EFFECTS OF SIMULATED LABORATORY AND ENRICHED LABORATORY GUIDE MATERIAL EXPERIMENTS ON STUDENTS' LEARNING OUTCOMES IN BASIC SCIENCE IN OYO STATE, NIGERIA

BY

Segun Jacob OGUNKUNLE

Matric. No.: 61923

A Thesis in the Department of Teacher Education
Submitted to the Faculty of Education,
in partial fulfillment of the requirement for the Degree of
DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN

FEBRUARY, 2017

ABSTRACT

Basic Science is a core subject at the basic education level in Nigeria. It is taught to lay foundation for future subjects, such as Biology, Chemistry and Physics. Evidence abound that students dislike, fear and therefore fail the senior secondary science subjects due to inadequate exposure to practical works and skills at the basic education level. Previous studies largely focused on factors affecting teaching and learning of Basic Science practical without emphasis on intervention through regular conduct of laboratory experiments in the subject. This study, therefore, determined the effects of Simulated Laboratory (SL) and Enriched Laboratory Guide Material (ELGM) experiments on students' achievement and acquisition of Science Process Skills (SPS) in Basic Science in Oyo State, Nigeria. The moderating effects of gender and future career interest in science were also examined.

Bruner's constructivist and Kolb's experiential learning theories provided the framework, while the pretest-posttest control group quasi-experimental design with a 3x2x2 factorial matrix was adopted. Three local government areas were randomly selected from each of Ibadan (Ibadan South-East, Ibadan South-West, Ibadan North) and Oyo (Afijio, Oyo-East, Oyo-West). Six co-educational public secondary schools were purposively selected based on availability of functional computer and science laboratories. Six randomly selected intact classes of junior secondary three students (130 males and 147 females, ±17 years) were randomly assigned to SL (110), ELGM (60) and Conventional (Expository) Laboratory - CEL (107). The instruments used were: Achievement test in Basic Science (r=0.87), Science process skills test in Basic Science (r=0.72) and Future career interest in Science questionnaire (r=0.99). The treatments lasted seven weeks. Data were analysed using Analysis of covariance and Scheffé post-hoc test at 0.05 level of significance.

Treatments had significant main effect ($F_{(2,264)}$=25.88; partial η^2=.16) on students' achievement in Basic Science. Participants in the ELGM group had highest achievement mean score (24.91) followed by CEL (24.77) and SL (19.40). Future career interest in science had significant main effect ($F_{(1,264)}$=4.08; partial η^2=.02) on students' achievement in Basic Science. Participants in the Science-Related (SR) group had higher achievement mean score (23.87) than Non-Science Related (NSR) group (22.18). Treatments had significant main effect ($F_{(2,264)}$=25.51; partial η^2=.16) on students' acquisition of SPS in Basic Science. Participants in the SL group had highest SPS mean score (15.00) followed by ELGM (14.66) and CEL (12.59). Future career interest in science had significant main effect ($F_{(1,264)}$=17.62; partial η^2=.06) on students' acquisition of SPS in Basic Science. Participants in the SR group had higher SPS acquisition mean score (14.81) than NSR (13.36). There was no significant main effect of gender on students' achievement and acquisition of SPS in Basic Science. There were no significant two-way and three-way interaction effects on students' achievement and acquisition of SPS in Basic Science.

Enriched laboratory guide material experiment was more effective in enhancing achievement while Simulated laboratory experiment was more effective on acquisition of science process skills. The two modes of laboratory experiments should be adopted for improved achievement and acquisition of science process skills in Basic Science.

Key words: Simulated laboratory experiments, Enriched laboratory guide experiments, Science process skills, Future career interest in Science, Basic Science

Word count: 489

DEDICATION

This work is dedicated to God – the Father, the Son and the Holy Spirit.

CERTIFICATION

I certify that this work was carried out under my supervision by Segun Jacob OGUNKUNLE in the Department of Teacher Education, University of Ibadan.

……………………………………... **……………………………**

Professor M. K. Akinsola **Date**

Department of Teacher Education

University of Ibadan, Nigeria

ACKNOWLEDGEMENTS

I return all glory, honour, majesty and gratitude to Almighty God who had been my sufficiency in terms of knowledge, wisdom and resources which were used to contemplate, commence, prosecute and successfully complete this academic exercise. He gave me life and protected me all through my studentship. He endowed me with and sustained the excellent state of my health.

I sincerely thank my Supervisor, Professor Mojeed Kolawole Akinsola, who graciously accepted to supervise me when all hope to continue and successfully complete the programme was lost. God used him to actualise my age-long dream of obtaining a Doctor of Philosophy degree of the University of Ibadan. I am grateful to him for his patience, guidance and words of encouragement while he painstakingly read through and corrected my work, in spite of his tight schedule as Dean, Faculty of Education, University of Ibadan. I appreciate him for believing in my ability to undergo this research endeavour. He, also, encouraged me to develop the simulated laboratory experiments software which was used in this study. His regular prayers were tonic for my weary soul whenever I felt discouraged.

I am grateful to Dr David Olugbade Fakeye who God used to bring me back to the programme after four years of abandonment. He provided a platform for the accomplishment of this research work right from my re-admission through the search for and selection of topic up to complete editorial work of the final thesis. He offered valuable advice and was an unaccredited dependable lieutenant to my Supervisor.

My thanks go to Dr Benson.A. Adegoke and Professor F. O. Ogundare,, my internal/external examiners, for their constructive criticism and suggestions which added value to this piece of work. I am indebted to Professor Josiah Olusegun Ajiboye for his immense contributions on the variables of the study. I appreciate the spiritual, moral and editorial supports of Professor Clement Olusegun Olaniran Kolawole, Head, department of Teacher Education, University of Ibadan.

I am sincerely grateful to Dr Adedeji Tella for his assistance to analyse the data collected and useful suggestions which he offered during the interpretation of results and writing of abstract. I thank all Professors, Lecturers and Postgraduate students in the department of Teacher Education, University of Ibadan for their constructive criticisms and advice during the science unit proposal, pre-field and post-field seminar presentations which improved the quality of this work. I appreciate Dr

Olubiyi Johnson Ezekiel for making available relevant textual materials and internet downloads in form of STAN conference proceedings, journals and online research reports. All these contributed immense enrichment to the literature reviewed for the study. I am deeply grateful to authors of all works cited in this thesis.

My thanks go to Mr. Tomisin Ogundele for the design and creation of images/models of laboratory apparatus, equipment and materials used in the development of the Simulated Laboratory Experiments Software (SLES). His technical services during the pre-field, post-field and final oral examinations are well acknowledged. I appreciate the immense contribution of Mr. Folajimi Fakoya for writing the computer program used to develop SLES. His efforts to transform the enriched laboratory guide material to "script" which made the SLES more interactive are desirous of commendation.

I am grateful to Mr. Clement Omolayo for the technical support on the initial effort at developing the SLES. Mr and Mrs Aare Kadiri are appreciated for making available their electricity generating set for use at Jobele during the initial effort. I hereby commend the efforts of Miss Sekinat Akinwale for the release of her electricity generating machine for use at Olivet Baptist High School Oyo during the field work. Also, her diligence as both personal and research assistant while the study lasted is acknowledged.

I am grateful to Mrs. Funmi Oladeji for her consistent words of encouragement which brought me back on the programme after a long period of unofficial leave. Her assistance during online re-admission, registration and renewal of registration at the Postgraduate school of this great citadel of learning are highly appreciated. My heartfelt thanks go to the Principal, staff and students of the six schools which participated in the study as well as the school used for validation of instruments. Mrs. Theresa Adeyoola Olaitan is greatly appreciated for facilitating the release of schools especially within Ibadan metropolis for use in this study. I thank Mr. Taiwo Adekunle for the role played in the collection of data at the Oyo State Ministry of Education, Secretariat, Ibadan. I appreciate the financial support of the Tertiary Education Trust Fund (TETFund).

I am sincerely grateful to my parents: Dr John Ogunyale Ogunkunle and Mrs. Felicia Taiwo Ogunkunle for supporting me educationally while I was a minor. I thank my wife: Mrs. Adekemi Olusegun for keeping late nights with me while I was writing this thesis, tolerating my excesses whenever I became irrational and irritable

as a result of challenges of this study and her prayers for me to succeed. I am highly grateful to my children: OreOluwa (Little Angel), OoreOluwa (Ebony) and IreOluwa (Baby of the house) for their cooperation which contributed in no small measure to the success of this research work.

