocity of zero.

Phase Two: Pre-service Teacher dominates.

The pre-service Teacher learn how to use predicting, questioning, clarifying and summarizing strategies respectively as taught by research assistance.

Phase Three: The research assistant reflects on the lesson:

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

UNIVERSITY OF IBADAN LIBRARY

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIT TWO

Duration: 3 HOURS

Topic: Graphical treatment of Speed, Velocity and Acceleration.

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

(i) Understand predicting, questioning classifying and summarizing strategies of reflective teaching.

(ii) Apply the strategy in teaching the graphical aspects of speed, velocity and acceleration.

(iii) Predict the shapes of the following graphs (a) distance plotted against time for uniform and non uniform speed

(b) displacement plotted against time for uniform and non uniform velocity.

(c) Velocity plotted against time for uniform and non uniform velocity.

(iv) use the graphs in calculating speed, velocity acceleration as well as instantaneous speed, velocity and acceleration.

(iv) Use the graph to calculate total distance travelled in each case.

UNIVERSITY OF IBADAN LIBRARY

Teaching Procedure

(a) Phase One: The research assistant model this section.

Pre-service teachers are grouped into small heterogeneous small groups. The research assistant provides instruction and teaches pre-service teachers on the use of the strategy.

(b) Predicting: Pre-Service teachers are encourage to make right guesses on the topic of the lesson

(i) Predict the shapes of graphs to be obtained in the each of the following cases.

a. Distance plotted against time

b. Displacement plotted against time

c. Velocity plotted against time.

Questioning

(1) Explain how you would obtain the speed, velocity and acceleration from each graph plotted above.

(2) Discuss how you would calculate the speed velocity, and acceleration at any given instant.

(3) How would you calculate the total distance travelled in each of the above cases?

Clarifying

Speed of motion is obtained from a distance time graph. If a graph of distance (s) is plotted against time (t) two graphs are possible to be obtained.

UNIVERSITY OF IBADAN LIBRARY

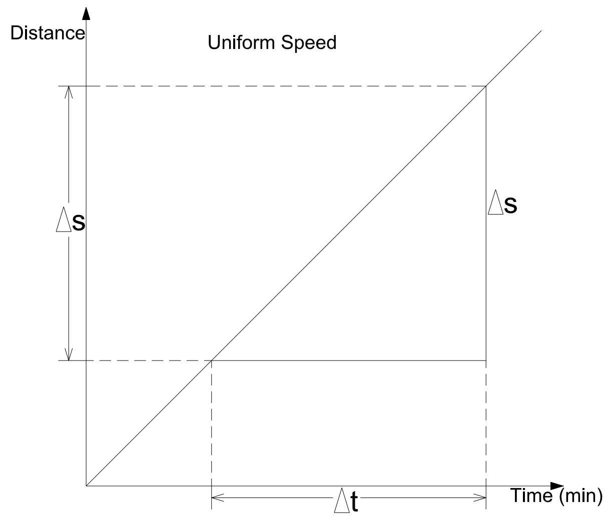


fig. 13a

Figure 13a : Graph of Uniform Speed

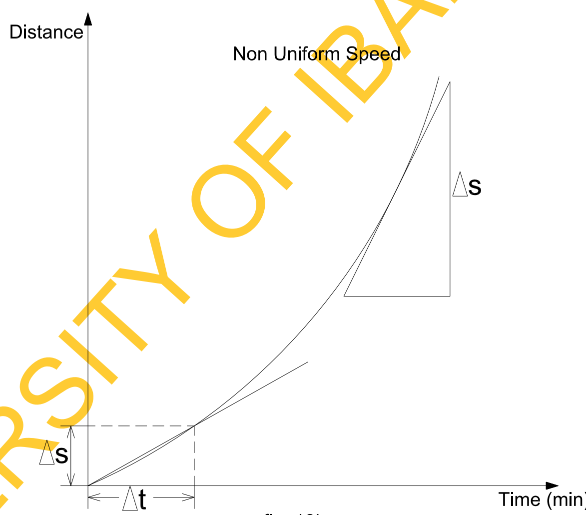


fig. 13b

Figure 13b: Graph of Non-Uniform Speed

The graph on fig. 13a shows that the speed is uniform, and it is obtained by $^{\Delta s}/_{\Delta t}$

While the graph in fig. 13b represents that the speed is non uniform, hence speed at any given instant can be calculated which is known as instantaneous speed. Example: instantaneous speed at x = $^{\Delta s}/_{\Delta t}$, while that at point y is $^{\Delta s}/_{\Delta t}$ etc. Velocity of motion is

UNIVERSITY OF IBADAN LIBRARY

obtained from a displacement time graph. If a graph of displacement is plotted against time, two different graphs are possible fig. 14a and 14b show the types.

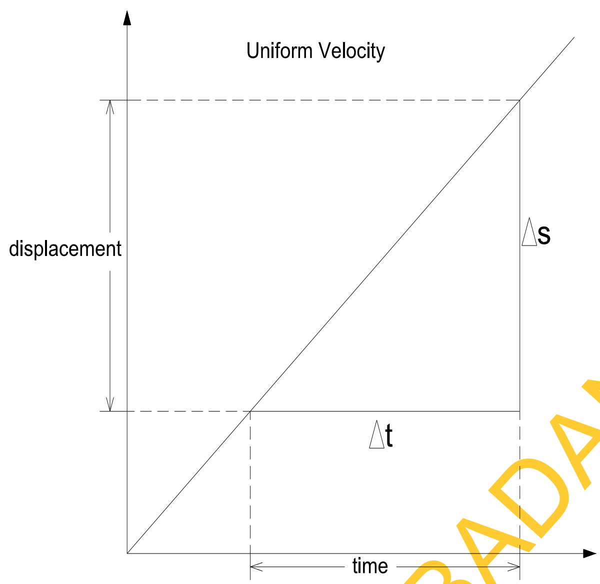


fig. 14a

Figure 14a: Graph of Uniform Velocity

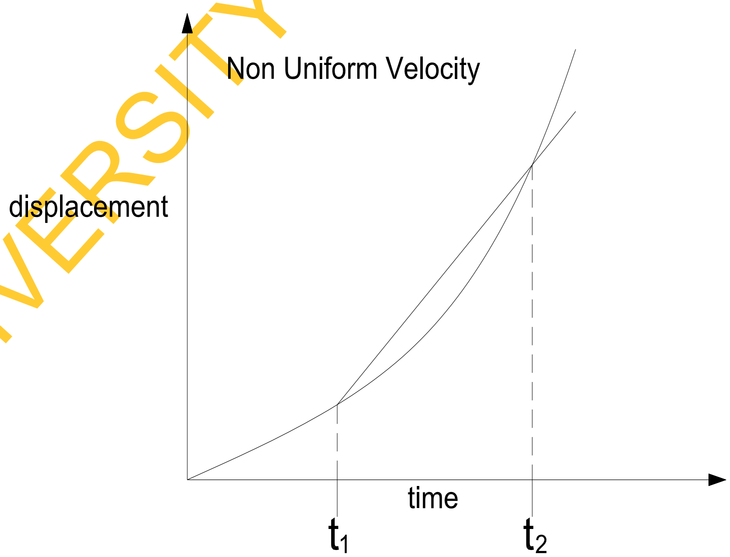


fig. 14b

Figure 14b: Graph of Non Uniform Velocity

UNIVERSITY OF IBADAN LIBRARY

Fig. 14a shows a straight line meaning that the change in displacement per change in time is constant hence velocity is uniform/constant.

It is obtained by calculating the slope of the graph in fig. 14a.

While figure 14b shows that the velocity is not constant, hence the velocity at a given point can be calculated by drawing a target to the curve at that particular point from these, draw a big triangle fig. 13b and calculate the velocity at that point. Also, instantaneous velocity at point $x = {}^{\Delta s}/_{\Delta t}$ = instantaneous velocity at point x

Total distance travelled is the area under the graph. Acceleration of a body can also be obtained from a velocity time graph. If velocity is plotted against time, three graphs are possible.

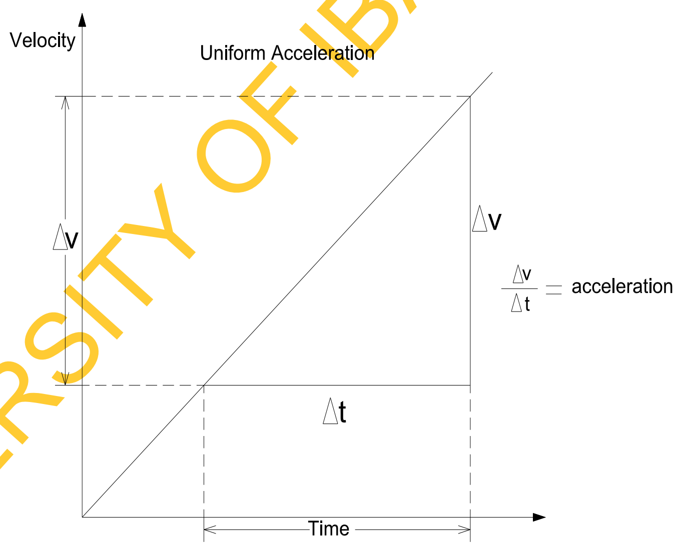


fig. 15a

UNIVERSITY OF IBADAN LIBRARY

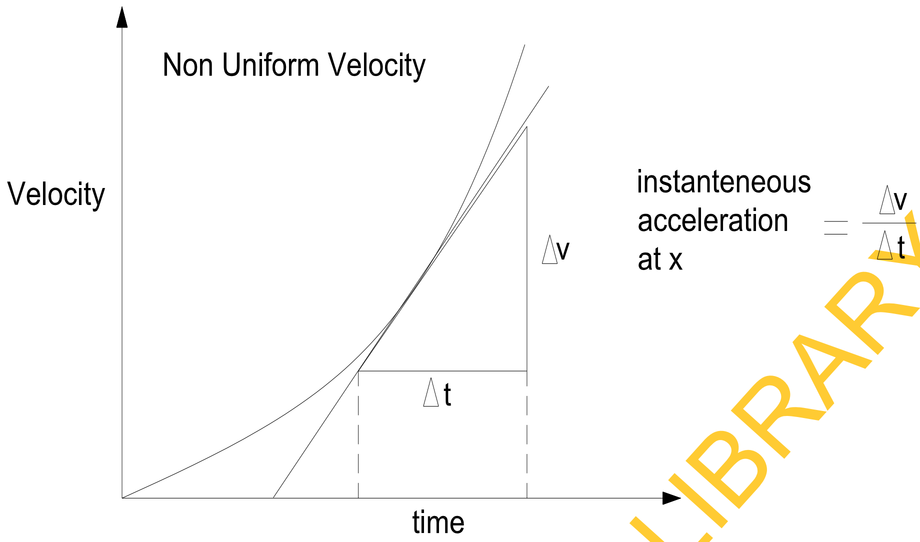


fig. 15b

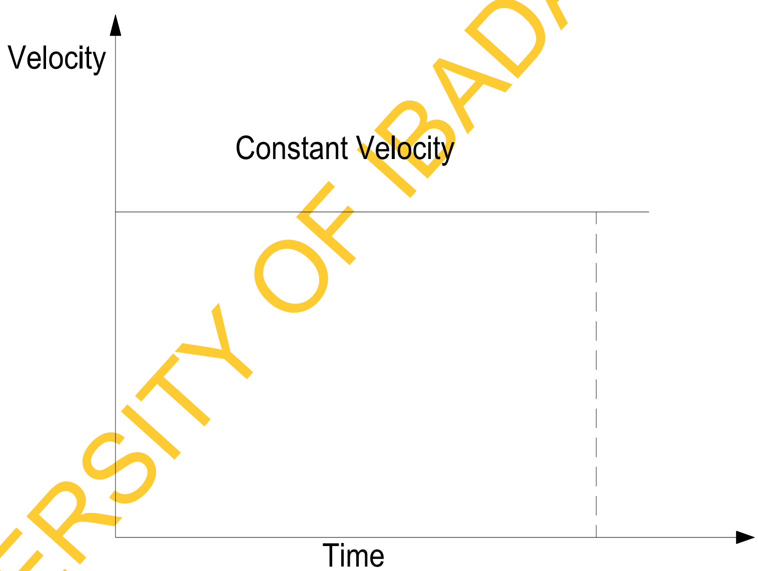


fig. 15c

Fig.15c: Graph of Constant Velocity

Fig.15a Show a straight line passing through the origin implying that change in velocity over change in time is constant. Therefore, from fig. 15b, the slope of the graph is acceleration.

i.e $^{\Delta v}/_{\Delta t}$ = acceleration and the acceleration is uniform.

UNIVERSITY OF IBADAN LIBRARY

Fig. 15b shows a curve meaning that the acceleration varies, it is not uniform, here acceleration at any given point is known as instantaneous acceleration example of instantaneous acceleration at point x is $^{\Delta v}/_{\Delta t}$ (fig. 15b)

Fig. 15c shows a straight line parallel to the x-axis indicating that the velocity is constant hence acceleration is zero.

Total distance travelled is the total area under the graph.

Summarizing

Speed can be obtained from the graph of distance plotted against time.

Velocity can be obtained from a displacement time graph.

Acceleration is the slope of a velocity time graph. For uniform speed, velocity and acceleration the graph is a straight line while it is a curve for non uniform speed, velocity and acceleration.

The area under the distance, displacement and velocity time graph represent the total distance travelled.

Phase Two

Pre-service teacher dominates

The pre-service teacher learn the above strategies i.e. predicting questioning clarifying and summarizing respectively as taught by the research assistant.

Phase Three: Briefing / Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIVERSITY OF IBADAN LIBRARY

UNIT THREE

Duration: 2 hours **Topic:** Linear Momentum

Behavioural Objectives: At the end of the lesson

Pre-service teachers should be able to:

(i) Understand predicting, questioning, clarifying and summarizing strategies of reflective teaching.

(ii) Apply the strategy in teaching the concept of linear momentum.

(iii) Predict the concept of momentum, impulse, inertia and collision

(iv) Solve simple calculation on linear momentum

(v) State Newton's laws of motion

(vi) List the three types of collision

(vii) Explain each type of collision with example

Teaching Procedure

Phase One: The research assistant model this section

Pre-service teachers are grouped into heterogeneous small groups. The research assistant provides instruction for pre-service teachers on how to use the strategy.

(a) Predicting: Pre-service teachers are encouraged to make the following guesses:

(i) A body of mass (m) moving with velocity (v) will have………?

(ii) When a body collide with another body what happen to two bodies?

(iii) Predict the unit of inertia and that of momentum

(iv) Predict what happen to momentum when a gun is fired.

UNIVERSITY OF IBADAN LIBRARY

(b) Questioning:

(i) Define linear momentum of a body

(ii) Distinguish between momentum and impulse

(iii) State Newton's laws of motion

(iv) Explain inertial of a body

(v) State the law of conservation of linear momentum

(vi) State the three types of collision you know and explain them.

(c) Clarifying:

(i) Linear momentum (p) of a body is defined as the product of mass (m) of the body and the velocity (v) at which the body is moving. Its unit is $kgms^{-1}$, it is a vector quantity. Its magnitude is Mv and its direction is the direction of the velocity (v).

(ii) Momentum is associated with motion, a body in motion can have momentum while impulse (I), is associated with collision. When a body collides with another body, each receives an impulse or blow. The impulse consists of a large force acting for a very short time. $I = Ft$ and $P = Mv$

Unit of I is Ns while unit of P is $kgms^{-1}$. I is also a vector quantity.

(iii) Newton laws of motion

Sir Isaac, Newton discovered the relationship between force and motion. He stated three important laws to explain motion. Newton's Law 1, states that every object continues in its state of rest or of uniform motion in a straight line unless it is acted upon by external force.

Newton's Law 2 states that the rate of change of momentum is proportional to the applied force and takes place in the direction of the force. i.e.