TABLE OF CONTENTS

CHAPTER THREE: METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Science and technology are the backbone of modern development throughout the world. Advancements in information and communication; efficient transportation through air, waters, rails, and good roads on land; improvements in health-care delivery, among others are made possible through products of science. Scientific knowledge underlines the design, fabrications and constructions by engineers, technicians and technologists. Science feeds technology with the truth regarding the nature of materials and other information necessary to enable technology to come up with products and other solutions to human problems. Thus, technology is powered by discoveries in science. The indispensable role of science and technology to human survival made science education to be included in the school curriculum at all levels of education in Nigeria.

Science education plays significant roles in the technological development of a nation as enumerated by Oloyede (2005). These include:

(i) Science is usually considered and recognized as an indispensable weapon, in any developing society, for confronting and perhaps surmounting many challenges that might surface in their future growth and in their efforts to eradicate ignorance and poverty. This is because scientific discoveries and breakthroughs had led to technological development which had given rise to improved standard of living in different countries of the world. In fact, technological advancement facilitated by scientific discoveries enhances the economic and political status of countries just as it promoted the Asian Tiger- India- from underdevelopment to developed country.

(ii) Science education can be used to develop talents and creative potentials of citizenry. Thus, the science-literate and science-cultured child can become the human resource that can make the achievement of a country's technological goals a reality.

(iii) Science education liberates people from the claws of superstitions and superstitious beliefs. Scientific literacy is provided by Basic Science component of the Basic Science and Technology in the basic education programme. Thus, scientific knowledge gained in the subject enable most people to make rational decisions on issues such as forest reserves, wild-life conservation, soil degradation, pollution, population control/family planning, and so on. They are also able to understand the occurrence of some natural phenomena like comets, eclipses, tsunami, earthquakes, hurricanes, and the likes.

(iv) Science education helps to develop a democratic spirit in a child through creation of science culture contained in science processes. Thus, the child assumes responsibilities for developing his country and not privileges to consumerism that is prevalent in the society.

(v) Science education promotes problem-based learning rather than prescriptive learning method which permeates other non-science based academic disciplines. Thus, people acquire through science education an art of initiating problem, investigating it and possibly resolving issues surrounding the problem for better living conditions.

Therefore, emphases are placed by nations of the world on the teaching and learning of science right from the onset of a child's formal education programme. These are alluded to by the various purposes and objectives of education at different levels of Nigeria educational system as contained in the National Policy on Education. One of the purposes of early childhood care development and education is "to inculcate in the child the spirit of enquiry and creativity through the exploration of nature, the environment, art, music and playing with toys etc." (FRN, 2013:19). At the primary school level, one of the objectives of education is "to lay a sound basis for scientific and reflective thinking" (FRN, 2013:19). Also, one of the objectives of post-basic education and career development (PBECD) in Nigeria is the provision of "trained manpower in the applied science, technology and commerce at sub-professional grades" (FRN, 2013:29).

According to the Nigerian Educational Research and Development Council (NERDC, 2008a), Basic Science as a form of science education in Nigeria was originally one of the twelve (12) compulsory subjects in the upper basic education curriculum structure (NERDC, 2008a:6). It replaces Integrated Science of the old junior secondary education curriculum (NERDC, 2008b:5) as "…a re-alignment and restructuring of the revised curricula for primary science and Junior Secondary School Integrated Science" (NERDC, 2006:iv). However, it now exists as one of the four components of the Basic Science and Technology in the curriculum for junior secondary education (FRN, 2013: 25). Basic Science and Technology is one of the ten (10) compulsory subjects in the basic education curriculum (NERDC, revised 2012: iv). The overall objectives of the Basic Science and Technology Curriculum include: to enable the learners to

> develop interest in science and technology; acquire basic knowledge and skills in science and technology; apply scientific and technological knowledge and skills to meet societal needs; take advantage of the numerous career opportunities offered by science and technology; become prepared for further studies in science and technology; avoid drug abuse and related vices; and be safety and security conscious (NERDC, revised 2012: vi).

However, science is taught in Nigeria schools through abstract lectures, exposure to long lists of unrelated facts and copious notes which students were expected to memorize (Ajala, 2004; Danmole, 2002). This scenario conforms more to prescriptive learning than problem-based learning (Fayemi and Fagbemi, 2005). Such strategy helped the students to acquire only the products and not processes of science which is essential in further study of science. Table 1.1 shows analysis of students' performance in the Basic Education Certificate Examination (BECE) in Basic Science between 2008 and 2015 in Oyo State.

Table 1.1: Analysis of Oyo State students' performance in the BECE in Basic Science (2008-2015)

Year	Total Candidate	Distinction (A)	Credit (C)	Pass (P)	Failure (F)	A+C
2008	80,070 (100.0%)	8,056 (10.0%)	51,627 (64.5%)	14,138 (17.7%)	6,249 (07.8%)	59,683 (74.5%)
2009	85,034 (100.0%)	9,740 (11.5%)	37,347 (43.9%)	29,935 (35.2%)	8,012 (09.4%)	47,087 (55.4%)
2010	80,355 (100.0%)	11,073 (13.8%)	50,435 (62.8%)	18,081 (22.5%)	766 (01.0%)	61,508 (76.5%)
2011	75,437 (100.0%)	16,517 (21.9%)	27,962 (37.1%)	15,640 (20.7%)	15,318 (20.3%)	44,479 (59.0%)
2012	89,047 (100.0%)	8,554 (09.6%)	44,345 (49.8%)	25,466 (28.6%)	10,682 (12.0%)	52,899 (59.4%)
2013	78,733 (100.0%)	259 (00.3%)	46,873 (59.6%)	20,723 (26.3%)	10,878 (13.8%)	47132 (59.9%)
2014	89,108 (100.0%)	6867 (07.7%)	62,796 (70.5%)	17,988 (20.2%)	1,457 (01.6%)	69663 (78.2%)
2015	96,421 (100.0%)	11,348 (11.77%)	65,541 (67.97%)	19,501 (20.23%)	31 (00.03%)	76,889 (79.74%)

Source: Department of Planning, Research and Statistics, Ministry of Education, Secretariat, Ibadan Oyo State (2015).

Table 1.1 indicates that the failure rates were lower than the percentages of distinctions and credit passes (A+C) in the BECE Basic Science for junior secondary school (JSS) students in Oyo State during the period under review. Thus, Nigeria students have potentials to do well on scientific tasks. However, there was the absence of practical work in the BECE in Basic Science because it is restricted to cognitive assessment. This contradicts Government plan to ensure that teaching is made practical, activity-based, experiential and IT supported (FRN, 2013:15). The students were not exposed to processes of science which are inherent in practical (Adejoh, 2006) and which could be used in everyday decision-making. This negates the intention of the upper basic education curriculum in Basic Science – "…to promote learning by doing and skills development" (NERDC, 2006: v). Also, the practice failed to anticipate the two-component assessment mode (theory and practical) of the Senior School Certificate Examinations (SSCE) in Biology, Chemistry and Physics.

It is expected that many students would be interested in the study of pure science subjects (Chemistry and Physics, since Biology is made compulsory for all students) as a result of their outstanding performance in the BECE Basic Science for junior secondary school (JSS) students in Oyo State. However, Table 1.2 indicates that 18.9%, 16.1% and 33.7% of the Basic Science graduates offered and sat for one or both of Chemistry and Physics in the West African Senior School Certificate Examinations (WASSCE) in 2011, 2012 and 2013 respectively.

Table 1.2: Transition rates from Basic Science to the senior secondary Chemistry and Physics in Oyo State

BECE		**WASSCE**		**% Population of BECE graduates who took science subjects (C=B/AX100%)**
Year taken	**Population (A)**	**Year taken**	**Science Population (B)**	
2008	80,070	2011	15,163	18.9
2009	85,034	2012	13,724	16.1
2010	80,355	2013	27,111	33.7

Source: Department of Planning, Research and Statistics, Oyo State Ministry of Education, Secretariat, Ibadan, Oyo State (2015).

Literature revealed that students' low enrolment in the senior secondary science is caused by some of the following factors: students' perceived difficult nature of science (Mbamara and Eya, 2015; Aina and Adedo, 2013); career aspiration (Adams and Salome, 2014), absence of adequately equipped science laboratories in schools (Nyamba and Mwajombe, 2012), intelligence, self-concept, attitude, motivational traits, misconception and locus of control (Odinko and Adeyemo, 1999; Osokoya, 1990; Bakare, 1976; Abe, 1975). These are in addition to teachers' use of the conventional instructional strategy which hardly exposed Basic Science students to science culture of inquiry through experimentation at early stages in life. Thus, the students are not made to experience science through the affective science (scientific attitudes and ethics of science) and manipulative science (science processes and science process skills which could be acquired in the practical classes). They are not taught nor assessed on Basic Science practical in the BECE.

Foulds and Rowe (1996) submitted that effective science learning and development of science process skills are inseparable activities. Also, a significant positive linear relationship was found between the extent to which science process skills were taught in the laboratory and achievement in science (Feyzioğlu, 2009). Furthermore, Ibe (2011) observed low overall scientific literacy among upper basic science (JSIII) students of Nsukka Local Government Area of Anambra State and attributed it to their non-exposure to Basic Science practical. This is because scientific literacy involves an understanding of science concepts and acquisition of science process skills (Özgelen, 2012). Thus, low scientific literacy among JSIII students contradicts the intention of the JSS curriculum in Basic Science and Technology – "…to sustain the interest of learners and promote meaningful learning by doing and skills development" (NERDC, revised 2012: viii) through the promotion of "…guided inquiry and activity-based teaching and learning…" in the science subjects (NERDC, revised 2012: viii).

Consequently, secondary school students were not adequately prepared in Basic Science as a foundation subject for further studies in Biology, Chemistry and Physics in the senior secondary school (SSS) as evident in Table 1.3. This weakens the foundation for future science learning at higher levels of education starting with the Basic Science at the JSS. It undermines the realisation of one of the overall objectives of the basic education curriculum: "to enable the learners to become prepare for further studies in science and technology" (NERDC, revised 2012: vi). This position corroborated Ekpunobi (2005) submission that for a child to be science inclined, the foundation has to be effectively laid at the basic education level.

Students are inadequately exposed to laboratory works in Biology, Chemistry and Physics in the senior secondary schools in Nigeria. Ezeliora (2004) reported that majority of the SSII science teachers in the south east zone in Nigeria did not begin science practical on time, nor had enough practical activities with the students before the West African Examinations Council (WAEC) conducted Senior School Certificate Examination (SSCE). This position is further strengthened by the observation of Bamidele (2004) that students were exposed to Physics practical in the last term of the SSIII when the WASSCE was approaching. The situation impacted negatively as visible under-achievement in Biology, Chemistry and Physics prevails in public examinations. Table 1.3 shows analysis of students' performance in SSCE conducted by WAEC in the three science subjects between 2010 and 2013 in Oyo State.

Table 1.3: Analysis of Oyo State students' performance in WASSCE science subjects (May/June 2010-2013)

Year		**Total Candidate**	**Distinction (A1,B2,B3)**	**Credit (C4,C5,C6)**	**Pass (D7,E8)**	**Failure (F9)**	**A1-C6**	**D7,D8,F9**
2010	Biology	41,845 (100.0%)	866 (02.1%)	7,613 (18.2%)	8,673 (20.7%)	24,693 (59.0%)	8,479 (20.3%)	33,366 (79.7%)
	Chemistry	13,634 (100.0%)	476 (03.5%)	2,477 (18.2%)	3,429 (25.1%)	7,252 (53.2%)	2,953 (21.7%)	10,681 (78.3%)
	Physics	13,350 (100.0%)	868 (06.5%)	3,735 (28.0%)	4,180 (31.3%)	4,567 (34.2%)	4,603 (34.5%)	8,747 (65.52%)
2011	Biology	45,970 (100.0%)	516 (01.1%)	5,728 (12.5%)	11,362 (24.7%)	28,372 (61.7%)	6,236 (13.6%)	39,734 (86.4%)
	Chemistry	14,954 (100.0%)	681 (04.5%)	2,717 (18.2%)	4,728 (31.6%)	6,828 (45.7%)	3,398 (22.7%)	11,556 (77.3%)
	Physics	15,163 (100.0%)	1,279 (08.4%)	4,697 (31.0%)	4,530 (29.9%)	4,657 (30.7%)	5,976 (39.4%)	9,187 (60.6%)
2012	Biology	43,164 (100.0%)	585 (01.3%)	6,001 (13.9%)	2,711 (06.3%)	33,867 (78.5%)	6,586 (15.2%)	36,578 (84.8%)
	Chemistry	12,750 (100.0%)	408 (03.2%)	3,486 (27.3%)	866 (06.8%)	7,990 (62.7%)	3,894 (30.5%)	8,856 (69.5%)
	Physics	13,724 (100.0%)	1,625 (11.8%)	5,745 (41.9%)	752 (05.5%)	5,602 (40.8%)	7,370 (53.7%)	6,354 (46.30%)
2013	Biology	73,618 (100.0%)	2,567 (03.5%)	21,586 (29.3%)	19,532 (26.5%)	29,933 (40.7%)	24,153 (32.8%)	49,465 (67.2%)
	Chemistry	27,109 (100.0%)	6,405 (23.6%)	9,249 (34.1%)	5,527 (20.4)	5,928 (21.9%)	15,654 (57.7)	11,455 (42.3%)
	Physics	27,111 (100.0%)	2,144 (07.9%)	8,857 (32.7%)	7,959 (29.3%)	8,151 (30.1%)	11,001 (40.6%)	16,110 (59.4%)

Source: Department of Planning, Research and Statistics, Oyo State Ministry of Education, Secretariat, Ibadan, Oyo State (2015).