UNIVERSITY OF IBADAN LIBRARY

$$F \propto \frac{\text{change in momentum}}{\text{Time taken for the change}}$$

$$F \propto \frac{mv - mu}{t}$$

$$F \propto \frac{m(r - u)}{t}$$

$$F \propto ma$$

$$F = Kma$$

K is a constant

with a value of 1

$$F = ma$$

F is in Newton

M is in Kilogram

a is in m/s^2

The Newton is a unit of force which gives a mass of 1kg an acceleration of $1ms^{-2}$. The second equation of motion gives a measure of force as the product of mass and acceleration of a body.

Law 3 states that to every action there is an equal and opposite reaction. This law is applicable to collision. Example, if a body, A collides with a body B. It follows that body A exerts a force F_A e.g. 10N on body B in turn body B exerts a force F_B on body A (10N). These two forces F_A and F_B are equal in magnitude (10N) each but opposite to each others.

(iv). Inertia of a body is the tendency of a body to remain in its rest position or to continue its motion in a straight line once it has started moving in the absence of

UNIVERSITY OF IBADAN LIBRARY

external forces. This implies that inertia is inherent in a body at rest or in a moving body with constant velocity. Inertia is a property of matter.

(v). Law of conservation of linear momentum states that in a closed system of colliding objects the total momentum is conserve.

Note: That a closed or isolated system is a system where there is no external forces acting.

Consider two objects of masses m, and m_2 moving with initial velocities u_1 and u_2 in the same direction collide with one another.

Applying Newton's 3rd law action and reaction are equal but opposite.

$m_1 (v_1 - u_1) = -m_2 (v_2 - u_2)$

Momentum change of objects are equal but opposite

$m_1v_1 - m_1u_1 = m_2v_2 + m_2u_2$

$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Momentum is conserved total momentum before collision is equal to total momentum after collision when there is no external force acting.

Types of Collision

(1) Perfect Elastic Collision

(2) Inelastic Collision

(3) Explosion

(1) Perfect Elastic Collision: is the one with total kinetic energy and momentum are conserved. Example: consider two objects of masses m_1 and m_2 moving with initial velocities u_1 and u_2 collide elastically with each other the velocity of m_1 is

UNIVERSITY OF IBADAN LIBRARY

reduced and that of m_2 is increased applying the principle of conservation of energy and momentum, K.e and momentum are conserved.

Examples of elastic collision are a ball bouncing off the ground back to its original height.

Inelastic collision

Momentum is conserved but kinetic energy decreases as it is converted to heat, sound and elastic.

Potential energy in it also causes deformation. Example: an object dropped into a mud. In inelastic collision the two objects stick together after collision, they then move with the same common velocity.

Explosion

Momentum is conserved but kinetic energy increases. Example when two cars are made to fly a part after colliding with one another (both of them experience impact). The impact of the first is equal and opposite to the impact of the second body. For examples, if a body of mass in with velocity v collides explosively with another body moving with velocity

$\therefore$ $mv = MV$

Such that:

$mv = -MV$

$mv + MV = 0$

Summarizing:

Linear momentum is defined as the product of mass and velocity of a body. It is a vector quantity. Impulse is the product of a large force and a short interval of time; unit is Ns.

UNIVERSITY OF IBADAN LIBRARY

There are three laws of motion propounded by Sir Isaac Newton:

(1) Every object remains in its position of rest or of uniform motion in a straight line unless it is acted by external forces.

(2) The rate of change of momentum is directly proportional to the applied force and take place in the direction of the force.

(3) To every action there is an equal and opposite reaction.

The three types of collision are elastic, inelastic and explosion.

Phase two: pre-service teacher dominates. The pre-service teacher learn how to use predicting, questioning, clarifying and summarizing strategies respectively as taught by the research assistant .

Phase three: Briefing / Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIT FOUR

Duration: 2 hrs

Topic: Work, Energy and Power

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

UNIVERSITY OF IBADAN LIBRARY

(1) Understand predicting, questioning, classifying and summarizing strategies of reflecting-reciprocal teaching

(2) Apply the strategies in the teaching of work, energy and power

(3) Predicting the concept of work, energy and power

(4) Perform simple calculations on them

(5) Derive the formula for kinetic energy and potential energy

(6) Clarify some misunderstanding and misconceptions on the concept.

(7) Summarizes the concept of work, energy and power.

Teaching Procedure

Phase One: The research assistant model this section

Pre-service teachers are grouped into heterogeneous small groups. The research assistant provides instruction/teaches pre-service teachers on how to use the strategies.

(a) *Predicting:* pre-service teachers are encourages to make a guess on the topic of the lesson.

(i) When is work said to be done?

(ii) Did a boy holding a pile of book does any work

(iii) What do you need to do work?

(iv) What are the different forms of energy?

(v) What are the unit of work, energy and power?

(b) *Questioning*

(i) What is work?

(ii) What is its unit?

(iii) What is its mathematical definition?

UNIVERSITY OF IBADAN LIBRARY

(iv) What is energy?

(v) Mention different forms of energy

(vi) Differentiate between K.E and P.E

(vii) Deduce the formula for K.E and P.E

(viii) State law of conservation of energy

(c) *Clarifying*

(i) Work is said to be done only when a force causes movement

Work= Force x distance moved in the direction of force

(ii) Its S.I unit is Joule

(iii) In symbols is w = f x s

(iv) Energy is what people or machines must have before they can do work. It is define as the ability to do work. Its S.I unit is Joule.

(v) Forms of energy includes:

- Chemical energy, nuclear energy, solar energy mechanical energy

  Mechanical energy can be potential or kinetic energy. Potential energy ils energy a body has because of its position while kinetic energy is the energy a body possess as a result of its motion

(vi) Derivation of K.E and P.E formula

i. Kinetic energy: suppose a body of mass m is at rest and is acted on by a steady force *f* which gives it a uniform acceleration *a*, so that the velocity of the body is *v* after it has moved a distance *s*. we can use the equation $v^2 = u^2 + 2as$ and, since u = 0

$$V^2 = u^2 + 2as$$

UNIVERSITY OF IBADAN LIBRARY

$V^2 = 2as$

$a = v^2/2a$

substituting in $f = ma$

$f = m(v^2/25)$ or $FxS = {}^1/_2 mv^2$

f x s is the work done on the body to give it velocity *v* and therefore equals to its K.E. Hence

Kinetic Energy = K.E = ${}^1/_2\ mv^2$

ii. Potential Energy: A body above the earth's surface is considered to have an amount of gravitation P.E. equal to the work that has been done against gravity by the force used to raised it. To lift a body of mass *m* through a vertical height h needs a force equal and opposite to the weight mg of the body, where *g* is the earth's gravitational field strength at the place.

Hence,

Work done by force = force x vertical height

:. P.E = mgh

(vii) Power is the rate at which work is being done or the rate at which it changes energy from one form to another

$$\therefore \text{Power} = \frac{\text{work done}}{\text{Time taken}} = \frac{\text{energy change}}{\text{time taken}}$$

Unit of power is Walt (w) which is a rate of working of 1 joule per second

1w = 1j/s

1 kw = 1000w

1 mw = 1,000,000w

UNIVERSITY OF IBADAN LIBRARY

(viii) Calculation, under work, energy and power

(a) How much work is done when a force of 10N moves an object a distance of 5.0m.

Solution f = 10N, s= 5.0m

Work = f x s

= 10 x 5.0

= 50Nm = 50J

(b) What is the velocity of an object of mass 1.0kg which has 200J of Kinetic energy

Mass = 1.0kg

K.E = 200J

From K.E = $^1/_2$ mv^2

$200 = {}^1/_2\ 1.0 \times v^2$

$100 = v^2/_1$

$V^2 = 100$

$V = \sqrt{100} = 10$ m/s

(c) Calculate the P.E of a 5kg mass when it is 3m above the ground.

P.E = mgh m=5kg, g=10m/s, m=3m

P.E = 5 x 10 x 3

= 150J

(d) A boy of mass 40kg runs up a flight of stairs of vertical height 5.0m in 8.0s. what is his average power?

m = 40kg s = 5.0m t = 8.0s

UNIVERSITY OF IBADAN LIBRARY

p = $\frac{\text{work done}}{\text{time take}}$

but work = force x distance

= mass x acceleration x distance

= 40 x 10 x 5

= 2000J

:. Average power = 2000/8.0 = 250w

(ix) Law of conservation of energy state that energy cannot be created or destroyed but it can be changed from one form into another.

(d) *Summarizing*

Work is done when a force causes motion while energy is the ability or capability to do work. Both are measured in joule

Work = Force x distance

K.E = $^1/_2mv^2$ i.e energy a body posses as a result of its motion while P.E = mgh which is the energy a body posses as a result of its position.

There are different forms of energy.

Power is the rate of doing work and its measured in watt.

Power = $\frac{\text{work done}}{\text{Time taken}}$

Phase Two: pre-service teacher dominates. The pre-service teacher learn how to use predicting, questioning, clarifying and summarizing strategies respectively as taught by the research assistant.

Phase three: Briefing / Reflection

UNIVERSITY OF IBADAN LIBRARY

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIT FIVE

Duration: 3 hrs

Topic: Determination of (g) using simple pendulum bob

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

1. Understand predicting, questioning, clarifying and summarizing strategies of reflective-reciprocal teaching.
2. Apply the strategies in the determination of acceleration due to gravity *(g)* using pendulum bob
3. State the necessary precaution to be taken in performing the experiment.
4. Perform some calculations under the acceleration due to gravity *(g)*

Teaching procedure

Phase One: Research assistant model this section.

UNIVERSITY OF IBADAN LIBRARY

Pre-service teacher are grouped into small groups. The research assistant provides instruction on how to use the strategies.

a. Predicting: pre-service teacher are encouraged to make guess on the topic of the lesson e.g

i. What do you think will happen when an orange is drop from a tree?

ii. If a piece of paper and a mango were drop from the top of building which of them do you think will first hit the ground

iii. What do you think responsible for your answer in (ii) above?

iv. In determining acceleration due to gravity (g) using simple pendulum, what materials do you think will be needed

v. Do you think it will be necessary to take any precaution?

b. Questioning

i. What is acceleration?

ii. What is acceleration due to gravity?

iii. On what does the acceleration of a free fall of an object depends

iv. What are the different method that can be used to determine the acceleration due to gravity

v. What materials do you need to determine acceleration due to gravity *(g)* using simple pendulum bob?

vi. What are the experimental steps to be taken in the determination of acceleration due to gravity?

vii. What are the theory and calculation involved in the experiment?

UNIVERSITY OF IBADAN LIBRARY

c. Clarifying

i. Acceleration is change in velocity in unit time

a. Acceleration due to gravity is the acceleration of a freely falling body denoted by the italic letter *g* and the value is $9.8mls^2$ (approximately $10mls^2$) but does varies slightly from one place on earth to another, this implies that where air resistance is negligible, the velocity of a falling body increase by 9.8mls every second. On the other hand, an object short straight upward decelerates by 9.8mls every seconds till it reaches its highest point. In calculation using the equation of motion, *g* replaces a. It is given a positive sign for falling bodies and a negative sign for a rising bodied since they are decelerating.

Acceleration due to gravity *(g)* can be determined using the following method

i Using steel ball and electric stop clock with the equation of motion $S=1/_2gt^2$

ii Using pendulum bob with the periods, $T=2\pi\sqrt{l/g}$

Materials needed: Pendulum bob (e.g a metal sphere with a hook attached or with a hole bored through its centre), cotton or thread, stop-watch, metre scale or metre rule, stand and clamp, small improvised vice.

Methods:

- Tie a metre length of the cotton or thread to the pendulum bob and suspend the cotton from the jaws of an improvised vice, such as a two small metal plates held in a clamp. Alternatively, two coins, two halves of a cork split length wise or the jaws of a pair of pliers serve equally well for the point of suspension when gripped in a clamp.

UNIVERSITY OF IBADAN LIBRARY

- Place a piece of paper with a vertical mark on it behind the pendulum so that when the later is at rest it hides the vertical mark from an observer standing in front of the pendulum.
- Set the pendulum bob swinging through a small arc of about 10^0. With a stop-watch measure the time for 20 complete oscillation setting the watch going when the pendulum passes the vertical mark and stopping it 20 complete oscillations later when it passes the mark in the same direction. Repeat the timing and record both times.
- Measure the length 1 of the cotton thread from the point of suspension to the middle of the bob. Shorten the length of the pendulum by successive amounts of 5cm by pulling the cotton thread through the vice and for each new length take two observations of the time for 20 oscillations.

Tabulate the readings as follows:

UNIVERSITY OF IBADAN LIBRARY

Table 5: Determination of "*g*"

Length of pendulum l/m	Time for 20 oscillations			Time for I oscillation T/s	T^2/S^2
	t_1/s	T_2/s	Mean t/s		

- Plot a graph with values of T^2/S^2 as ordinates (y-axis) against the corresponding values of l/m as the x-axis.

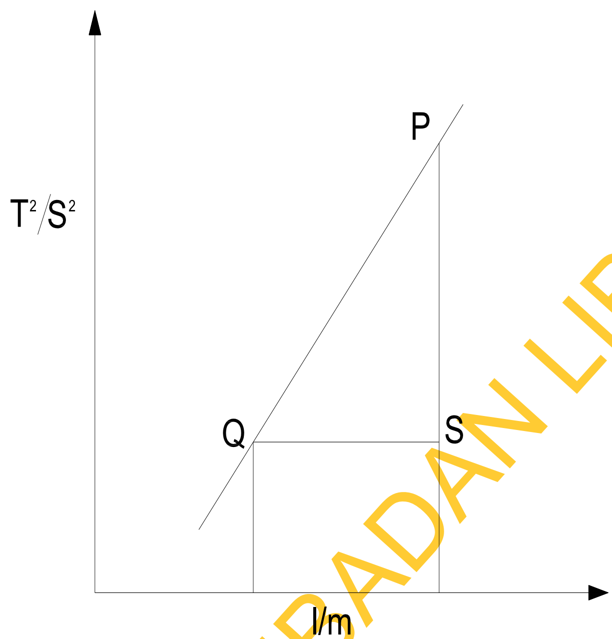


Fig. 16: Graph of Period against Time

Calculation:

The periodic time T of a simple pendulum is given by

$$T=2\pi\sqrt{l/g}$$

Where *g* is the acceleration of free fall

$$\therefore T^2=4\pi^2 l/g$$

From which it is seen that the graph of T^2 against *I* will be a straight line whose slope PN/QN measured from two convenient and well-separated points P and Q on the line, is numerically equal to $4\pi^2/g$,

Thus $PNs^2/QNm = 4\pi^2/g$

$\therefore g = 4\pi^2$ QN/PN ms^{-2}

UNIVERSITY OF IBADAN LIBRARY

Precautions:

The following necessary precaution needs to be taken for accurate result and to minimized error

- The counting of the oscillations most be correct
- Be careful to count complete oscillation
- Varying the lengths of the pendulum between 100cm to 30cm but do not go beyond these limit. Length exceeding 100cm are difficult to measure and the experiment becomes increasingly inaccurate. The shorter the length of the pendulum the more accurate the result.
- Try to minimize error in timing.

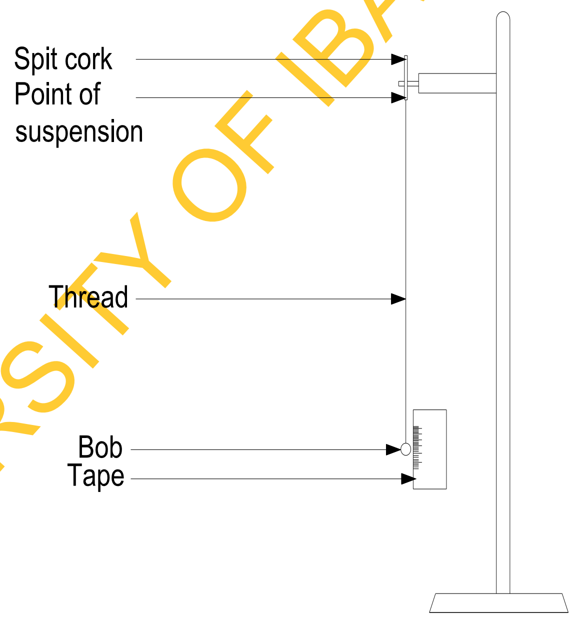


Fig. 17: Experimental set-up of Determination of "g" using Simple Pendulum Bob

d. **Summarizing**

- acceleration due to gravity is the acceleration of a freely falling object

UNIVERSITY OF IBADAN LIBRARY

- it is denoted by (g) and measured in ms^{-2}

- it can be determine using simple pendulum bob

- it can be calculated from the formular of a periodic time $T = 2\pi\sqrt{l/g}$

- when carryout the experiment some precaution needs to be taken.