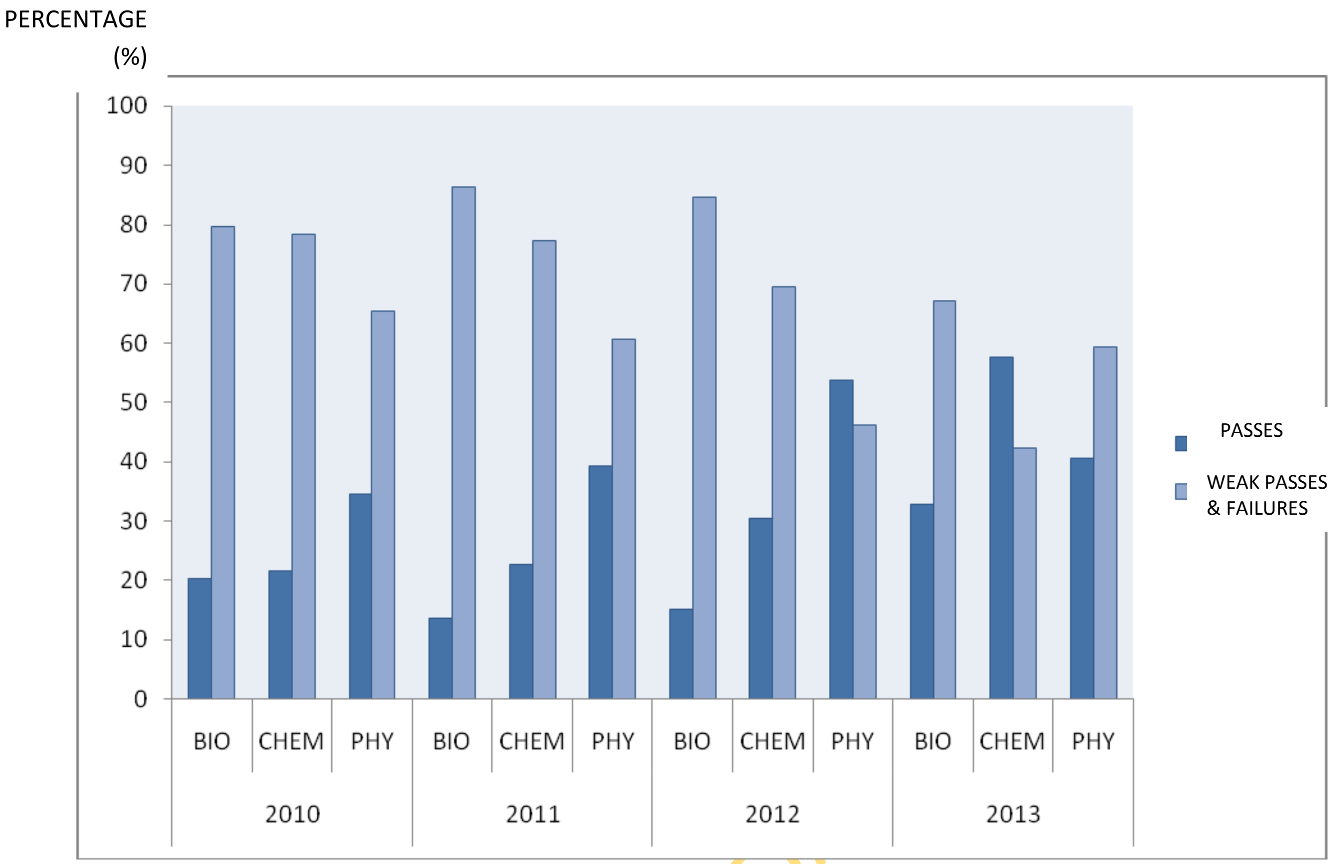


***Fig. 1.1**: Percentage of Oyo State Students' Performance in WASSCE Science Subjects (May/June 2010-2013)*

Table 1.3 and Fig. 1.1 reveal that except 53.7% for Physics in 2012 and 57.7% for Chemistry in 2013, the rates of distinctions and credit passes (A1-C6) in Biology, Chemistry and Physics are below 50% during the years under consideration. This observation could be explained by Isa (2007) finding that students' performance in Biology was poor due to inadequate exposure to practical work and skills. Also, Omilani (2015) submitted that poor knowledge of practical is a major cause of students' under-achievement in Chemistry. Thus, secondary school students have not been able to demonstrate adequate cognitive and practical skills since WASSCE assessed theoretical and practical works in Biology, Chemistry and Physics. Also, the negative relationship between students' performance in BECE Basic Science and WASSCE science subjects contradicts the findings of Olatoye and Afuwape (2004) who noted that students' achievement in Integrated Science (now Basic Science and Technology) significantly predicts later achievement in Biology, Chemistry and Physics in that order.

The inability of students' achievement in BECE Basic Science to predict positively their achievement in WASSCE Biology, Chemistry and Physics could be explained by the observation of Aboki and Badmus (2005) that instructional strategies used by teachers are at variance with the strategies recommended on the science curriculum and that for most teachers the pattern of behaviour is overwhelmingly expository. The NERDC Basic Science and Technology Curriculum (revised, 2012) suggests teachers' and pupils' activities which are intended to make its implementation activity-based and pupil-centred. Pupils are expected to experience science through constant involvement in practical activities (in the science laboratory or using science kits in the classroom) which should be evaluated on continuous basis while teachers are expected to facilitate science teaching and learning processes.

However, Ndirika (2011) found that many teachers with training in innovative strategies for enhancing the science classroom learning environment (such as adequate use of information and communication technology in science instruction) continue to lecture. Ndirika observed further that the teachers ignore instructional strategies and textbooks that encourage pupils to develop scientific understanding through observing, classifying, counting, measuring and interacting with scientific objects and events, manual skills through manipulating and using scientific tools and doing. Thus, Basic Science teachers do not create laboratory experiences that would help students to developing science process skills nor teach the students the required skills effectively. Perhaps, these deficiencies could be explained by the teachers' very poor conceptual understanding of the science process skills and low interest in learning more about the skills although they are familiar with the science process skills (Mbewe, Chabalengula and Mumba, 2010). Also, Eya and Elechi (2011) found that secondary school teachers in the six education zones of Enugu state did not utilize laboratory facilities to teach Basic Science because of lack of adequate laboratory facilities, lack of teachers' guide and practical manuals.

Ajeyalemi (2011) decried the poor state of science teaching and learning in Nigeria when he reported that more than 90% of Nigeria public schools neither have laboratory space and/or equipment nor are supplied with necessary science kits for practical activities intended in the curriculum. Also, Ajeyalemi confirmed the submissions by Ajala (2004) that teachers of Integrated Science in those schools had no cognate formal training or competence in science content and pedagogy because they are either specialists in the teaching of one /two single science subjects or with specialization in applied subjects (like Agricultural or Health Science). Furthermore, Ajeyalemi observed that many Nigeria junior secondary schools either convert ordinary classrooms to Basic Science laboratory or make use of the senior secondary school science laboratories to conduct practical in Basic Science. Ajeyalemi added that the 'make-shift' or 'improvised' Basic Science laboratories are ill-equipped and have inadequate consumables. He concluded that little or no science is taught because in most science lessons at the basic education level, teachers are involved in information giving and/or the lecture–demonstration type of practical activities which is teacher-centred. These observations are corroborated by the findings of Taiwo, Adeniji and Muazu (2012) that most secondary schools in Abeokuta North, Abeokuta South and Odeda Local Government Areas of Ogun state have no qualified laboratory personnel (technologist, technician, attendant and/or assistant). They submitted that consumables (reagents), equipment and materials are rarely available in most laboratories. Haastrup (2005) submitted that the poor performance and under-achievement in science classrooms are the products of Nigeria secondary school operating without the necessary complement of teachers and equipment.

Science process skills are expertise needed by a scientist to effectively carry out scientific activities. They are transferrable skills that are applicable to many sciences and that reflect the behaviour of scientists (Raj and Devi, 2014). They are the hubs of scientific discoveries and technological breakthroughs. They have potentials to increase students' achievement and scientific creativity (Aktamiş and Ergin, 2008). The American Associations for the Advancement of Science (AAAS) identified fourteen process skills and these have been grouped into basic and integrated science process skills in the Science-A Process Approach (SAPA) Curriculum project. The basic (simple) science process skills provide a foundation for learning the integrated (more complex) science process skills (Padilla, 1990). Science process skills could be taught and developed through constant practice in the laboratory (Bulunuz and Jarrett, 2010; Feyzioğlu, 2009 and National Association of Biology Teachers, NABT, 2005). Hence, there is the need to promote the teaching and learning of science process skills through regular students' involvement in laboratory activities.

In order to improve science teaching and learning in Nigeria, science educators have suggested the use of some instructional approaches, methods and strategies which they have found to promote students' interest and enhance their achievement in science. Alake (2007) observed gradual development of students' interest in Integrated Science (now Basic Science component of the Basic Science and Technology) when taught using Floor Puzzle Game (FPG). Opara and Elekalachi (2007) reported that the application of indigenous technology in science teaching makes it more meaningful and thereby captivates the interest of boys and girls in the learning process. Pictorial and advance organisers (Onwioduokit and Akinbobola, 2005) in Physics; hypothetico-deductive approach (Ige and Arowolo, 2003), multimedia approach (Oyediran, Agoro and Fabiyi, 2004) and gender sensitization package (Nworgu, 2005) in Integrated Science; problem-solving instructional strategies in Biology (Akubuilo, 2004); blended learning in Chemistry (Makinde, 2005); and context-based teaching strategy in Physical Chemistry (Ogbu, 2012) have all been found to contribute positively to students' achievement in science. However, there are no Basic Science laboratories and laboratory guide material to teach practical in the subject. Also, most of these researches did not encourage students learning from each other through group conduct of science practical. In order to make up for this deficiency in previous strategies, scholars (Shaheen and Khattab, 2005; Ogunbowale, 2012)) have advocated the use of simulated laboratory and enriched laboratory guide material experiments combined with learning together instructional strategy. Simulated laboratory (SL) experiment could be used to reduce the challenges of absence of Basic Science laboratories as well as non-availability of materials and equipment in the Biology, Chemistry and Physics laboratories which could have been adapted to perform laboratory experiments in Basic Science. It is an application of computer assisted/aided learning (CAL) to conducting experiments in the laboratory (Akanbi, 2005). It consists of either still or mobile images/models of real apparatus, equipment and materials. These models could be assembled by "drag and drop" using high level programming language such as Action Script and JavaScript. It affords students the opportunity to observe, measure, input and store values of the variables during the experimental procedure. It is available online or as stand-alone application package in compact disc (CD)-ROM, digital video disc (DVD) among others (Saka, 2005).

Stand-alone simulations could be obtained as "downloads" from virtual laboratories on the internet. They could also be developed as customized in-house software for teaching and learning of Basic Science component of Basic Science and Technology. Stand-alone application packages are not affected by limited internet connectivity and other challenges associated with using online simulations. This is because 'stand-alone applications are computer programmes that run without connection to telephone, television, satellite or other electronic transmissions' (Olutunmbi, 2004). Thus, it was adopted, developed and used in this study.

Simulated Laboratory Experiments Software (SLES) was developed using Adobe Complete Suite (CS6) which consists of Adobe Fireworks, Adobe Flash Professional, User Interface, Adobe Audition and Adobe After Effect. Adobe Fireworks was used to create images/models and edit imported pictures of laboratory apparatus, equipment and materials. The images/models were translated to vector format using Adobe Flash Professional. User Interface provided the platform for simulating the experiments while shielding the activities of the operating system. It was used for simultaneous display of created images in order to monitor the simulated process. However, it conceals image boundary layers to project continuous events. Adobe Audition was used to create background audio tracks, control sound effects and click sounds for the programme. Adobe After Effect was used to create introductory graphic animation clip and transitional graphic effects. The SLES is available in Web-based flash format and executable flash for ease of use on all desktops and laptops (systems/browsers).