Phase Two: Pre-Service teacher dominate.

The pre-service teacher learn how to use the strategies of predicting, questioning, clarifying and summary as taught by the research assistance. They are allowed to carry out the experiment within their various groups, plot the graph and determine the value of *g*

Phase Three: The research assistant and the pre-service teachers reflect on the lesson thus

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIVERSITY OF IBADAN LIBRARY

APPENDIX II

Operational Guide for Experimental group II

Reflective-Reciprocal peer tutoring Teaching strategies

Duration: 2hours

Topic: Speed and Acceleration

Behavioral objectives:

At the end lesson, pre-service teachers should be able to:

(1) Explain the strategy of reflective –reciprocal peer tutoring

(2) Apply the strategies in teaching the concept of speed, velocity and acceleration.

(3) Explain the concept of speed, velocity and acceleration

(4) Perform simple calculations on them

(5) Derive the three equations of motion

(6) State differences between speed, velocity and acceleration

Teaching Procedure

Phase One: Administration of test (The research assistant dominates)

Step 1: The research assistant administer a ten minutes quiz to pre-service teachers

Questions: (1) what is motion?

(2) When is a body said to be in motion?

(3) What is the major cause of motion?

(4) What stops a body from motion?

(5) Distinguish between contact force and non contact force

(6) Is mass and weight the same? Justify your answer.

(7) Mention one instrument for measuring weight of an object

UNIVERSITY OF IBADAN LIBRARY

Step 2: The research assistant presents instruction on how to solve problems and also explains the content of the subject matter as:

Speed is the rate of change of distance moved with time while velocity is the rate of change of displacement moved with time.

Displacement is the distance covered by a body in a specified direction

$$\text{Average speed} = \frac{\text{distance moved}}{\text{Time taken}}$$

$$\text{Unit} \quad \frac{m}{s} = ms^{-1}$$

S.I unit of distance is metre

S.I unit of time is second

S.I unit of speed = ms^{-1}

$$\text{Velocity} = \frac{\text{distance moved in a specified direction}}{\text{Time taken}}$$

$$= \frac{\text{displacement}}{\text{time taken}}$$

$$\text{S.I unit} = \frac{m}{s} = ms^{-1}$$

$$\text{Acceleration} = \frac{\text{increase in velocity}}{\text{Time taken}} = \frac{v-u}{t}$$

S.I unit of a= ms^{-1} = ms^{-2} or m/s^2

Equation of motion: If a body is moving with uniform acceleration (a) and its velocity increase form u 1st equation to v in time t,

$$\text{Acceleration (a)} = \frac{v-u}{t}$$

UNIVERSITY OF IBADAN LIBRARY

$v-u=at$

$v=u + at$…….(1)

2nd equation

If velocity of a body moving with uniform acceleration increases steadily. Its average velocity therefore equals half the sum of its initial and final velocities

That is average velocity = $\frac{u+v}{2}$

If s is the distance moved in time (t), then since average velocity =

$$\frac{\text{Distance or displacement}}{\text{Time}}.$$

$\frac{u+v}{2} = \frac{d}{t}$ but from equation (1) $v= u + at$

.'. $\frac{u+v}{2}$ becomes $\frac{u+ u + at}{2} = \frac{\text{distance}}{t}$

Becomes = $\frac{2u + at}{2} = \frac{\text{distance}}{t}$

Becomes= $u + 1/2at = \frac{\text{distance}}{t} = \frac{s}{t}$

$\frac{s}{t} = u+1/2at$

$S= \frac{(u+{}^{1}/_{2}at)\ t}{2}$

$S= ut+{}^{1}/_{2}at^{2}$ ………. second equation of motion

3rd equation of motion

Form equation (1) $v = u + at$

UNIVERSITY OF IBADAN LIBRARY

Form equation (2) average velocity = $\frac{u + u + at}{2} = \frac{2u+at}{2}$

Eliminate *t* from equations (1) & (2)

Procedure: square equal (1)

To give $v^2 = (u^2+at)^2$

$V^2 = (u+at) + at\ (u+at)$

$V^2 = u^2 + uat + uat + a^2t^2$

$V^2 = u^2 + 2uat + a^2\ t^2$

$V^2 = u^2 + 2a\ (ut + {}^1/_2\ at^2)$

But $S = ut + {}^1/_2$ at 2

Substitute $S = ut + {}^1/_2\ at^2$ to get

$v^2 = u^2 + 2as$ 3rd equation of motion

Summary

Speed, velocity and acceleration are used in motion; speed is a scalar quality while velocity and acceleration are vector quantities. Increase in velocity gives rise to deceleration .

A body is said to be moving with uniform velocity whenever the velocity of the body is constant it does not change, it covers the same distance or displacement in equal interval of time.

A body from rest has initial velocity (u) equal to zero. A body come to rest has a final Velocity v =0

UNIVERSITY OF IBADAN LIBRARY

Pre-service teachers

Phase two: grouping of pre-service teachers

Step 1: the pre-service teaches are mixed into small, mixed ability groups based on their performance from the quiz

Step 2: Tutor training section, the research assistant train each groups on how to

(1) Introduce the lesson

(2) Explain basic concepts

(3) Provide examples, derive formulas

(4) Solve some problems.

Step 3: peer tutoring section

(a) Peer tutors present tutees with worksheets and problems to solve. Problem: A body starts form rest and accelerates at 1.0m/s2 for 20 seconds, it then travel with constant velocity for 1 minute and finally decelerates at 2.0 m/s2 until it stops. Find the maximum velocity and the total distance travelled.

(b) Tutees are allowed to solve the problem.

(c) Tutors mark tutees solution to problem; correct answer attract praise and movement to the next problem stage while incorrect answer attract tutors structural help and coaching.

Such coaching is as follows:

Solution

Body starts form rest, initial Velocity u =o

Solution: First stage (acceleration)

$u=0$, $a=1.0m/s^{2,}$ $t=20s$, $v=?$

UNIVERSITY OF IBADAN LIBRARY

Using v=u+at

V=0+1.0×20=20m/s

To find distance s moved in the first stage we use $s=ut+1/2at^2$

$S=0\times20+1/2\times1\times20^2$

S=200m

Second stage: v=20, t=60

Distance=velocity × time (since velocity is constant)

=20×60

=1200m

Third stage: using $v^2=u^2+2as$

$$S=\frac{v^2-u^2}{2a}$$

S=0-400/-4 =100m

Total distance travelled=200+1200+100 =1500m.

(d) Tutees try the solution again, correct answer attract praise and movement to the next stage while in correct answer attract the attention of the research assistant who is to coach and help the tutees in their weak areas. The tutees are giving another chance to try the problem.

Step 4: peers shift roles and continue tutoring following (a) (b), (c) (d) till every member has completed to be a tutor

Step 5: A 10 problem quiz is giving tutee participants

(1) What is speed?

(2) What is velocity?

UNIVERSITY OF IBADAN LIBRARY

(3) Identify one difference between speed and velocity.

(4) What is the S.I unit of velocity?

(5) What is the value of initial velocity for a body that starts form rest?

(6) What is the value of final velocity for a body that comes to rest?

(7) When does a body accelerate?

(8) When does a body decelerates

(9) What is the S.I unit of acceleration?

(10) state the first equation of motion

Step 6: individual goals are combined with unit/ group goals.

Phase three: Briefing / Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIVERSITY OF IBADAN LIBRARY

UNIT TWO

Topic: Graphical treatment of speed, velocity and acceleration

Duration: 3hrs

Behavioural Objectives by the end of the lesson, pre-service teachers should be able to:

1. explain the strategy of reflective-reciprocal peer tutoring
2. apply the strategy in teaching graphical treatment of speed, velocity and acceleration.
3. plot the graphs of distance against time, displacement against time, and velocity against time.
4. calculate speed, velocity acceleration and total distance travelled from the graphs plotted.
5. distinguish between speed, velocity acceleration and instantaneous speed, velocity and acceleration graphically.
6. explain the various shapes of speed, velocity and acceleration graphs

Teaching procedure

Phase One: Administration if quiz (The research assistant dominates)

Step 1: The research assistant administer a ten minutes quiz to pre-service teachers

Questions (1) when a graph of distance, displace and velocity are plotted against time what are the various shapes of graph likely to get

(2) explain the shapes of each graph

(3) explain how speed, velocity and acceleration of the motion can be calculated from each graph.

(4) what is instantaneous speed, velocity and acceleration?

(5) how would (4) be obtained from graphs?

UNIVERSITY OF IBADAN LIBRARY

Step 2: The research assistant presents instruction on how to solve the questions above and present the content of the lesson/subject matters to pre-service teachers as:

If a graph of distance is plotted against time the following shapes are the graphs

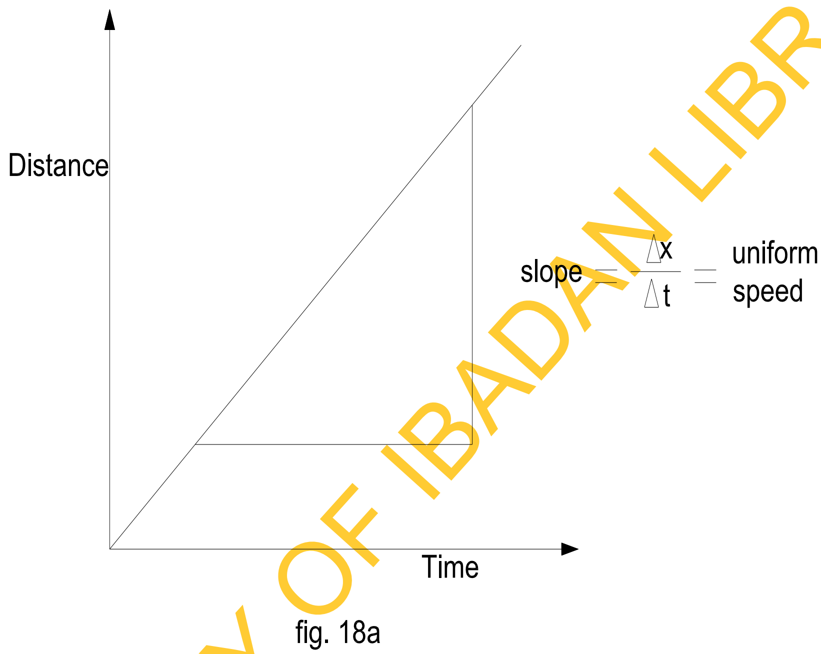


Fig. 18a: Shape of uniform speed

UNIVERSITY OF IBADAN LIBRARY

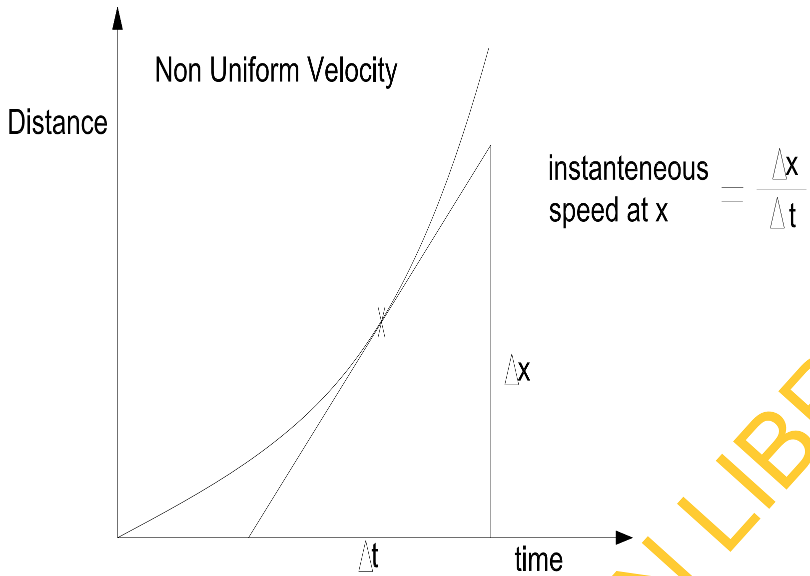


fig. 18b

Fig18b : Shape of Instantaneous speed

In fig. 18a the shape of the graph obtained shows that distance moved with time is constant, hence a straight line graph is obtained. Hence the shape of the graph in fig. 18a $^{\Delta x}/_{\Delta t}$ is a uniform speed

While in fig. 18b, a curve is obtained when a graph of distance is plotted against time, the curve shows that distance moved with time is not constant, hence, speed calculated at different points on the graph are not constant, it varies. The speed at any given point is called instantaneous speed at that particular point.

Step II

Graphical treatment of velocity from displacement time graph

If a graph if displacement is plotted against time, the following graphs are obtained.

UNIVERSITY OF IBADAN LIBRARY

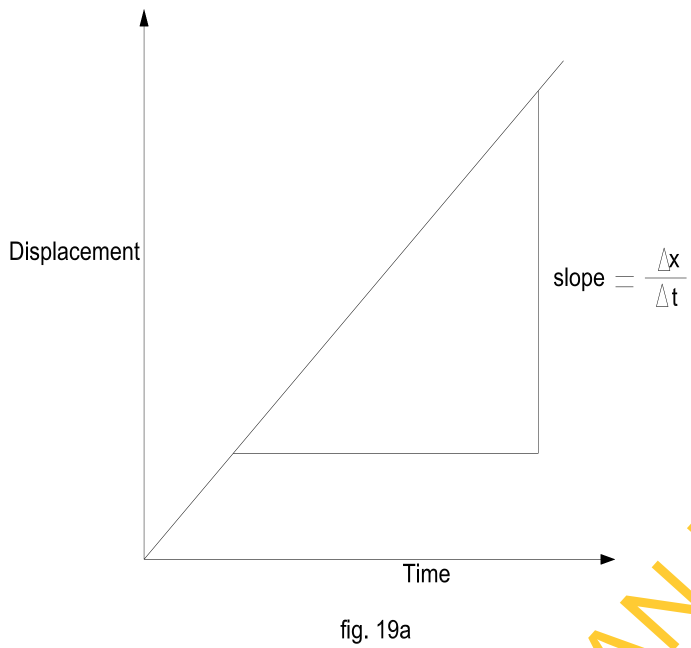


fig. 19a: Graph of Uniform Velocity

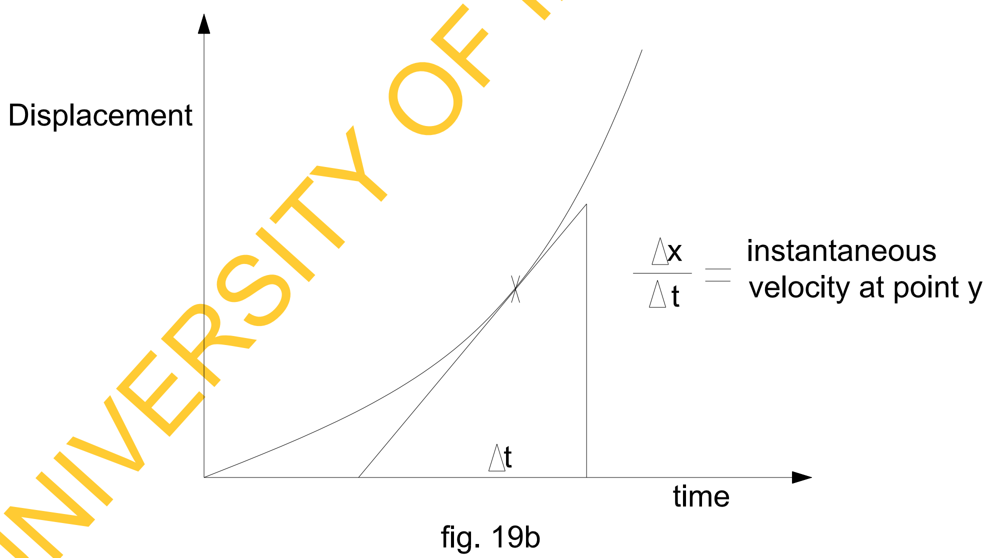


fig.19b: Graph of Instantaneous Velocity

UNIVERSITY OF IBADAN LIBRARY

The research assistant explains each of the graph obtained and how to calculate velocity and instantaneous velocity as in fig.19a&b and total distance covered.