Simulation is an imitation of some real thing, state of affairs, or process. It is used whenever the real system cannot be engaged because it is not easily accessible, or it is dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist (Sokolowski and Banks, 2009). Thus, computer simulation is defined as an experiment performed on a computer model of real or hypothetical system in order to observe how it works and make predictions about the behaviour of the system (Akinsanya, 2012). It has been used to model many natural systems in Biology, Chemistry and Physics in order to gain insight into the operation of those systems. Thus, it is a methodology for conducting experiments using a model of the real system (Austin and Burns, 1985). This is frequently done whenever it is essential to save time; achieve a tremendous reduction in loss and damage of physical laboratory materials and equipment; as well as help to conserve inadequate and scarce laboratory materials.

Simulated laboratory experiments have been shown to enhance students' achievement in science. Kim (2007) found that 3D virtual reality simulated experiment significantly improved fifth-grade pupils' achievement in science more than the traditional 2D visuals. Geban, Askar and Özkan (2010) and Tüysüz (2010) observed more positive effects of computer-simulated experiments (CSE) on ninth-grade students' achievement in Chemistry than traditional teaching strategies. Huppert, Lomask and Lazarowitz (2010) concluded that simulated experiment produced significantly higher academic achievement of tenth-grade students in Biology than the "hands-on" experiment. Kelly, Bradley and Gratch (2008) reported a significant positive effect of simulated laboratory experiments on students' achievement in undergraduate Physics courses more than the traditional laboratory experiments. Bartholomew, Oyedepo and Yusuf (2011) found that simulated laboratory experiments improved the achievement of higher national diploma students in Electronic Engineering more than the "hands-on" laboratory experiments.

Research findings indicated that SL experiments as simulation mode of computer assisted/aided learning (CAL) could promote students' science process skills acquisition. Lazarowitz and Huppert (2014) found that computer-assisted learning (CAL) software improved the mastery of tenth-grade students' science process skills in Microbiology. Yang and Heh (2007) observed enhanced posttest mean score in science process skills of tenth-grade students in internet virtual Physics laboratory (IVPL). Leonard (2006) reported the effectiveness of an interactive computer/videodisc learning package at improving students' level of acquisition of science process skills in Biology. Furthermore, Saat (2004) found three stages involved in the development of science process skill (controlling variables) in a web-based learning environment: phases of recognition, familiarisation and automation.

The second mode of laboratory experiment is the enriched laboratory guide material (ELGM) experiment which could be used to reduce the challenges posed by the absence of guidelines for conducting Basic Science experiments in schools where there are functional Biology, Chemistry and Physics laboratories. The ELGM contains activities which will enable the students to explore in order to discover relationship(s) between experimental variables in a physical laboratory. This is in addition to the essential features of a laboratory guide/manual. A laboratory manual contains information carefully selected to familiarise learners with the aim, theory, materials needed (usually referred to as apparatus), experimental procedure, observations to be made, how to state the results, draw conclusions from the results and directions for students to follow in order to minimise potential equipment damage, time wasted, injury, and material wasted while maximising potentials for generating usable data (National Council of Education Research and Training, NCERT, 2014; Pyatt and Sims, 2007). It could be produced as hard copies or delivered in electronic form (Hofstein and Lunetta, 2004). The ELGM facilitates smooth and hitch-free conduct of experiments in science laboratories.

However, there was no laboratory guide material at the basic education level. Although, the NERDC Basic Science and Technology Curriculum (revised, 2012) suggests teacher's and students' activities as well as teaching and learning resources, it did not specify the experiment, identify its aim nor provide the procedure for conducting it. Thus, Basic Science teachers would have to make use of the contents of "Activity" suggested in Basic Science textbooks, especially the Science Teachers Association of Nigeria (STAN) Nigerian Basic Science Project Pupils' Textbook, in order to conduct experiment. Unfortunately, the activity did not identify the aim of the experiment nor follow the conventional organisational mode contained in the laboratory guide material. Consequently, most Basic Science teachers do not deem it fit to take students through many of the activities. They teach only the science contents with little lecture-demonstration type of experiment. Therefore, there is a dire need to design ELGM suitable for use in Basic Science classes. This is because it identifies the experiment, its aim and contains the experimental procedure that will make students to experience science through the conduct of such experiment. The ELGM presents Basic Science as a subject with two inseparable components (theory and practical) and thereby it extols the important roles of experimentation in generating the science contents (the products of science).

Literature revealed that the use of enriched laboratory guide material experiments could improve students' performance in science. Ertepinar and Geban (2006) observed that eighth-grade students exposed to investigative-oriented laboratory activities performed significantly better in science than those exposed to worksheet-oriented laboratory activities. Freedman (1998) found a significantly higher achievement of students in science for hands-on laboratory instruction than the conventional instructional strategy. Dechsri, Jones and Heikkinen (1998) observed that a Chemistry laboratory manual enriched with pictures or diagrams enhanced university students' achievement in general Chemistry course than the Chemistry laboratory manual without pictures or diagrams enrichment.

Research findings indicated that the use of enriched laboratory guide material experiments had improved acquisition of science process skills. Feyzioğlu (2009) observed a significant positive linear relationship between level of acquisition of six science process skills by Turkish University students and efficient use of Chemistry laboratory. Jeenthong, Ruenwongsa and Sriwattanarotha (2013) found that laboratory experiments enhanced learning of integrated science process skills among high school students. Chebii, Wachanga and Kiboss (2012) reported better Kenya students' acquisition of Chemistry practical skills using science process skills mastery learning approach than the conventional teaching strategy. However, Hirça (2013) reported no significant improvement in the level of acquisition of science process skills in hands-on laboratory experiments in Physics.

Furthermore, science educators have demonstrated that a combination of SL and ELGM experiments could be more effective in science teaching than either SL or ELGM experiments. Jaakkola and Nurmi (2008) observed that simulation-laboratory combination environment produced significantly greater learning gains in the conceptual understanding of simple electricity by elementary school students than the use of either simulation or laboratory activities alone. Zacharia (2007) found that the combination of Real Experimentation (RE) with Virtual Experimentation (VE) produced more conceptual understanding of electric circuits by the pre-service elementary school teachers (undergraduates) than either RE or VE. Olympiou and Zacharia (2012) concluded that a blended combination of Physical Manipulative (PM) and Virtual Manipulative (VM) enhanced undergraduates' conceptual understanding of "Light and Colour" in introductory Physics than either PM or VM alone.

Başer and Durmuş (2010) found that there was no significant difference in the conceptual understanding of Direct Current Electricity (DCE) in Physics displayed by pre-service elementary school teachers (undergraduates) taught in a Virtual Laboratory Environment (VLE) and Real Laboratory Environment (RLE). Chukwunenye (2014) observed that the use of online computer simulated experiments (CSE) improved significantly SSS students' achievement in Physics more than a combination of Computer Simulated Experiments and Hands-On Experiments (CSE+HOE) as well as the conventional Hands-On Experiments (HOE). Therefore, the literature reviewed reveal that most researches on the effectiveness of SL, ELGM and a combination of both modes of experiments were not conducted in Basic Science as they were performed among the senior secondary school, higher national diploma and university students.

In view of the role of cooperative learning in encouraging students learning from each other through group conduct of Basic Science experiments, the two modes of laboratory experiments were combined with learning together instructional strategy which is a family of cooperative learning. Hofstein and Lunetta (2004) submitted that productive cooperative learning interactions could be promoted among students in a school laboratory than the conventional classroom environment. Cooperative learning occurs when students acquire knowledge from experiences (personal and group) which they gained from performing learning tasks/activities with other students in small groups/teams of two to five in size. The strategy of cooperative learning was developed and recommended for use in American schools by James Coleman in 1959 with the intention to facilitate positive ethnic relation and discourage observed competition which hinders improvement in academic achievement in heterogeneous classrooms (Coleman, 1961). In 1981, cooperative learning was introduced to Australia by Joan Dalton, Julie Boyd, Sue Hill and Polly Eckert (Boyd, 2001). Cooperative learning has many instructional strategies. Examples of cooperative learning strategies are Student Team Learning (STL), Student-Teams-Achievement Division (STAD), Team-Games-Tournament (TGT), Cooperative Integrated Reading and Composition (CIRC), Peer-Assisted Learning Strategies (PALS), IMPROVE, Jigsaw, Learning Together (LT) and Group Investigation (GI) (Slavin, 1995).

Learning together instructional strategy, a family of cooperative learning, was developed in 1975 by David W. Johnson and Roger T. Johnson at the University of Minnesota (Bilesanmi-Awoderu and Oludipe, 2012). Its operation is guided by five principles: positive interdependence, face-to-face promotive interaction, individual accountability, social skills and group processing (Johnson and Johnson, 1991). According to Slavin (1995), learning together instructional strategy involves students working on learning task(s)/assignment(s) in heterogeneous groups of five; students having regular discussions within the groups about their progress and challenges on the task(s); students produce a common report for the group which they will present during class discussion; and students are assessed based on both individual performance within the group and the group report but they do not compete with one another within the groups.

Evidences abound in literature to show that learning together instructional strategy, a variant of cooperative learning, had improved teaching and learning of science, technology and Mathematics. Gokkurt, Dundar, Soylu and Akgun (2012) and Özsoy and Yildiz (2004) found that learning together strategy of cooperative learning is more effective than traditional teachers' expository strategy at improving Mathematics achievement of the ninth–grade and seventh-grade Turkish pupils respectively. Campbell (2013) concluded that learning together instructional strategy enhanced fifth–grade students' achievement in Physical Science more than the traditional strategy. Furthermore, Bilesanmi-Awoderu and Oludipe (2012) observed significant effects of learning together and jigsaw II strategies of cooperative learning on the immediate and delayed academic achievement of Ogun State junior secondary three (JSIII) students.

Bilgin (2006) found hands-on activities incorporating a cooperative learning approach to be more effective at improving the science process skills of eighth-grade students than the conventional approach. Also, Berge (2006) observed that cooperative learning using microcomputers with a file-management programme and structured activities promoted learning of science process skills by the seventh- and eighth-grades students. Okebukola and Ogunniyi (2006) reported that science laboratory experiments which were conducted using mixed ability group enhanced achievement and acquisition of practical skills by junior secondary class three students than those performed individually. Also, they recorded no significant difference in achievement and acquisition of practical skills between competitive and individualistic groups.

In this study, each student in the five-member experimental stand group was required to lead the conduct of experiments on light and electricity for one glancing angle and electromotive force (E.M.F.) of battery respectively. Each group member discussed his/her reading/measurement (one reading/measurement per member). All members in each group shared the readings/measurements to produce group report on the experiment.

Gender is one of the two moderator variables which were investigated in this study. Research findings were divergent on the influence of gender on achievement of males and females in science. Farooq, Chaundhry, Shafiq and Berhanu (2011) observed that girls performed significantly better than boys in English and Mathematics as well as in the overall achievement in the ninth-grade annual examination of secondary school students in Pakistan. Also, Mishra and Yadav (2013) reported that girls performed significantly better than boys in knowledge based of science when taught using activity based approach in India class VII high school.

On the other hand, Ige and Arowolo (2003) found that male students performed better than female students in junior secondary class three (JSIII) Integrated Science when they were taught using hypothetico-deductive and conventional approaches. Also, Okafor (2007) reported that male students were significantly better than female students in science achievement. However, several studies have shown that there was no significant gender difference in secondary school students' achievement of males and females exposed to CAI (Durowoju and Busari, 2012; Iravani and Delfechresh, 2011; Huppert, Lomask and Lazarowitz, 2010 and Murugan and Jaseena, 2010). Specifically, Yusuf and Afolabi (2010) found no significant gender difference in the achievement of private secondary schools' students in Biology in Oyo and Ibadan. Also, Oludipe (2012) reported gender parity in the achievement of JSIII students in Integrated Science (Energy and Force components) in Ogun State. Furthermore, literature reviewed indicated no gender difference in the level of acquisition of some science process skills except observing skills among the IXth-standard students (Raj and Devi, 2014) and tenth-grade students in Biology (Huppert, Lomask and Lazarowitz, 2010; Lazarowitz and Huppert, 2014). Therefore, there is need to determine achievement and level of acquisition of other science process skills by boys and girls in Basic Science.

The second moderator variable is future career interest in science. It is an expression of preference for a profession in science or related field which one intends to practice after formal schooling. It is usually influenced by gender-role stereotyping, informal science experience, future jobs expectation, absence of career talk and inadequate career information on science-related options, among others (White and Harrison, 2012; Wyss, Heulskamp and Siebert, 2012; Wang and Staver, 2010; Farenga and Joyce, 1999; Cooley, 1963). Future career interest in science has been found to significantly improve students' achievement in science (Adodo and Gbore, 2012; Park, Khan and Petrina, 2009; Osokoya, 2003). However, Odetoyinbo (2004) found no significant contribution of future career interest in science to JSIII students' achievement in Integrated Science in Oyo State.

Although, Wyss, Heulskamp and Siebert (2012) found no gender difference in the Science, Technology and Mathematics Education (STEM) career choices of middle school students who were provided with STEM career information using video interviews of STEM professionals; Farenga and Joyce (1999) observed that many students between ages 9 and 13 supported female participation in life science courses and male participation in physical science courses. Also, future career interest determined later enrolment in science-related disciplines in New York. Thus, Biology and related courses could be used to promote acquisition of science process skills in females whereas physical sciences (Chemistry and Physics) and related courses could enhance development of the skills in males. Therefore, there is need to determine the career interest and how it affects the achievement and acquisition of science process skills in Basic Science.

1.2 Statement of the problem

Basic Science is a core subject taught at the basic education level in order to lay foundation for future courses such as Biology, Chemistry and Physics in science related subjects. As a foundational subject, students are expected to be exposed to both theory and practical in the subject. However, reports have shown that students are not sufficiently exposed to Basic Science practical and when they are made to perform practical, ineffective strategy that do not allow them to be actively involved in and interact with peers is used. Previous studies focused on effective strategies of teaching Basic Science such as floor puzzle game, indigenous technology and hypothetico-deductive to the neglect of the effects of simulated laboratory and enriched laboratory guide material experiments. However, where there are no Basic Science laboratories, students do not seem to perform optimally in science especially at the senior secondary level. This study, therefore, determined the effects of simulated laboratory and enriched laboratory guide material experiments on students' achievement and acquisition of science process skills in Basic Science. Also, it examined the moderating effect of gender and students' future career interest in science on the dependent measures.

1.3 Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

H_0 1: There is no significant main effect of treatment on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

H_0 2: There is no significant main effect of gender on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

H_0 3: There is no significant main effect of future career interest in science on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

H_0 4: There is no significant interaction effect of treatment and gender on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

H_0 5: There is no significant interaction effect of treatment and future career interest in science on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

H_0 6: There is no significant interaction effect of gender and future career interest in science on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

H_0 7: There is no significant interaction effect of treatment, gender and future career interest in science on students'

(a) achievement in Basic Science;

(b) acquisition of science process skills in Basic Science.

1.4 Scope of the study

The study determined the effects of simulated and enriched laboratory guide material experiments on students' achievement and acquisition of science process skills in Basic Science. Also, the experiments were conducted on reflection of light as well as relationship between potential difference and electric current which are inherent in light and electrical energy under the sub-theme: "You and Energy" in the NERDC (revised, 2012) Basic Science and Technology curriculum. This study was carried out among the junior secondary three (JSIII) students in Oyo State, Nigeria.

1.5 Significance of the study

The findings of this study had shown that simulated and enriched laboratory guide material experiments improved students' achievement and acquisition of science process skills in Basic Science.

It is hoped that the results of this study would provide a justification for the curriculum planners to include the simulated and enriched laboratory guide material experiments in the Basic Science curriculum.

The findings of this study would serve as a basis for government and professional bodies like the Science Teachers' Association of Nigeria (STAN) to organize workshops, seminars and conferences on the importance and use of the simulated and enriched laboratory guide material experiments to teach Basic Science practical.

The study would provoke further researches in the methodologies of teaching and learning of Basic Science.

1.6 Operational definition of terms

Learning together instructional strategy: This involves participatory laboratory activities through which students are made to learn Basic Science by taking turns in groups of five to perform simulated laboratory and enriched laboratory guide material experiments in light and electrical energy.

Simulated laboratory experiment: An interactive virtual laboratory experiment recorded on a DVD and which is performed with the aid of a computer in order to determine new relationship(s) between experimental variables.

Enriched laboratory guide material: A sequential account of laboratory materials and activities which facilitate the conduct of hands-on laboratory experiment and lead the students to determine new relationship(s) between experimental variables.

Enriched laboratory guide material experiment: Hands-on experiment conducted in a physical laboratory using the Enriched Laboratory Guide Material.

Learning outcomes: Learner's achievement and acquisition of Basic Science process skills in class/laboratory activities in Basic Science.