Step III:

Graphical treatment of acceleration from velocity time graph.

If a velocity is plotted, against time, the following graphs are obtained

Fig.290a

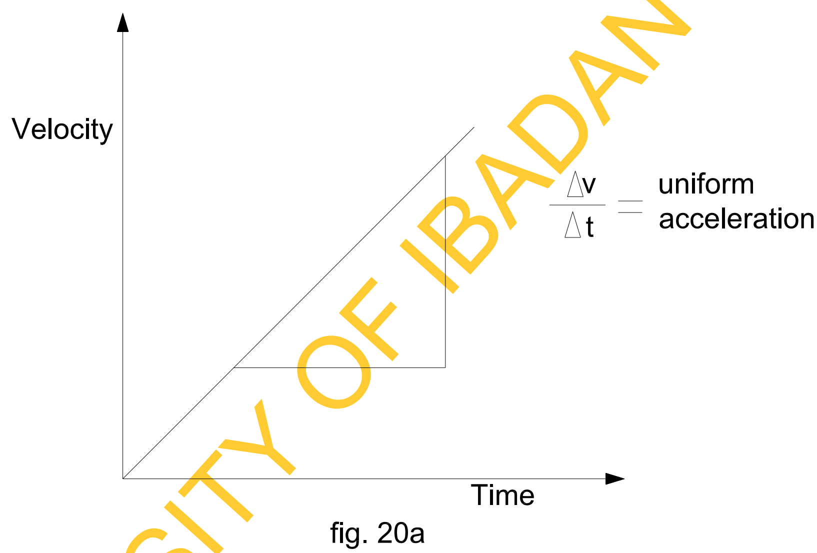


Fig. 20a: Uniform Velocity / Time

UNIVERSITY OF IBADAN LIBRARY

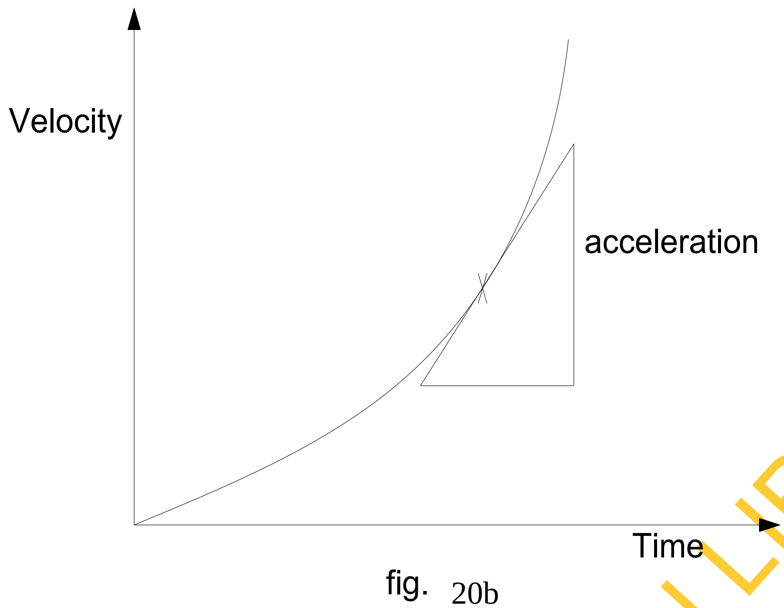


Fig. 20b.:Instantaneous Velocity

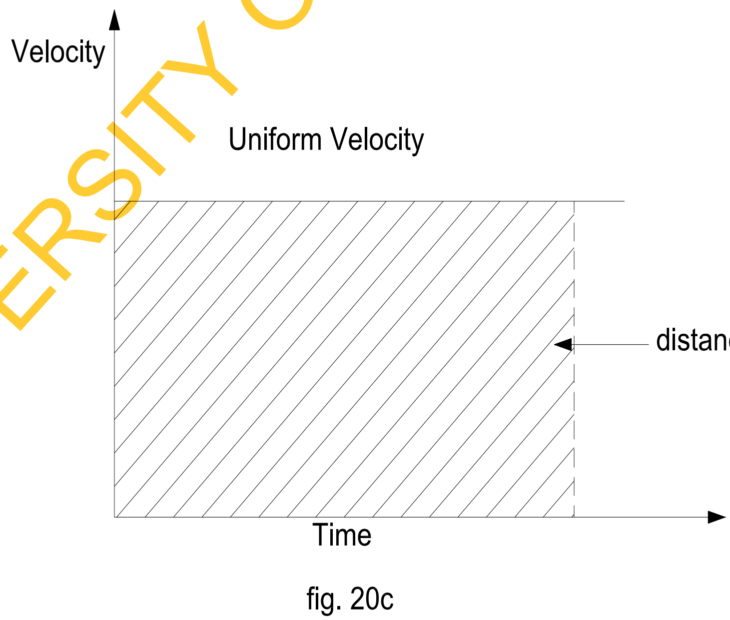


Fig. 20c.: Constant Velocity i.e acceleration=0

UNIVERSITY OF IBADAN LIBRARY

Note: if the graph is a curve, to calculate instantaneous speed velocity or acceleration at any given point, draw a target to the curve at that particular point from it you can then draw a large triangle ABC and calculate the slope. The

total distance travelled can be calculated as the total area under the graph.

Summary

(1) For uniform speed, velocity and acceleration their graphs against time are straight line graphs.

(2) If a curve is obtained the instantaneous speed, velocity and acceleration are calculated by drawing a target to the curve at a particular place from these, a large triangle can be constructed and the slope of the triangle at that instant gives instantaneous speed velocity and acceleration at that point.

(3) The area under the distance, displacement and velocity graphs gives the total distance travelled.

Phase Two:

Grouping of pre-service teachers

Step 1: the pre-services teachers are grouped into small mixed ability groups based on their performance in the pretest.

Step 2:tutor training section:

The research assistant train each groups on how to:

1 introduce the lesson

2 explain basic concepts

3 provide examples, plot graph

4 solve some simple problems using graph

UNIVERSITY OF IBADAN LIBRARY

Step 3: peer tutoring section

(a) Peer tutors present tutees with worksheets and problem to solve.

Question: A body starts from rest and accelerates at 1.oms-^{2} for 20 second then travels with contact velocity for 1 minute and finally decelerates at 2.oms-^{2} until it stops. Sketch the graph of motion and calculate the maximum velocity and total distance traveled from the graph

(b) Tutees are allowed to solve the problem.

(c) Tutors mark tutees solution, correct answer permits movement of tutees to the next stage while incorrect answer attract the attention of the research assistant who is the coach and help the tutees in their weak areas.

Step 4: peers shift roles and continue tutoring following (a), (b), (c), (d) till every member has completed tutoring.

Step 5: tutees are giving test on displacement, and velocity and acceleration.

1. when graphs of distance are plotted against time what are the shapes of the graph one is likely to get?
2. explain the shapes of each graph.
3. explain how speed, velocity and acceleration of the motion could be obtained from each graphs.
4. what is instantaneous speed, velocity and acceleration?
5. How would (4) be obtained from the plotted graph?

UNIVERSITY OF IBADAN LIBRARY

Step 6: individual goals are combined with group goals

Phase 3: Briefing / Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIT THREE

Duration: 2 hours **Topic:** Linear Momentum

Behavioral Objectives: At the end of the lesson, Pre-service teachers should be able to:

(i) Define and explain the concept of momentum, impulse, inertia, collision and weightlessness.

(ii) Solve simple calculation on linear momentum

(iii) State Newton's laws of motion

(iv) List the three types of collision

(v) Explain each type of collision with example

Teaching Procedure

Phase one: Administration of test (research assistant dominates)

Step 1: research assistant administers a ten minutes quiz to pre-service teachers.

UNIVERSITY OF IBADAN LIBRARY

Questions:

(1) Define linear momentum of a body

(2) Distinguish between momentum and impulse

(3) State Newton's laws of motion

(4) Explain the concept inertia

(5) State the laws of conservation of linear momentum

(6) List the three types of collision you know

Step 2: The research assistant presents instruction on how to solve problems and also explains the content of the subject matter as:

Linear Momentum (p) of a body is defined as the product of mass (m) of the body and the velocity (v) at which the body is moving. Its unit is $Kgms^{-1}$. It is a vector quantity its magnitude is M and its direction is the direction of velocity (v). Momentum is associated with motion, a body in motion is said to have momentum while Impulse (I) is associated with collision. Whenever a body collides with another body, each receives an impulse or consists of large force acting for a very short time.

Impulse = Ft and P = Mv unit of Impulse is Ns while unit of P is $Kgms^{-1}$. I & P are vector quantities.

Newton's laws of motion, Sir Isaac Newton discovered the relationship between force and motion. He formulated three important laws to explain motion.

Newton's first law of motion states that every object continues in its state of rest or of uniform motion in a straight line unless it is acted upon by external force. Second law states that the rate of change of momentum is proportional to the applied force and take place in the direction of the force.

UNIVERSITY OF IBADAN LIBRARY

i.e. $F \alpha \frac{\text{Change in momentum}}{\text{time taken for the change}}$

$F \alpha \frac{mv - mu}{t}$

$F \alpha \frac{m(v - u)}{T}$

$F\alpha \quad ma$

$F = Kma$

K = a constant with a value of 1

F = ma, F is in Newton

M is in Kilogram

a is in ms^{-2}

The Newton is a unit of force which gives a mass of 1kg an acceleration of $1ms^{-2}$. The second equation of motion gives a measure of force as the product of mass and acceleration of a body.

Newton's Law 3 states that to every action there is an equal and opposite reaction. This law is applicable to collision. Example, if a body, A collides with a body B. It follows that body A exerts a force F_A e.g. 10N on body B in turn body B exerts a force F_B on body A (10N). These two forces F_A and F_B are equal in magnitude (10N) each but opposite to each others.

(i). Inertia of a body is the tendency of a body to remain in its rest position or to continue its motion in a straight line once it has started moving in the absence of external forces. This implies that inertia is inherent in a body at rest or in a moving body with constant velocity. Inertia is a property of matter.

UNIVERSITY OF IBADAN LIBRARY

(ii). Law of conservation of linear momentum states that in a closed system of colliding objects the total momentum is conserve.

Note: That a closed or isolated system is a system where there is no external forces acting.

Consider two objects of masses m, and m_2 moving with initial velocities u_1 and u_2 in the same direction collide with one another.

Applying Newton's 3rd law action and reaction are equal but opposite.

$m_1 (v_1 - v_2) = -m_2 (v_2 - u_2)$

Momentum change of objects are equal but opposite

$m_1v_1 - m_1u_1 = m_2v_2 + m_2u_2$

$m_1v_1 + m_2u_2 = m_1v_1 + m_2u_2$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Momentum is conserved total momentum before collision is equal to total momentum after collision when there is no external force acting.

Types of Collision

(1) Perfect Elastic Collision

(2) Inelastic Collision

(3) Explosion

(1) Perfect Elastic Collision: is the one in which the total kinetic energy and momentum are conserved. Example consider two objects of masses m_1 and m_2 moving with initial velocities u_1 and u_2 collide elastically with each other the velocity of M_1 is reduced and that of M_2 is increased applying the principle of conservation of energy and momentum, K.E and momentum are conserved.

UNIVERSITY OF IBADAN LIBRARY

Examples of elastic collision are a ball bouncing off the ground back to its original height.

Inelastic collision

Momentum is conserved but kinetic energy decreases as it is converted to heat, sound and elastic.

Potential energy and heat also causes deformation. Example: objects dropped into a mud. In inelastic collision the two objects stick together after collision, they then move with the same common velocity.

Explosion

Momentum is conserved but kinetic energy increases. Example when two cars are made to fly a part after colliding with one another (both of them experience impact). The impact of the first is equal and opposite to the impact of the second body. For examples, if a body of mass m with velocity v collides explosively with body of mass M with velocity v.

$\therefore \quad mv =- MV$

Such that:

$mv =- MV$

$mv + MV= 0$

Summary:

Linear momentum is defined as the product of mass and velocity of a body. It is a vector quantity. Impulse is the product of a large force and a short interval of time; unit is Ns.

UNIVERSITY OF IBADAN LIBRARY

There are three laws of motion propounded by Sir Isaac Newton:

(1) Every object remains in its position of rest or of uniform motion in a straight line unless it is acted by external forces.

(2) The rate of change of momentum is directly proportional to the applied force and take place in the direction of the force.

(3) To every action there is an equal and opposite reaction.

Phase two: grouping of pre-service teachers

Step 1: The pre-service teachers are grouped into small mixed ability groups based on their performance on the quiz.

Step 2: Tutor training section: The research assistant train each groups on how to train using the following formulae:

(1) Introduce the lesson

(2) Explain basic concepts

(3) Provide example on how to derive formula

(4) Solve simple questions

Step 3: Peer Tutoring Section

(a) Peer tutors present tutees with worksheet and problems, they are required to solve problem.

Question 1: A reluctant force of 15.00N acts for 6.0s on a body of mass 4kg. Calculate the change in momentum of the body within this period.

Question 2: A ball of mass 200g, traveling with a velocity of 100ms-1, collides with another ball of mass 800g, moving at $50ms^{-1}$ in the same direction. If they stick together, what will be their common velocity?

UNIVERSITY OF IBADAN LIBRARY

(b) Tutees are allowed to solve the problem

(c) Tutors mark tutees solution to problem; correct answer attract praise and movement to time next problem stage while incorrect answer attract tutors structural help and coaching.

Such coaching is as follows:

Solution:

(1) Given resultant force = 15N

t = 6.0 Sec

m = 4kg

Change in momentum

$$\frac{Mv - Mu}{t} = F$$

$$Mv - Mu = Ft$$

Change in momentum is Mv – Mu

= Ft

= 15 x 6

= $90kgms^{-1}$

= 0.2kg

(2). Given M = 200g, = 0.2kg

u_1 = 100ms-1

m_2 = 800g = 0.8kg

u_2 = 50ms-1

Find common velocity:

Apply $m_1u_1 + m_2u_2 = v(m_1 + m_2)$

$v_1 = v_2$ common velocity

UNIVERSITY OF IBADAN LIBRARY

Hence $m_1u_1 + m_2u_2 = r(m_1 + M_2)$

$$V = \frac{m_1u_1 + m_2u_2}{m_1 + m_2}$$

$$\frac{0.2 \times 100 + 0.8 \times 50}{0.2 + 0.8}$$

$$V = \frac{20 + 40}{1}$$

$$V = 60ms^{-1}$$

(d). Tutees try the solution again, correct answer attract praise and movement to the next stage while in correct answer attract the attention of the research assistant who is to coach and help the tutees in their weak areas. The tutees are giving another chance to try the problem.

Step 4: Peers shift roles and continue tutoring following (a), (b), (c), (d) till every member has completed tutor.

Step 5:

(1) What do you understand by the form linear velocity?

(2) What is inertial of a body?

(3) Define impulse of a force

(4) State the unit of momentum, and impulse of a force.

(5) State Newton's laws of motion

(6) List three types of collision and give example of each.

Step 6: Individual goals are combined with unit /group goals

Phase three: Briefing / Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

UNIVERSITY OF IBADAN LIBRARY

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIT FOUR

Topic: Work, Energy and Power

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

(1) Explain the strategies of reflective-reciprocal peer tutoring

(2) Apply the strategies in teaching the teaching of speed, velocity and acceleration.

(3) Explain the concept of work, energy and power.

(4) Perform simple calculations on them

(5) Derive the formula for kinetic energy and Potential Energy

(6) State law of conservation of energy

Teaching Procedure

Phase One: Administration of test (The research assistant dominates)

Step 1: The research assistant administer a ten minutes quiz to pre-service teachers

Questions: (1) what is motion?

(2) when does a body said to be in motion?

(3) what is the major cause of motion?

UNIVERSITY OF IBADAN LIBRARY

(4) what stops body from motion?

(5) Distinguish between contract force and non contract force

(6) Is mass and weight the same? Justify your answer.

(7) Mention one instrument for measuring weight of an object

Step 2: The research assistant presents instruction on how to solve problems and also explains the content of the subject matter as:

- Work is said to be done only when a force causes movement

  Work= Force x distance moved in the direction of force
- Its S.I unit is Joule
- In symbols is w = f x s
- Energy is what people or machines must have before they can do work. It is define as the ability to do work. Its S.I unit is Joule.
- Forms of energy includes:
  - Chemical energy, nuclear energy, solar energy mechanical energy

    Mechanical energy can be potential or kinetic energy. Potential energy iIs energy a body has because of its position while kinetic energy is the energy a body possesses as a result of its motion
- Derivation of K.E and P.E formula

iii. Kinetic energy: suppose a body of mass m is at rest and is acted on by a steady force *f* which gives it a uniform acceleration *a*, so that the velocity of the body is *v* after it has moved a distance *s*. we can use the equation $v^2 = u^2 + 2as$ and, since u = 0

$$v^2 = u^2 + 2as$$

UNIVERSITY OF IBADAN LIBRARY

$v^2 = 2as$

$a = v^2/2a$

substituting in $f = ma$

$f = m\ (v^2/25)$ or $FxS = {}^1/_2 mv^2$

f x s is the work done on the body to give it velocity *v* and therefore equals to its K.E. Hence

Kinetic Energy = K.E = $^1/_2\ mv^2$

iv. Potential Energy: A body above the earth's surface is considered to have an amount of gravitation P.E. equal to the work that has been done against gravity by the force used to raise it. To lift a body of mass *m* through a vertical height h needs a force equal and opposite to the weight mg of the body, where *g* is the earth's gravitational field strength at the place.

Hence,

Work done by force = force x vertical height

:. P.E = mgh

- Power is the rate at which work is being done or the rate at which it changes energy from one form to another

:. Power = $\frac{\text{work done}}{\text{Time taken}} = \frac{\text{energy change}}{\text{time taken}}$

Unit of power is Walt (w) which is a rate of working of 1 joule per second

1w = 1j/s

1 kw = 1000w

1 mw = 1,000,000w

UNIVERSITY OF IBADAN LIBRARY

- Calculation, under work, energy and power

(a) How much work is done when a force of 10N moves an object a distance of 5.0m?

Solution f = 10N, S= 5.0m

Work = f x s

= 10 x 5.0

= 50Nm = 50J

(b) What is the velocity of an object of mass 1.0kg which has 200J of Kinetic energy

Mass = 1.0kg

K.E = 200J

From K.E = $\frac{1}{2} mv^2$

$200 = \frac{1}{2} 1.0 \times v^2$

$100 = v^2/_1$

$V^2 = 100$

$V = \sqrt{100} = 10$ m/s

(c) Calculate the P.E of a 5kg mass when it is 3m above the ground.

P.E = mgh m=5kg, g=10m/s, m=3m

P.E = 5 x 10 x 3

= 150J

(d) A boy of mass 40kg runs up a flight of stairs of vertical height 5.0m in 8.0s. what is his average power?

m = 40kg s= 5.0m t= 8.0s

UNIVERSITY OF IBADAN LIBRARY

$p = \frac{\text{work done}}{\text{time taken}}$

but work = force x distance

= mass x acceleration x distance

= 40 x 10 x 5

= 2000J

:. Average power = 2000/8.0

= 250w

- Law of conservation of energy state that energy cannot be created or destroyed but it can be changed from one form into another.

Summary

Work is done when a force causes motion while energy is the ability or capability to do work. Both are measured in joule

Work = Force x distance

K.E = $^1/_2mv^2$ i.e energy a body posses as a result of its motion while P.E = mgh which is the energy a body posses as a result of its position.

There are different forms of energy.

Power is the rate of doing work and its measured in watt.

$\text{Power} = \frac{\text{work done}}{\text{Time taken}}$

UNIVERSITY OF IBADAN LIBRARY

Phase two: grouping of pre-service teachers

Step 1: the pre-service teaches are mixed into small, mixed ability groups based on their performance from the quiz

Step 2: Tutor training section, the research assistant train each groups on how to

(1) Introduce the lesson

(2) Explain basic concepts

(3) Provide examples, derive formulas

(4) Solve some problems.

Step 3: peer tutoring section

(a) Peer tutors present tutees with worksheets and problems to solve problem.

(b) Tutees are allowed to solve the problem.

(c) Tutors mark tutees solution to problem; correct answer attracts praise and movement to the next problem stage while incorrect answer attract tutors structural help and coaching.

(d) Tutees try the solution again, correct answer attract praise and movement to the next stage while in correct answer attract the attention of the research assistant who is to coach and help the tutees in their weak areas. The tutees are giving another chance to try the problem.

Step 4: peers shift roles and continue tutoring following (a) (b), (c) (d) till every member has completed tutoring

Step 5: A 10 problem quiz is giving tutee participants

(1) What is work?

(2) What is energy?

UNIVERSITY OF IBADAN LIBRARY

(3) Identify one difference between K.E and P.E.

(4) What is their S.I unit?

(5) What is power?

(6) What is its S.I unit?

(7) State the law of conservation of energy

(8) List 6 forms of energy

(9) A 500kg mass is lifted through a vertical height of 10m in 25s by a crane. Calculate the power output of the motor driving the crane.

(10) A force F acting on a body increases its K.E by 400j over a distance of 2.0m. (a) Neglecting friction, how much work was done on the body? (b) What is the value of F?

Step 6: individual goals are combined with unit/ group goals.

Phase three: Briefing / Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIVERSITY OF IBADAN LIBRARY

UNIT FIVE

Duration: 3 hrs

Topic: Determination of (*g*) using simple pendulum bob

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

1. Define acceleration due to gravity, *g*.
2. Identify the materials needed for the determination of acceleration due to gravity.
3. Determine acceleration due to gravity using simple pendulum bob.
4. State the necessary precaution to be taken in performing the experiment.
5. Perform some calculations under the acceleration due to gravity *(g)*

Teaching procedure

Phase One: Administration of quiz (The research assistant dominates)

Step 1: The research assistant administers a ten minutes quiz to pre-service teachers.

Questions:

i What is acceleration?

ii differentiate between velocity and acceleration

iii list all the equations of motion and define all the terms in it.

Step 2: The research assistant presents instruction on how to solve problems and also explains the content of the subject matter as:

Acceleration is change in velocity in unit time

Acceleration due to gravity is the acceleration of a freely falling body denoted by the italic letter *g* and the value is 9.8mls^2 (approximately 10mls^2) but does varies slightly from one place on earth to another, this implies that where air resistance is negligible, the velocity of a falling body increase by 9.8mls every second. On the other hand, an object

UNIVERSITY OF IBADAN LIBRARY

short straight upward decelerates by 9.8mls every seconds till it reaches its highest point. In calculation using the equation of motion, *g* replaces a. It is given a positive sign for falling bodies and a negative sign for a rising bodied since they are decelerating.

Acceleration due to gravity *(g)* can be determined using the following method

i Using still ball and electric stop clock with the equation of motion $S=1/_2gt^2$

ii Using pendulum bob with the periods, $T=2\pi\sqrt{l/g}$

Materials needed: Pendulum bob (e.g a metal sphere with a hook attached or with a hole bored through its centre), cotton or thread, stop-watch, metre scale or metre rule, stand and clamp, small improvised vice.

Methods:

- Tie a metre length of the cotton or thread to the pendulum bob and suspend the cotton from the jaws of an improvised vice, such as a two small metal plates held in a clamp. Alternatively, two coins, two halves of a cork split length wise or the jaws of a pair of pliers serve equally well for the point of suspension when gripped in a clamp.
- Place a piece of paper with a vertical mark on it behind the pendulum so that when the later is at rest it hides the vertical mark from an observer standing in front of the pendulum.
- Set the pendulum bob swinging through a small arc of about 10^0. With a stop-watch measure the time for 20 complete oscillation setting the watch going when the pendulum passes the vertical mark and stopping it 20 complete oscillations later when it passes the mark in the same direction. Repeat the timing and record both times.

UNIVERSITY OF IBADAN LIBRARY

- Measure the length 1 of the cotton thread from the point of suspension to the middle of the bob. Shorten the length of the pendulum by successive amounts of 5cm by pulling the cotton thread through the vice and for each new length take two observations of the time for 20 oscillations.

  Tabulate the readings as follows:

Table 5: Determination of '*g*' using simple pendulum bob

Length of pendulum l/m	Time for 20 oscillations			Time for I oscillation T/s	T^2/S^2
	t_1/s	T_2/s	Mean t/s		

- Plot a graph with values of T^2/S^2 as ordinates (y-axis) against the corresponding values of l/m as the x-axis.

UNIVERSITY OF IBADAN LIBRARY

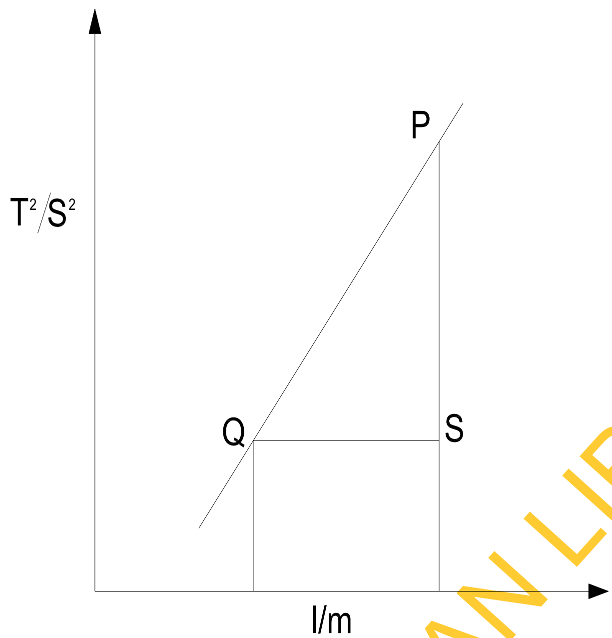


Figure 21: Graph of Period against Time

Calculation:

The periodic time T of a simple pendulum is given by

$$T=2\pi\sqrt{l/g}$$

Where *g* is the acceleration of free fall

$$\therefore T^2=4\pi^2 l/g$$

From which it is seen that the graph of T^2 against *l* will be a straight line whose slope PN/QN measured from two convenient and well-separated points P and Q on the line, is numerically equal to $4\pi^2/g$,

Thus $PNS^2/QNm = 4\pi^2/g$

$\therefore g = 4\pi^2\ QN/PN\ ms^{-2}$

UNIVERSITY OF IBADAN LIBRARY

Precautions:

The following necessary precaution needs to be taken for accurate result and to minimized error

- The counting of the oscillations most be correct
- Be careful to count complete oscillation
- Varying the lengths of the pendulum between 100cm to 30cm but do not go beyond these limit. Length exceeding 100cm is difficult to measure and the experiment becomes increasingly in accurate. The shorter the length of the pendulum the more accurate the result.
- Try to minimize error in timing.

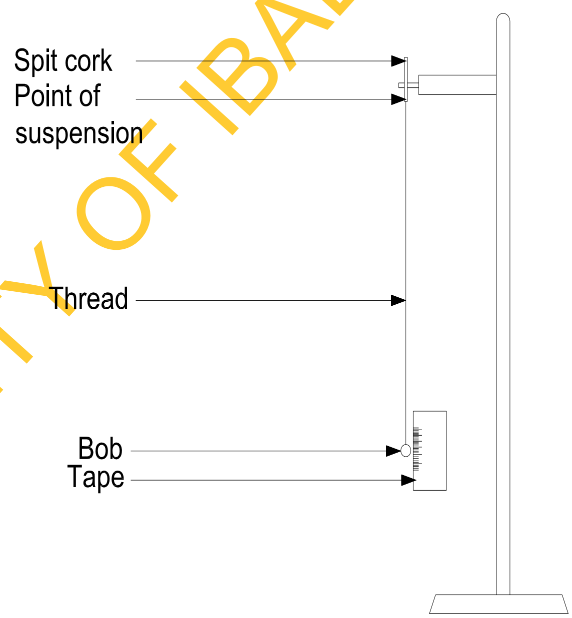


Fig. 22: Experimental set-up of Determination of "g" using Simple Pendulum Bob

UNIVERSITY OF IBADAN LIBRARY

Phase two: grouping of pre-service teachers

Step 1: the pre-service teaches are grouped into small, mixed ability groups based on their performance from the quiz

Step 2: Tutor training section,

The research assistant train each groups on how to set-up the experiment

Step 3: peer tutoring section

(a) Peer tutors present tutees with recording sheets

(b) Tutees are allowed to watch and record experimental reading.

Step 4: peers shift roles and continue with the experiment till every member has completed tutor

Step 5: each member of the group tabulate their readings and use it to plot a graph

Step 6: from the graph the group calculate the acceleration due to gravity *g*

Step 7: individual goals are combined with unit group goals.

Phase three: Reflection

Step 1: The research assistant discusses his/her self assessment with colleague after the class.

Step 2: the pre-service teachers also discuss their self assessment with their mate after the lesson.

Step 3: they describe what happen in the class and what the general step of the lesson is.

Step 4: they react on how well/badly the lesson went.

Step 5: general comment are made about the group and the class as a whole and suggestion were made for modification against next class.

UNIVERSITY OF IBADAN LIBRARY

APPENDIX THREE

Operational Guide for Conventional Teaching Strategy (OGCTS)

Topic: Speed and Acceleration

Duration: 2hours

Behavioral objectives: At the end lesson, pre-service teachers should be able to:

(1) Explain the concept of speed, velocity and acceleration

(2) Perform simple calculations on them

(3) Derive the three equations of motion

(4) State differences between speed, velocity and acceleration

The procedure is as follows:

Step1: Research assistant introduces the lesson

Step 2: Research assistant explains theoretical bases on the topic as follows:

Speed is the rate of change of distance moved with time while velocity is the rate of change of displacement moved with time.

Displacement is the distance covered by a body in a specified direction

$$\text{Average speed} = \frac{\text{distance moved}}{\text{Time taken}}$$

$$\text{Unit} \quad \frac{m}{s} = ms^{-1}$$

S.I unit of distance is metre

S.I unit of time is second

S.I unit of speed = ms^{-1}

$$\text{Velocity} = \frac{\text{distance moved in a specified direction}}{\text{Time taken}}$$

UNIVERSITY OF IBADAN LIBRARY

$= \frac{\text{displacement}}{\text{time taken}}$

S.I unit = $\frac{m}{s}$ = ms^{-1}

Acceleration = $\frac{\text{increase in velocity}}{\text{Time taken}} = \frac{v-u}{t}$

a = v-u S.I unit is

S.I unit of a= ms^{-1} = ms^{-2} or m/s^2

Equation of motion: If a body is moving with uniform acceleration (a) and its velocity increase form u 1st equation to v in time t,

Acceleration (a) = $\frac{v-u}{t}$

v- u = at

v= u + at…….(1)

2nd equation

If the velocity of a body moving with uniform acceleration, increase steadily, its average velocity therefore equals half the sum of its initial and final velocities

That is average velocity = $\frac{u+v}{2}$

If S is the distance moved in time (t), then since average velocity =

$\frac{\text{Distance}}{\text{Time}}$ or displacement.