Achievement in Basic Science: Scores obtained by the student in Achievement Test in Basic Science.

Science process skills: Learner's expertise for participating in the conduct of simulated or enriched laboratory guide material experiments as indicated on Science Process Skills Test in Basic Science score.

Future career interest in science: Learner's after school preferred profession as indicated on the Future Career Interest in Science Questionnaire. These are classified as science-related and non-science related.

CHAPTER TWO

LITERATURE REVIEW

This chapter contains reviews of educational theories, concepts and reports of empirical studies already carried out which are considered relevant to the study. The reviews are organised under the following headings and sub-headings:

2.1 Theoretical framework

2.1.1 Constructivist theory of learning

2.1.2 Experiential learning theory

2.2 Conceptual review of literature

2.2.1 Evolution of Basic Science in schools

2.2.2 Objectives of Basic Science

2.2.3 Laboratory experiments in science education

2.2.4 Learning together instructional strategy

2.2.5 Computer technology and Simulation

2.2.6 Software development

2.2.7 Science process skills

2.2.8 Factors affecting Future career interest in science

2.3 Empirical review of literature

2.3.1 Studies on teaching and learning of science

2.3.2 Learning together instructional strategy and Students' achievement in Basic Science

2.3.3 Learning together instructional strategy and Students' acquisition of Science process skills in Basic Science

2.3.4 Simulated laboratory experiments and Students' achievement in Basic Science

2.3.5 Simulated laboratory experiments and Students' acquisition of Science process skills in Basic Science

2.3.6 Enriched laboratory guide material experiments and Students' achievement in Basic Science

2.3.7 Enriched laboratory guide material experiments and Students' acquisition of Science process skills in Basic Science

2.3.8 Gender and Students' achievement in Basic Science

2.3.9 Gender and Students' acquisition of Science process skills in Basic Science

2.1 Theoretical framework

This study is anchored in Jerome Bruner's perspectives of constructivist learning theory and discovery learning, as well as David A. Kolb's experiential learning theory.

2.1.1 Constructivist theory and Discovery learning

According to Bruner (1966), learning occurs when a learner can construct new ideas or concepts (i.e. knowledge) using the knowledge existing in the cognitive structure. Cognitive structure means schema or mental models. A schema is the knowledge that a learner has acquired before, that is, prior knowledge. Bruner submitted further that constructing new knowledge by a learner is synonymous to categorising learning on the basis of the similarities or differences which they bear to the existing knowledge. Thus, learning is a process of adjusting one's mental model to accommodate new experiences or information. Bruner's constructivist theory emphasises the significance of categorisation in learning. It is the learner's cognitive structure that provides meaning (interpretation) and organisation (structure) to experience or information preparatory to transfer and application of learning to new situations. Bruner observed that to categorise implies to perceive, to conceptualize, to learn and to make decisions.

Bruner postulated three stages of intellectual development which determines the nature and extent of learning that may be relevant to a learner. These include enactive, iconic and symbolic stages. At the enactive stage, a learner is able to learn information and experiences emanating from activities which they perform and the outcomes of their actions on physical objects. The learner encodes/represents past events through motor responses. Although, this is the major form of learning associated with children (0-1years), it also exists in adults.

Iconic stage is a stage at which a learner could acquire information and experiences from both actions and consequences of actions the learner performs on physical objects as well as pictures and models of objects and situations. The learner then stores information and experiences visually in the form of images (a mental picture in the learner's mind's eye(s)). This form of learning is found with children (1-6years) and it also exists in adults. At the symbolic stage, a learner is able to use symbols (words/ language and mathematical symbols) to store or encode information or experience obtained through enactive, iconic or other forms. At this stage, the learner develops the capacity to think in abstract terms. It is the characteristic of people older than 6years.

Bruner's constructivist theory believes that any subject could be taught at any stage of development in a way that fits the child's cognitive abilities. He suggests that an instruction would be effective when it follows a progression from enactive (physical and hands-on activities) through iconic (pictorial and modeling) to symbolic (imaginations and designs) representations. Bruner (1966) therefore identifies the features of an effective instruction as one

(i) which relates to learner's predisposition (readiness) and facilitates the learner's interest towards learning;

(ii) whose contents are so structured that they could be easily grasped by the learner – spiral organisation of curriculum contents using themes (i.e. basic ideas);

(iii) whose contents are so sequentially presented to the learner that they facilitate extrapolation and/or fill in the gaps;

(iv) in which rewards and punishment are carefully selected and appropriately spaced to facilitate learning.

Constructivist teaching believes in the use of strategies that could guide a learner to discover principles, discuss, appreciate and verbalise the new knowledge. Bruner (1961) therefore recommends discovery learning – "learning by doing". It occurs whenever a learner is not provided with exact answer but rather the materials in order to find out the answer alone while the learner draws on the existing experience and prior knowledge. It is an instructional strategy through which learners interact with their environment by exploring and manipulating objects, wrestling with questions and controversies or performing experiments. According to Alfieri, Brooks, Aldrich and Tenebaum (2011), a discovery learning task can range from implicit pattern detection, to the elicitation of explanations and working through manuals to conducting simulations. Discovery learning strategy could be pure (self) or guided. In pure/self discovery learning strategy, the learner is given little or no assistance in an attempt to discover new content through conducting investigations or carrying out procedures. Guided (or enhanced) discovery learning strategy involves giving the learner some form of assistance which could only facilitate learning by asking the learner open-ended question(s) whenever need arises.

Bruner argues that pure/self discovery learning strategy enhances retention and promotes remembering of concepts and knowledge discovered by the learner than expository. However, the strategy have been found to be less effective because its learning may have errors, misconceptions or be confusing or frustrating to the learner (Alfieri, Brooks, Aldrich and Tenebaum, 2011; Kirschner, Sweller and Clark, 2006; Tuovinen and Sweller, 1999). This is because learners may not have the necessary skills to interpret the new information using their prior knowledge.

Kirschner, Sweller and Clark (2006) suggest guided discovery learning strategy as an alternative to pure/self discovery learning strategy. In their opinions, the strategy would produce more immediate recall of facts, long term transfer of learning and better problem-solving skills than pure/self discovery learning strategy. Also, Mayer (2004) observed that people learn better with guided discovery strategy in which the instructor imposes some structure on the task than with pure discovery strategy in which they are free to interact as they please. This position is further strengthened by one of the reasons adduced by the National Research Council (2000: 116) on the preference of guided discovery problems to expository approach. The Council believes that “the ability to apply knowledge to novel situations, that is, transfer of learning is affected by the degree to which students learn with understanding”.

Bruner’s ideas of constructivist theory and guided discovery learning strategy find relevance in the present study on the following grounds. First, learners are made to construct new knowledge from their personal and group past experiences which they acquired through their active participation in group conduct of SL and ELGM experiments in small groups/teams of five members. Second, learners are encouraged to discuss and verbalize their progress and challenges in the conduct of laboratory experiments within their various groups. Third, learners are taught basic concepts in reflection of light and electric circuits as building blocks (existing or prior knowledge) for the students to interpret the experimental results.

Fourth, the teacher demonstrated and drilled the students on how to conduct SL and ELGM experiments on the two topics.. These activities and their consequences form parts of their existing or prior knowledge needed to conduct further laboratory experiments. Fifth, the learners are made to use their existing or prior knowledge to set up and conduct SL or ELGM experiment in order to make observations or collect usable data. Sixth, learners are led to use their existing or prior knowledge to organise their data using tables and diagrams to obtain relationship(s) between experimental variables. These aid formation of mental pictures or images (pictorial modeling) by the learners. Seventh, learners are required to make generalisation(s) and prediction(s) about the experimental result(s). These are the features of symbolic stage on Bruner's stages of intellectual developmental.

2.1.2 Experiential learning theory

According to Kolb (1984:38), "Learning is the process whereby knowledge is created through the transformation of experience". Kolb believes that the information needed to bring about learning could be obtained from either concrete experience (CE) or abstract conceptualisation (AC) but not both simultaneously. Kolb submitted further that the information so acquired by the learner is usually processed through either reflective observation (RO) or active experimentation (AE) but not both at the same time. Thus, concrete experience-abstract conceptualisation axis forms the north-south axis of the perception continuum (learner's emotional response, or how learner thinks or feels about a task) while the reflective observation-active experimentation axis serves as the east-west axis of the processing continuum (how a learner approach a task). Kolb summarises the processes involved in the creation of knowledge through combinations of grasping and transforming experiences in a four-stage cyclic model of experiential learning as shown in fig. 2.1.