$\frac{u+v}{2} = \frac{d}{t}$ from equation (1) v= u + at

.'. $\frac{u+v}{t}$ becomes $\frac{u + u + at}{2} = \frac{d}{t}$

UNIVERSITY OF IBADAN LIBRARY

Becomes = $\frac{2u + at}{2} = \frac{distance}{t}$

Becomes= $u + 1/2at = \frac{distance}{t} = \frac{s}{t}$

$\frac{s}{t} = u+1/2at$

S= $\frac{(u+{}^{1}/_{2}at)}{2}$ t

S= ut+$^{1}/_{2}$at 2 ………. second equation of motion

3rd equation of motion

Form equation (1) v = u + at

Form equation (2) average velocity = $\frac{u + u + at}{2} = \frac{2u+at}{2}$

Eliminate *t* from equations (1) & (2)

Procedure: square equal (1)

To give $v^2 = (u^2+at)^2$

$v^2 = (u+at) + at\ (u+at)$

$v^2 = u^2 + uat + uat + a^2t^2$

$v^2 = u^2 + 2uat + a^2\ t^2$

$v^2 = u^2 + 2a\ (ut + {}^{1}/_{2}\ at^2)$

But S = ut +$^{1}/_{2}$ at 2

Substitute S = ut + $^{1}/_{2}$ at^2 to get

$v^2 = u^2 + 2as$ 3rd equation of motion

Step 3: Research assistant solves problems on the application of the equations of motion e.g.

UNIVERSITY OF IBADAN LIBRARY

A body starts form rest and accelerates at $1.0 m/s^2$ for 20 seconds, it then travel with constant velocity for 1 minute and finally decelerates at $2.0\ m/s^2$ until it stops. Find the maximum velocity and the total distance travelled.

Solution: First stage (acceleration)

$u=0$, $a=1.0m/s^{2,}$ $t=20s$, $v=?$

Using $v=u+at$

$v=0+1.0\times20=20m/s$

To find distance s moved in the first stage we use $s=ut+1/2at^2$

$S=0\times20+1/2\times1\times20^2$

$S=200m$

Second stage: $v=20$, $t=60$

Distance=velocity × time (since velocity is constant)

=20×60

=1200m

Third stage: using $v^2=u^2+2as$

$$S=\frac{v^2-u^2}{2a}$$

$S=0-400/-4 =100m$

Total distance travelled=200+1200+100 =1500m.

Step 4: Research assistant solicit questions from the class and give class work

Step 5: Research assistant marks students work

Step 6: Research assistant concludes the lesson with corrections to students work.

UNIVERSITY OF IBADAN LIBRARY

UNIT TWO

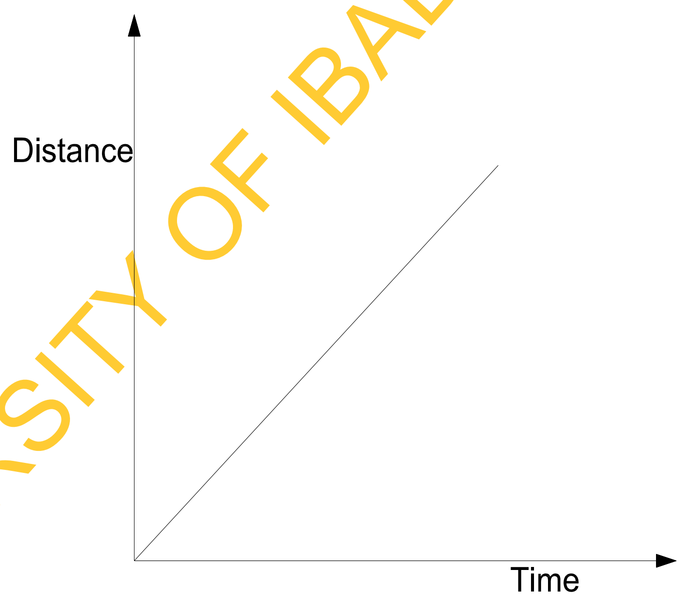
Topic: Graphical treatment of speed, velocity and acceleration

Duration: 2hrs

Research assistant presents the topic of the lesson on the chalkboard.

Research assistant introduces the lesson to the student. As speed, velocity and acceleration can be obtained from graphs just as from equation.

Step 1: Research assistant sketches the various graphs possible if a graph of distance is plotted against time.



UNIVERSITY OF IBADAN LIBRARY

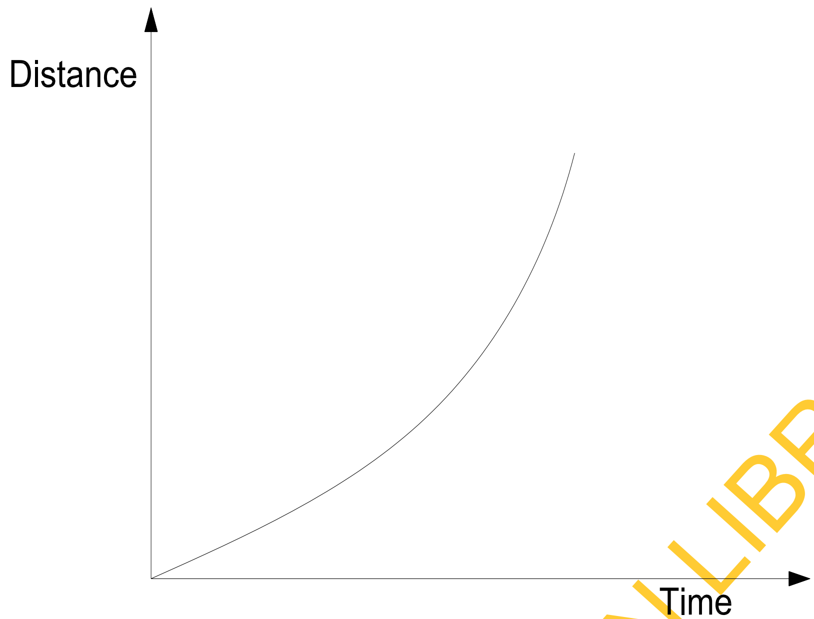


Fig.23: Various Shape of Distance Time Graph

Research assistant explains the shape of the two graphs and demonstrates how to obtain speed from the plotted graphs.

Step 2: plotting of displacement time graph

Research assistant sketches the graph of displacement against time.

UNIVERSITY OF IBADAN LIBRARY

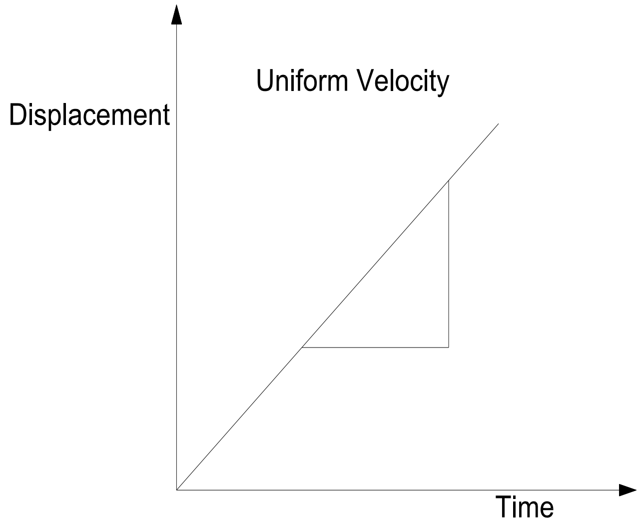


fig. 23a

Figure 23a.: Uniform Velocity

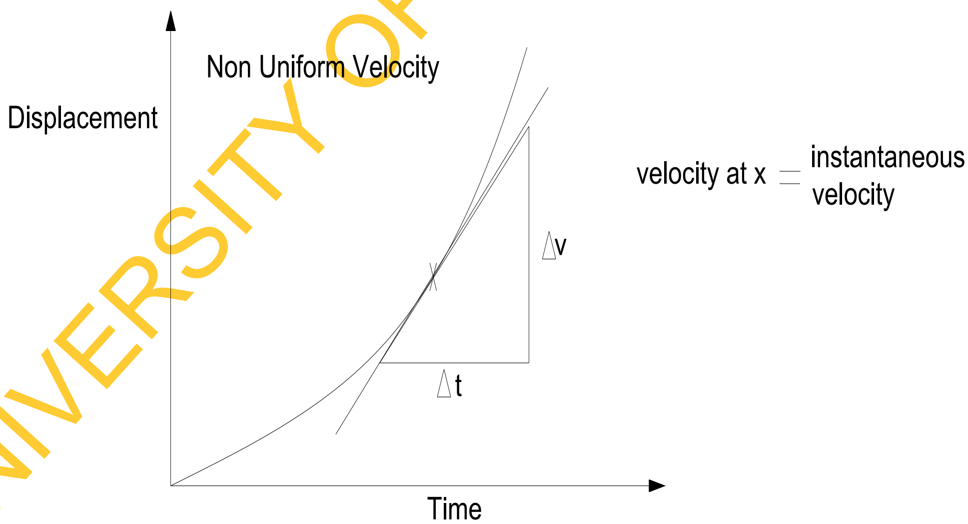


fig. 23b

UNIVERSITY OF IBADAN LIBRARY

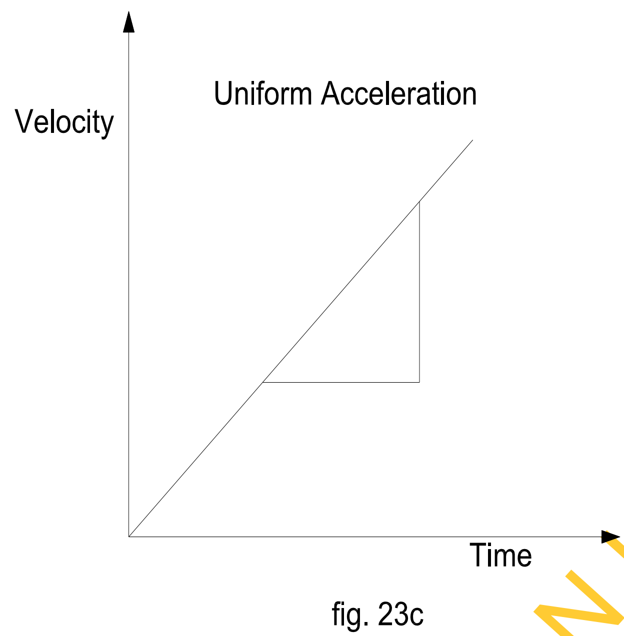


Fig.23c: Uniform Acceleration

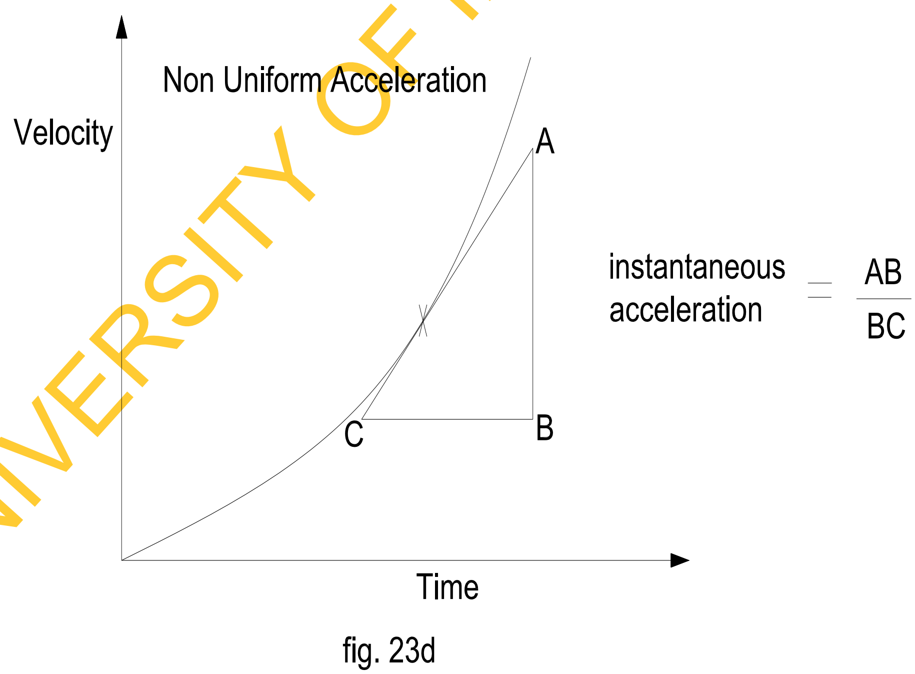


Figure 23d. Graph of instantaneous Acceleration

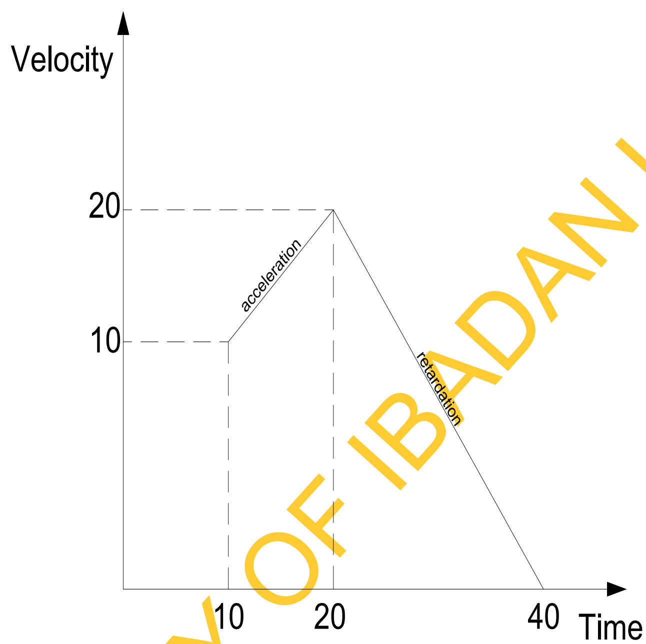
UNIVERSITY OF IBADAN LIBRARY

Step 4: Research assistant solve problem for student as an example:

An object is working with a velocity of 2ms-! For 10 minutes, after which its accelerates at the rate of $5m/s^2$ for 10 minutes after which velocity decrease at the rate of 5m/s for another 20 second when it finally comes to rest.

Sketch the graph of motion and calculate its total distance traveled.

Solution



Total distance traveled =Area of Δ of trapezium + Area of Δ=L+B+½ (5+25) 10+½bh

5× 10 + 15× 10 + ½ × 20 × 25

50+150 +10 × 25

50+ 150 + 250

= 450M

Teacher concludes the lesson.

UNIVERSITY OF IBADAN LIBRARY

UNIT THREE

Duration: 2 hours **Topic:** Linear Momentum

Behavioral Objectives: At the end of the lesson the pre-service teachers should be able to:

(i) Define the concept of momentum, impulse, inertia, collision and weightlessness.

(ii) Solve simple calculation on linear momentum

(iii) State Newton's laws of motion

(iv) List the three types of collision

(v) Explain each type of collision with example

Step 1: Research assistant introduces the lesson with the concept of linear momentum

(i) Linear momentum (p) of a body is defined as the product of mass (m) of the body and the velocity (v) at which the body is moving its unit is $kgms^{-1}$. It is a vector quantity. Its magnitude is MV and its direction is the direction of velocity (V).

(ii) Momentum is associated with motion, a body in motion cell have momentum while impulse (I), is associated with collision. When a body collides with another body, each receives an impulse or blow. The impulse consists of a large force acting for a very short time. I = Ft and P = Mv

Unit of I is Ns while unit of P is $kgms^{-1}$. I is also a vector quantity.

Step 2: Research assistant states and explains Newton's laws of motion

(iii) Newton laws of motion

Sir Isaac, Newton discovered the relationship between force an motion. He stated three important laws to explain motion law I states that every object continues in

UNIVERSITY OF IBADAN LIBRARY

its state of rest or in a uniform motion in a straight line unless it is acted upon by external force.

Law 2 states that the rate of change of momentum is proportional to the applied force and takes place in the direction of the force. i.e.

$$F\alpha = \frac{\text{change in momentum}}{\text{Time taken for the change}}$$

$$F\alpha = \frac{mv - mu}{t}$$

$$F\alpha = \frac{m(v-u)}{t} \text{ but } a = \frac{v-u}{t}$$

$$F\alpha = ma$$

$$F = Kma$$

K is a constant

with a value of 1

$$F = Ma$$

F is in Newton

M is in Kilogram

a is in m/s^2

The Newton is a unit of force which gives a mass of 1kg an acceleration of $1ms^{-2}$. The second equation of motion gives a measure of force as the product of mass and acceleration of a body.

Law 3 states that to every action there is an equal and opposite reaction. This law is applicable to collision. Example, if a body, A collides with a body B. It follows that body A exerts a force F_A e.g. ION on body B in turn body B exerts a force F_B on body A

UNIVERSITY OF IBADAN LIBRARY

(10N). These two forces F_A and F_B are equal in magnitude (10N) each but opposite direction to each others.

Step 3: Research assistant explains, concept of inertia, law of conservation of linear momentum and types of collision.

(iv) Inertia of a body is the tendency of a body to remain in its rest position or to continue its motion in a straight line once it has started moving in the absence of external forces. This implies that inertia is inherent in a body at rest or in a moving body with constant velocity. Inertia is a property of matter.

(v) Law of conservation of linear momentum states that in a closed system of colliding objects the total momentum is conserve.

Note: That a closed or isolated system is a system where there is no external forces acting.

Consider two objects of masses m, and m_2 moving with initial velocities u_1 and u_2 in the same direction collide with one another.

Applying Newton's 3rd law action and reaction are equal but opposite.

$m_1 (v_1 – v_2) = -m_2 (v_2 – u_2)$

Momentum change of objects are equal but opposite

$m_1v_1 – m_1u_1 = m_2v_2 + m_2u_2$

$m_1v_1 + m_2u_2 = m_1v_1 + m_2u_2$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Momentum is conserved total momentum before collision is equal to total momentum after collision when there is no external forces acting.

UNIVERSITY OF IBADAN LIBRARY

Types of Collision

(1). Perfect Elastic Collision

(2). Inelastic Collision

(3). Explosion

(1). Perfect Elastic Collision: is the one with total kinetic energy and momentum are conserved. Example consider two objects of masses m_1 and m_2 moving with initial velocities u_1 and u_2 collide elastically with each other the velocity of m_1 is reduced and that of m_2 is increased applying the principle of conservation of energy and momentum, K.e and momentum are conserved.

Examples of elastic collision are a ball bouncing off the ground back to its original height.

Inelastic collision

Momentum is conserved but kinetic energy decreases as it is converted to heat, sound and elastic.

Potential energy and heat also causes deformation. Example objects dropped into a mud. In inelastic collision the two objects stick together after collision, they then move with the same common velocity.

Explosion

Momentum is conserved but kinetic energy increases. Example when two cars are made to fly a part after colliding with one another (both of them experience impact). The impact of the first is equal and opposite to the impact of the second body. For examples, if a body of mass in with velocity v collides explosively with body N, most with velocity

$\therefore$ Mv = MV

Such that:

Mv = MV

Mv + MV= 0

UNIVERSITY OF IBADAN LIBRARY

Step 4: Research assistant solves problem

Question 1: A reluctant force of 15.00N acts for 6.0s on a body of mass 4kg. Calculate the change in momentum of the body within this period.

Question 2: A ball of mass 200g, traveling with a velocity of 100ms-1, collides with another ball of mass 800g, moving at $50ms^{-1}$ in the same direction. If they stick together, what will be their common velocity?

Solution:

(1). Given resultant force = 15N

t = 6.0 Sec

m = 4kg

Change in momentum

$$\frac{mv - mu}{t} = f$$

$$mv - mu = ft$$

Change in momentum is mv – mu

= Ft

= 15 x 6

= $90kgms^{-1}$

= 0.2kg

(2). Given M = 200g, = 0.2kg

u_1 = 100ms-1

m_2 = 800g

u_2 = 50ms-1 = 0.8kg

UNIVERSITY OF IBADAN LIBRARY

Find common velocity:

Apply $m_1u_1 + m_2u_2 \quad = \quad r\,(m_1 + m_2)$

$v_1 = r_2$ common velocity

Hence $m_1u_1 + m_2u_2 = r(m_1 + M_2)$

$$V = \frac{m_1u_1 + m_2u_2}{m_1 + m_2}$$

$$\frac{0.2 \times 100 + 0.8 \times 50}{0.2 + 0.8}$$

$$V = \frac{20 + 40}{1}$$

$$V = 60ms^{-1}$$

Step 5: Research assistant asks question from pre-service teachers

Question 1:

The property of a body to remain at rest, or to continue to move in a straight line is known as……………………………………..

Question 2:

A body of mass 10kg, moving with velocity of $10ms^{-1}$, hit a stationary body and had its direction reversed and velocity changed to $7.5ms^{-1}$ in 5 seconds. Calculate the force of impact.

Step 6: Research assistant marks pre-service teachers work

Step 7: Research assistant concludes the lesson with corrections to pre-service teachers' work

UNIVERSITY OF IBADAN LIBRARY

UNIT FOUR

Topic: Work, Energy and Power

Duration: 2 hours

Behavioral Objectives: at the end of the lesson, pre-service teachers should be able to:

(1) Explain the concept of work, energy and power.

(2) Perform simple calculations on them

(3) Derive the formula for kinetic energy and potential Energy

(4) State law of conservation of energy

Teaching Procedure

Step 1: Research assistant introduces the lesson with the concept of work, energy and power

Step 2: Research assistant gives explanation on the topic as follows:

- Work is said to be done only when a force causes movement

  Work= Force x distance moved in the direction of force

- Its S.I unit is Joule
- In symbols is w = f x s
- Energy is what people or machines must have before they can do work. It is define as the ability to do work. Its S.I unit is Joule.
- Forms of energy includes:
  - Chemical energy, nuclear energy, solar energy mechanical energy

UNIVERSITY OF IBADAN LIBRARY

- Mechanical energy can be potential or kinetic energy. Potential energy is energy a body has because of its position while kinetic energy is the energy a body possess as a result of its motion

Derivation of K.E and P.E formula

i. Kinetic energy: suppose a body of mass m is at rest and is acted on by a steady force *f* which gives it a uniform acceleration *a*, so that the velocity of the body is *v* after it has moved a distance *s*. we can use the equation $v^2 = u^2 + 2as$ and, since u = 0

$v^2 = u^2 + 2as$

$v^2 = 2as$

$a = v^2/2a$

substituting in $f = ma$

$f = m (v^2/25)$ or $FxS = {}^1/_2 mv^2$

f x s is the work done on the body to give it velocity *v* and therefore equals to its K.E. Hence

Kinetic Energy = K.E = ${}^1/_2\, mv^2$

ii. Potential Energy: A body above the earth's surface is considered to have an amount of gravitation P.E. equal to the work that has been done against gravity by the force used to raised it. To lift a body of mass *m* through a vertical height h needs a force equal and opposite to the weight mg of the body, where *g* is the earth's gravitational field strength at the place.

Hence,

Work done by force = force x vertical height

:. P.E = mgh

UNIVERSITY OF IBADAN LIBRARY

- Power is the rate at which work is being done or the rate at which it changes energy from one form to another

$$\therefore \text{Power} = \frac{\text{work done}}{\text{Time taken}} = \frac{\text{energy change}}{\text{time taken}}$$

Unit of power is Walt (w) which is a rate of working of 1 joule per second

1w = 1j/s

1 kw = 1000w

1 mw = 1,000,000w

Step 4 Research assistant solves problem.

(a) How much work is done when a force of 10N moves an object a distance of 5.0m?

Solution f = 10N, S= 5.0m

Work = f x s

= 10 x 5.0

= 50Nm = 50J

(b) What is the velocity of an object of mass 1.0kg which has 200J of Kinetic energy

Mass = 1.0kg

K.E = 200J

From K.E = $\frac{1}{2} mv^2$

$200 = \frac{1}{2} 1.0 \times v^2$

$100 = v^2/_1$

$v^2 = 100$

$v = \sqrt{100} = 10$ m/s

UNIVERSITY OF IBADAN LIBRARY

(c) Calculate the P.E of a 5kg mass when it is 3m above the ground.

P.E = mgh m=5kg, g=10m/s, m=3m

P.E = 5 x 10 x 3

= 150J

(d) A boy of mass 40kg runs up a flight of stairs of vertical height 5.0m in 8.0s.

what is his average power?

m = 40kg s= 5.0m t= 8.0s

p = $\frac{\text{work done}}{\text{time take}}$

but work = force x distance

= mass x acceleration x distance

= 40 x 10 x 5

= 2000J

:. Average power = 2000/8.0 = 250w

Step 5 Research assistant asks question from pre-service teachers

(1) What is work?

(2) What is energy?

(3) Identify one difference between K.E and P.E.

(4) What is their S.I unit?

(5) What is power?

(6) What is its S.I unit?

(7) State the law of conservation of energy

(8) List 6 forms of energy

UNIVERSITY OF IBADAN LIBRARY

(9) A 500kg mass is lifted through a vertical height of 10m in 25s by a crane. Calculate the power output of the motor driving the crane.

(10) A force F acting on a body increases its K.E by 400j over a distance of 2.0m. (a) Neglecting friction, how much work was done on the body? (b) What is the value of F?

Step 6: Research assistant marks pre-service teachers' work

Step 7: Research assistant concludes the lesson with corrections to pre-service's work

UNIT FIVE

Duration: 3 hrs

Topic: Determination of (*g*) using simple pendulum bob

Behavioral Objectives: At the end of the lesson, pre-service teachers should be able to:

1. Define acceleration due to gravity, *g*.
2. Identify the materials needed for the determination of acceleration due to gravity.
3. Determine acceleration due to gravity using simple pendulum bob.
4. State the necessary precaution to be taken in performing the experiment.
5. Perform some calculations under the acceleration due to gravity *(g)*

The procedure is as follow:

Step1: Research assistant introduces the lesson

Step 2: Research assistant explains theoretical bases on the topic as follows:

Acceleration is change in velocity in unit time

UNIVERSITY OF IBADAN LIBRARY

Acceleration due to gravity is the acceleration of a freely falling body denoted by the italic letter *g* and the value is 9.8mls^2 (approximately 10mls^2) but does varies slightly from one place on earth to another, this implies that where air resistance is negligible, the velocity of a falling body increase by 9.8mls every second. On the other hand, an object short straight upward decelerates by 9.8mls every seconds till it reaches its highest point. In calculation using the equation of motion, *g* replaces a. It is given a positive sign for falling bodies and a negative sign for a rising bodied since they are decelerating.

Acceleration due to gravity (*g*) can be determined using the following method

i Using still ball and electric stop clock with the equation of motion $S=1/_2gt^2$

ii Using pendulum bob with the periods, $T=2\pi\sqrt{l/g}$

Step 3: Research assistant list the materials needed for the experimental determination of g using simple pendulum as follows:

Materials needed: Pendulum bob (e.g a metal sphere with a hook attached or with a hole bored through its centre), cotton or thread, stop-watch, metre scale or metre rule, stand and clamp, small improvised vice.

Step 4: Research assistant demonstrates the experimental method to the pre-service teacher thus:

Methods:

- Tie a metre length of the cotton or thread to the pendulum bob and suspend the cotton from the jaws of an improvised vice, such as a two small metal plates held in a clamp. Alternatively, two coins, two halves of a cork split length wise or the jaws of a pair of pliers serve equally well for the point of suspension when gripped in a clamp.

UNIVERSITY OF IBADAN LIBRARY

- Place a piece of paper with a vertical mark on it behind the pendulum so that when the later is at rest it hides the vertical mark from an observer standing in front of the pendulum.
- Set the pendulum bob swinging through a small arc of about 10^0. With a stop-watch measure the time for 20 complete oscillation setting the watch going when the pendulum passes the vertical mark and stopping it 20 complete oscillations later when it passes the mark in the same direction. Repeat the timing and record both times.
- Measure the length 1 of the cotton thread from the point of suspension to the middle of the bob. Shorten the length of the pendulum by successive amounts of 5cm by pulling the cotton thread through the vice and for each new length take two observations of the time for 20 oscillations.

  Tabulate the readings as follows:

Table 5: Determination of '*g*' using simple pendulum bob

Length of pendulum l/m	Time for 20 oscillations			Time for I oscillation T/s	T^2/S^2
	t_1/s	T_2/s	Mean t/s		

- Plot a graph with values of T^2/S^2 as ordinates (y-axis) against the corresponding values of l/m as the x-axis.

UNIVERSITY OF IBADAN LIBRARY

-

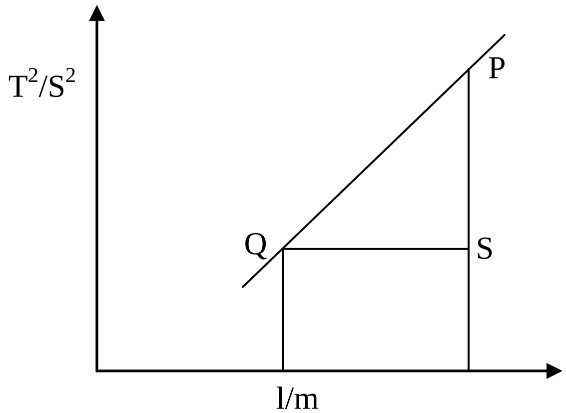


Figure 24: Graph of Period against Time

Calculation:

The periodic time T of a simple pendulum is given by

$$T=2\pi\sqrt{l/g}$$

Where *g* is the acceleration of free fall

$$\therefore T^2=4\pi^2 l/ g$$

From which it is seen that the graph of T^2 against *I* will be a straight line whose slope PN/QN measured from two convenient and well-separated points P and Q on the line, is numerically equal to $4\pi^2/g$,

Thus $PNS^2/QNm = 4\pi^2/g$

$\therefore g = 4\pi^2$ QN/PN ms^{-2}

Precautions:

The following necessary precaution needs to be taken for accurate result and to minimized error

- The counting of the oscillations most be correct
- Be careful to count complete oscillation

UNIVERSITY OF IBADAN LIBRARY

- Varying the lengths of the pendulum between 100cm to 30cm but do not go beyond these limit. Length exceeding 100cm are difficult to measure and the experiment becomes increasingly in accurate. The shorter the length of the pendulum the more accurate the result.
- Try to minimize error in timing.

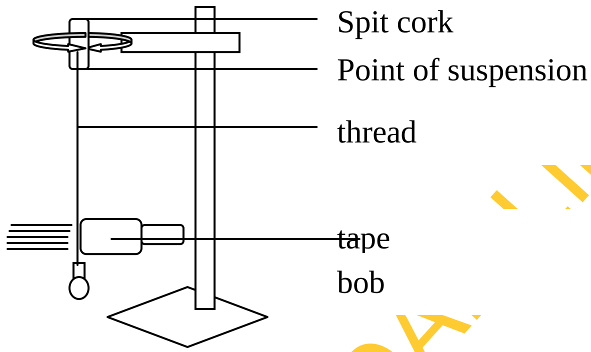


Figure 25: Experimental set-up of Determination of "g" using Simple Pendulum Bob

Step 5: Research assistant allows the pre-service teacher to carry out the experiment in groups

Step 6: Each member of the group tabulate their readings and use it to plot a graph

Step 7: From the graph the group calculate the acceleration due to gravity *g*

Step 8: Research assistant concludes the lesson with corrections to pre-service teachers' work.

UNIVERSITY OF IBADAN LIBRARY

APPENDIX FOUR

Pre-service Teachers 'Numerical Ability Test (PTNAT)

SECTION A

INSTRUCTIONS:

1. This test is aimed at testing your numerical ability. So work through the problems very well and gives the solution on the space provided on the question paper.

2. Pleased kindly indicate the following:

   (a) College:…………………………………………………………………

   (b) Name:…………………………………………………………………..

   (c) Matric No:………………………………………………………………

   (d) Sex: Male{ } Female{ }

   (e) Mode of Entry: Direct{ } Prelim{ }

TIME ALLOWED: 50 Minutes

SECTION B

1, Express 0.00000265 in standard form.

2. Simplify (-35) x (-5) ÷(-7).

3. Divide 2800 in the ratio 1 :3.

UNIVERSITY OF IBADAN LIBRARY

4. Remove brackets and simplify: $3(3a-b) - 5(a - 4b)$.

5. Expand $(5x - 2y)(2x - 3y)$.

6. Factorise $9x + 6 - 3x^2 - 2x$

7. Solve the equation $6x + 1 = 26 - 2x$.

8. Solve the equation $3x - 8 \leq 5x$.

9. Simplify $(3m^4)^2$

10. Simplify $\frac{(-c)^2 \times c^4}{(-c)^5}$

11. Simplify $9^{\frac{1}{2}}$

UNIVERSITY OF IBADAN LIBRARY

12. Simplify $(1/27)^{-2/3}$

13. Simplify $\frac{21/2 + 33/4}{21/6 - 11/3}$

14. Determine which is the greatest of 7/9, ¾, 10/13

15. What is the product of 17/9 and 3 3/4?

16. Express 21/50 in decimal

17. Evaluate 0.725 × 1000

18. Add 18.058, 0.302, 7.82, and 0.004 and give your answers correct to 3 significant figures.

19. Evaluate 0.047 × 70 correct to 1 decimal place.

20. Make x the subject of the equation $a = \frac{2b + 3x}{3b - 2x}$

UNIVERSITY OF IBADAN LIBRARY

21. Make s the subject of the formula $v^2 = u^2 - 2as$

22. Find x if $x^2 - 7x + 10 = 0$

23. Find the sum of the first eight terms of the progression 3, 5, 7, …………..

24. Evaluate $\frac{6.3 \times 10^3}{8.1 \times 10^3}$

25. Find the arithmetic means of the following scores 24, 6, 30, 13, 11, 20, and 36

26. A workman is paid ₦15200 for a 40 hr week. Calculate his hourly rate of pay

27. Divide 576 in the ratio 1: 3: 5

28. Expand $(p + 3)^3$

29. Evaluate 81

30. Simplify $3^1 \times 3^0 \times 3^9$

UNIVERSITY OF IBADAN LIBRARY

APPENDIX FIVE A

Pre-service Teachers 'Achievement Test in Integrated Science (PTATIIS)

INSTRUCTIONS:

This test is aimed at testing your achievement on Integrated Science. So work through the problems very well and do not guess the answers.

SECTION A

Pleased kindly indicate the following:

(i) College:……………………………………………………………

(ii) Name:…………………………………………………………..

(iii) Matric No:…………………………………………………………

(iv) Sex: Male{ } Female{ }

(v) Mode of Entry: Direct{ } Prelim{ }

SECTION B

Circle the correct letter from a, b, c, and d of the item you have chosen in the answer sheet provided. Please do not write on this question sheet.

TIME ALLOWED: 60 Minutes

1. Which of the following is a displacement?

(a) 10 metres south

(b) 10 metres per second

(c) 10 metres per second south

(d) South

UNIVERSITY OF IBADAN LIBRARY

2. A body starts from rest and accelerates uniformly at a rate of $5m/s^2$. Calculate its velocity after moving 90m

(a) 18m/s

(b) 30m/s

(c) 225m/s

(d) 450m/s

3. A mango falling vertically downward falls with

(a) uniform velocity

(b) non-uniform velocity

(c) constant acceleration

(d) constant deceleration

4. When a body is moving with a constant force which of the following is correct?

(a) Its acceleration is constant

(b) its velocity is constant

(c) its momentum is constant

(d) its power is not necessarily constant

5. Which of the following is a vector quantity?

(a) Speed

(b) Distance

(c) Energy

(d) Momentum

UNIVERSITY OF IBADAN LIBRARY

6. A body of mass 10kg falls from a height of 5m above the ground. What is the kinetic energy of the body just before it strikes the ground? (Neglect loss of energy and take $g=10m/s^{-2}$)

(a) 625J

(b) 500J

(c) 250J

(d) 25J

7. The speedometer of a car gives you a reading of the car's

(a) Constant speed

(b) average speed

(c) instantaneous speed

(d) total speed

8. For a trip of several hours duration, a ratio of the total distance traveled to the total time elapsed is a (an):

(a) Instantaneous speed

(b) average speed

(c) constant speed

(d) total speed

9. The symbol v is used to represent

(a) Instantaneous speed

(b) average speed

(c) constant speed

(d) total speed

UNIVERSITY OF IBADAN LIBRARY

10. If v=d/t, then d=?

(a) v/t

(b) t/v

(c) vt

(d) (v)/(It)

11. The size of a quantity is called

(a) vector

(b) scalar

(c) ratio

(d) magnitude

12. A quantity of 15m/s to the north is a measure of

(a) velocity

(b) acceleration

(c) speed

(d) directional distance in the metric system

13. A quantity of 5m/s2 is a measure of

(a) metric area

(b) acceleration

(c) speed

(d) velocity

14. A ratio Δv/Δt is a measure of motion that is

(a) speed

(b) acceleration

UNIVERSITY OF IBADAN LIBRARY

(c) mass density

(d) Displacement

15. You can find average velocity by adding the initial and find velocity and dividing by 2 only when the acceleration is

(a) changing

(b) uniform

(c) increasing

(d) decreasing

16. Two objects are released from the same height at the same time, and one has twice the weight of the other, ignoring air resistance:

(a) the heavier objects hits the ground first

(b) the lighter objects hits the ground first

(c) they both hit the same time

(d) which ever hits first depends on the distance dropped

17. The distance that an object in free fall has covered is proportional to the square of the:

(a) Weight of the object

(b) mass of the object

(c) time of fall

(d) distance of the fall

18. What is the average speed in km/hr for a car that travels 22km in exactly 15min?

(a) 0.011km/hr

(b) 88km/hr

UNIVERSITY OF IBADAN LIBRARY

(c) 5.5km/hr

(d) 40km/hr

19. Suppose a radio signal travels from the earth and through space at a speed of 3.0 x 10^8 m/s^2. How far into space did the signal travel during the first 20.0 minutes?

(a) 1.50 x 10^{11}m

(b) 3.80^{11}m

(c) 3.60 x 10^{11}m

(d) 40 x 10^8m

20. Which of the following is a combination of unit called watt?

(a) N. m/s

(b) kg $m^2/s^2/s$

(c) j/s

(d) all the above

21. Power is

(a) the rate at which work is done

(b) the rate at which energy is expended

(c) work per unit time

(d) any of the above

22. According to the scientific definition of work, pushing on a rock accomplishes no work unless there is

(a) movement

(b) a net force

(c) an opposing force

UNIVERSITY OF IBADAN LIBRARY

(d) movement in the same direction as the direction of the force

23. The most widely used source of energy today is

(a) Coal

(b) petroleum

(c) nuclear

(d) water power

24. How much work is done in raising a 10.0 kg backpack from one floor to a shelf 1.5m above the floor?

(a) 150J

(b) 15J

(c) 1.5J

(d) 1500J

25. What is the velocity of a 1,000 kg car if its kinetic energy is 200 Kj?

(a) 40 m/s

(b) 20m/s

(c) 400 m/s

(d) 200 m/s

26. How long will it take an electric motor of power output 25KW to raise a lift of mass 1000 kg through 20m?

(a) 1.25 s

(b) 4s

(c) 8s

(d) 16s

UNIVERSITY OF IBADAN LIBRARY

27. A worker climbs a hill 400m high. If his mass is 50kg, what work does he do on lifting himself to the top of the hill?

(a) 200kJ

(b) 20KJ

(c) 0.2 KJ

(d) 2000KJ

28. Which of the following is not a source of energy?

(a) Fossil fuel

(b) wave energy

(c) Nuclear energy

(d) chemical energy

29. What is the impulse of a force of 5N acting for 2s?

(a) 2.5N

(b) 0.4N

(c) 10N

(d) None of the above

30. A football of mass 0.50kg has a velocity of 20m/s after a kick lasting 0.025s. The gain in momentum of the ball is:

(a) 100kg m/s

(b) 0.50Kg m/s

(c) 10kg m/s

(d) 16kg m/s

UNIVERSITY OF IBADAN LIBRARY

31. A trolley of mass 2kg collides with a stationary trolley of mass 1kg and sticks to it. If they move on together with a velocity of 4m/s, what was the original velocity of the 2kg trolley?

(a) 5m/s

(b) 6m/s

(c) 5m/s

(d)24m/s

32. What is the momentum of a 100kg football player who is moving at 6m/s?

(a) 16.6kg m/s

(b) 106 Kg m/s

(c) 600kg m/s

(d) 0.6kg m/s

33. A 15g bullet is fired with a velocity of 200m/s from a 6kg rifle. What is the recoil velocity of the rifle?

(a) 50m/s

(b) 5m/s

(c) 0.5 m/s

(d) 0.05m/s

34. What is momentum of 50kg person walking at a speed of 2m/s?

(a) 100kg m/s

(b) 25kg m/s

(c) 25kg m/s^2

(d) 1000kg m/s

UNIVERSITY OF IBADAN LIBRARY

35. Which of the following represent mass in the English system of measurement?

(a) 1b

(b) $1b/ft/s^2$

(c) kg

(d) 1kg/b

36. The force that accelerates a car over a road comes from

(a) the engine

(b) the tires

(c) the road

(d) the gear

37. Ignoring all external forces, the momentum of the exhaust gases from a flying jet air plane that was initially at rest is:

(a) much less than the momentum of the air plane

(b) equal to the momentum of the air plane

(c) somewhat greater than the momentum of the air plane

(d) greater than the momentum of the air plane when the aircraft is accelerating

38. From the equation K.E =1/2 mv^2, v is equal to

(a)√ 2K.E/m

(b) b√K.E/2m

(c) (K.E) 2/2m

(d) d $(2K.E/m)^2$

UNIVERSITY OF IBADAN LIBRARY

39. Which of the following is the correct unit of weight?

(a) Kilogram

(b) Newton

(c) kg. M/s

(d) N/Kg

40. Mass is:

(a) a measure of inertia

(b) a measure of how difficult it is to stop a moving object

(c) a measure of how difficult it is to change the direction of travel of a moving object

(d) all of the above

41. The law of inertia is another name for Newton's

(a) Law of motion

(b) first law of motion

(c) Second law of motion

(d) third law of motion

42. The extent of resistance to a change of motion is determined by an object's

(a) Weight

(b) mass

(c) density

(d) inertia

UNIVERSITY OF IBADAN LIBRARY

43. For a trip of several hours duration, a ratio of the total distance traveled to the total time elapsed is a (an)

(a) instantaneous speed

(b) average speed

(c) constant speed

(d) total speed

44. About how many watt are equivalent to 1 house power

(a) 7.5

(b) 75

(c) 750

(d) 7500

45. Which of the following is not an equation of motion?

(a) $v = u + at$

(b) $v^2 = v^2 + 2as$

(c) $s = ut + {}^{½}at^2$

(d) $f = ma$

46. If a body traveling at 20m/s is subjected to a steady deceleration of $5.0m/s^2$, how long will it take to come to rest?

(a) 4s

(b) 8s

(c) 100s

(d) 0.25s

UNIVERSITY OF IBADAN LIBRARY

47. What is the mathematical statement of Newton second law of motion?

(a) f=ma

(b) m=ft

(c) f=m(v-u)/t

(d) f = m(v-u)/a

48. What is the name of the force needed to keep a body moving in a circle?

(a) Resistant force

(b) resultant force

(c) centripetal force

(d) centrifugal force

49. If an object moves with a constant speed round a circle, it has an acceleration which is:

(a) constant in magnitude and varying, indirection

(b) varying in magnitude and constant in direction

(c) varying in magnitude and direction

(d) constant in magnitude and direction

50. Which of the following cases is not doing work?

(a) a stationary tree

(b) a moving car with certain velocity

(c) an airplane in motion

(d) a women hawking with basket of orange on her head

UNIVERSITY OF IBADAN LIBRARY

APPENDIX 5B

ANSWER SHEET FOR PTATIS

(i) College:……………………………………………………………

(ii) Name:…………………………………………………………..

(iii) Matric No:…………………………………………………………

(iv) Sex: Male{ } Female{ }

(v) Mode of Entry: Direct{ } Prelim{ }

1. A B C D	18. A B C D	34. A B C D
2. A B C D	19. A B C D	35. A B C D
3. A B C D	20.A B C D	36. A B C D
4. A B C D	21. A B C D	37. A B C D
5. A B C D	22. A B C D	38. A B C D
6. A B C D	23. A B C D	39. A B C D
7. A B C D	24. A B C D	40. A B C D
8. A B C D	25. A B C D	41. A B C D
9. A B C D	26. A B C D	42. A B C D
10. A B C D	27. A B C D	43. A B C D
11. A B C D	28. A B C D	44. A B C D
12. A B C D	29. A B C D	45. A B C D
13. A B C D	30. A B C D	46. A B C D
14. A B C D	31. A B C D	47. A B C D
15. A B C D	32. A B C D	48. A B C D
16. A B C D	33. A B C D	49. A B C D
17. A B C D	34. A B C D	50. A B C D

UNIVERSITY OF IBADAN LIBRARY

APPENDIX 5C

KEY TO PTATIS

1. A	18. B	34. B
2. B	19. C	35. B
3. C	20. D	36. C
4. A	21. D	37. B
5. D	22. D	38. A
6. B	23. B	39. B
7. C	24. A	40. D
8. B	25. B	41. B
9. B	26. C	42. B
10. C	27. A	43. B
11. D	28. D	44. C
12. A	29. C	45. D
13. B	30. C	46. A
14. B	31. B	47. B
15. B	32. C	48. C
16. C	33. C	49. C
17. C	34. A	50. A

UNIVERSITY OF IBADAN LIBRARY

APPENDIX 6

PRE-SERVICE TEACHERS' SCIENCE PROCESS SKILLS RATING SCALE (PTSPSRS)

Dear Sir,

Your responses to the underlisted items are expected to help in carrying out a research in the area of science process skills. The information is purely for academics work and your responses will be treated with utmost confidence.

SECTION A

Student Teachers' name……………………………………………………………

Institution……………………………………………………………………....

Sex: MALE [ ] FEMALE [ ]

Mode of Entry:……………………………………………………………………

Kindly rate the student teacher in each of the skills listed below using the 5 point scale ranging from 1=poor, 2=fair, 3=very fair, 4=good, 5=very good.

SECTION B

SKILLS	RATING SCALE				
	1	2	3	4	5
A. Observing 1. Selecting					
2. Identifying					
3. Describing					

UNIVERSITY OF IBADAN LIBRARY

4. Listing					
5. Using formula					
6. Distinguishing					
7. Reporting					
B. Classifying 1. Sorting					
2. Classifying					
3. Grouping					
4. Ordering					
5. Arranging					
C. Measuring 1. comparing					
2. differentiating					
3. Using formula					
4. Calculating					
5. Summarizing data					
6. Recording					
D. Communicating 1. Reporting					
2. Communicating					
3. Using graph					
4. Drawing					

UNIVERSITY OF IBADAN LIBRARY

E. Inferring 1. Concluding					
2. Explaining					
3. Interpreting					
4. Formulation of idea					
F. Predicting 1. Analysing					
2. Developing question					
3. Generalising					
4. Identifying relationship					
5. Applying principle					
6. Recognising patterns					

UNIVERSITY OF IBADAN LIBRARY