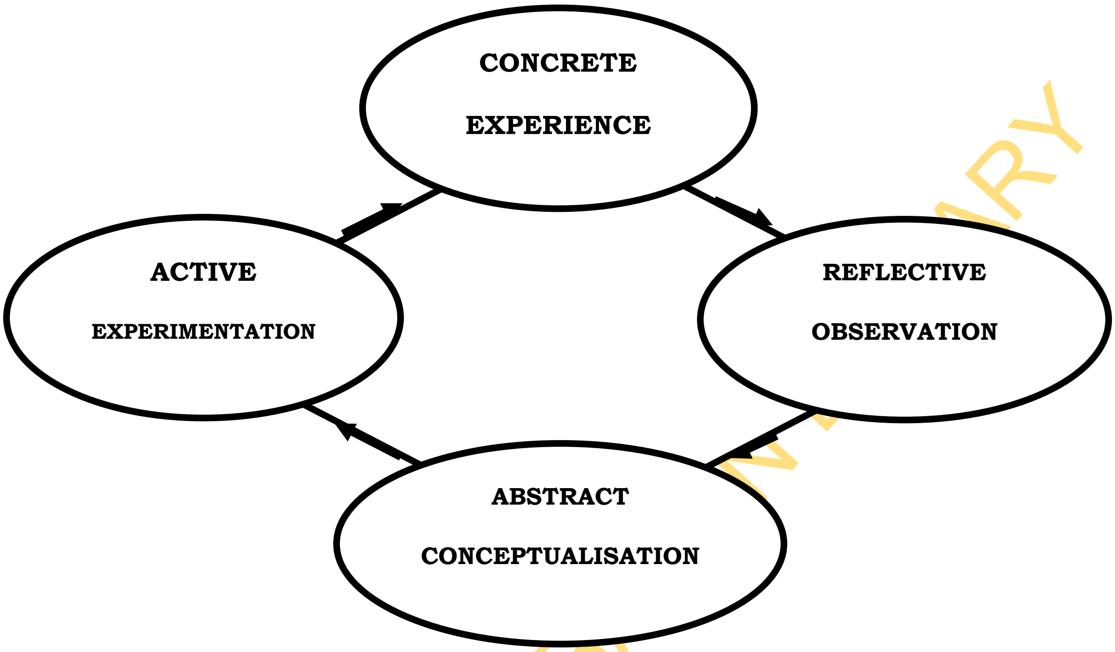


Fig. 2.1: Kolb's Experiential Learning Model

Source: Kolb, D.A. (1984). Experiential Learning: Experiences as the Source of Learning and Development. Eaglewood Cliffs, N.J.: Prentice-Hall, Inc. p.38.

Kolb explains further that the learner consciously reflects on the information gathered (most often to resolve inconsistencies between experiences and understanding) from concrete experiences (such as laboratory session or field work) in order to assimilate it and use it to form abstract concepts (new ideas arising from reflections on the concrete observation or a modification of an existing abstract concept). The concrete experience may be a new experience of situation encountered or a re-introduction of existing experience. The learner then uses the concepts to form theories or models of what have been observed. The learner plans how to test these theories or models; or plan for a forth-coming experience (active experimentation). During the course of testing theories or models, the learner collects information through experience. Thus, the learner repeats the four-stage model.

Kolb, however, cautioned that a learner could commence the process of experiential learning at any stage of the model depending on his/her learning style preference. The learner should ensure that he/she completes the stages logically in order to ensure that effective learning takes place. Kolb identified four different learning styles, each corresponding to a combination of two modes/stages of his four – stage experiential learning cycle. These include:

Assimilating Learning Style – An assimilator is one who thinks (Abstract Conceptualisation, AC) on whatever has been watched (Reflective Observation, RO). Assimilator's experiential learning cycle starts from RO progresses through AC and AE to CE. The assimilator is usually more attracted to logically sound theories than approaches based on practical value. An assimilator prefers readings, lectures, exploring analytical models and having time to think things through.

Converging Learning Style – A converger is one who thinks (Abstract Conceptualisation, AC) before taking action (Active Experimentation, AE). Converger experiential learning cycle commences from AC, moves through AE and CE to RO. The converger is usually attracted to finding practical uses for ideas and theories. A converger likes to experiment with ideas, to simulate and to work with practical applications.

Accommodating Learning Style – An accommodator is one who acts (Concrete Experience, CE) on information provided by other people. The accommodator does (Active Experimentation, AE) before feeling (Concrete Experience, CE). An accommodator's experiential learning cycle starts from AE progresses through CE and RO to AC. The accommodator is usually attracted to challenges and experiences, and to carrying out plans.

Diverging Learning Style – A diverger is one who views concrete situations (Concrete Experience, CE) from different perspectives and reflects (Reflective Observation, RO) on them. Diverger's experiential learning cycle commences from CE moves through RO and AC to AE. A diverger is attracted to solving problems through imaginations.

McLeod (2010) summarises the interplay between Kolb's experiential learning cycles and styles in a two-by-two form as shown in fig.2.2.

Continuum Processing →	**Doing (Active Experimentation-AE)**	**Watching (Reflective Observation-RO)**
Perception ↓		
Feeling (Concrete Experience-CE)	Accommodating (AE/CE)	Diverging (RO/CE)
Thinking (Abstract Conceptualisation-AC)	Converging (AE/AC)	Assimilating (RO/AC)

Fig. 2.2: A two-by-two matrix showing interplay between Kolb's Experiential Learning Cycles and Styles

The matrix (whose elements are contained in the parenthesis in fig. 2.2) shows that a learning style is a combination of two learning cycles.

Experiential teaching is anchored on the belief that people learn from experience which is a function of practice or hands-on activities and sometimes the consequences of actions performed on physical objects. This is the basis of discovery learning found in the simulated and enriched laboratory guide material experiments. However, Moon (2004) observes that experiential learning requires self- initiative, an intention to learn and active phase of learning. She argues that effective experiential learning involves a reflective learning phase; a phase of learning resulting from the actions inherent in experiential learning; and a further phase of learning from feedback. The learner should be allowed to reflect on their experience using analytical skills in order that they gain better understanding of the new knowledge and retain information for a longer time. Reflection could be facilitated or independent. Jacobson and Ruddy (2004) suggest a five question model which could be used by the facilitator/instructor to promote critical reflection in experiential learning. These include: Did you notice…? Why did that happen? Does that happen in life? Why does that happen? How can you use that? Thus, the facilitator/instructor is only responsible for providing the experiential stimulus. In the present study, the stimuli are the simulated laboratory and enriched laboratory guide material experiments.

According to Kolb's learning cycles and styles, people learn and develop in different ways and directions, if they could be given the chance or opportunity to do so. Thus, the facilitator/instructor should ensure that activities are designed and carried out in ways that offer each learner the chance/opportunity to be engaged in the manner that suits him best. Simulated laboratory and enriched laboratory guide material experiments offer the needed variations in approaches to conducting science experiments while ensuring cognitive (science contents), affective (scientific attitudes and ethics) and psychomotor (manipulative skills) development of the learner. Both modes of laboratory experiment draw on learner's abilities at each stage of experiential learning cycle and take the learner through the whole process in sequence. Therefore, experiential learning exists when a personally responsible participant cognitively, affectively and behaviourally processes knowledge, skills, and/or attitudes in a learning situation characterised by a high level of active involvement.

Experiential learning believes that experience is a structured and closely-monitored one such that positive aspects of learning are fostered and negative features are eliminated. These features are subsumed in simulated laboratory and enriched laboratory guide material experiments. They contained specific sequentially arranged activities garnished/spiced with formative and summative tasks that could lead the learner to discover novel relationships between experimental variables.

Kolb's experiential learning theory finds relevance in the present study because the use of simulated laboratory and enriched laboratory guide material experiments enables learners to create knowledge from taking turns to lead the conduct of the experiments and subsequent discussion, clarification and explanation of their performance in the group learning activities. Furthermore, learners create knowledge from the results of the simulated laboratory and enriched laboratory guide material experiments which they perform. They use computers and enriched laboratory guide material to conduct Basic Science experiments during which they generate usable data (Concrete Experience, CE), organize them using tables or diagrams (Reflective Observation, RO) to be able to obtain latent relationship(s) between experimental variables (Abstract Conceptualisation, AC) and generalise their results to similar situation(s) while collecting further data to test (Active Experimentation) their generalisation(s) and prediction(s).

2.2 Conceptual review of literature

2.2.1 Evolution of Basic Science in schools

Basic Science was originally one of the twelve (12) compulsory subjects in the upper basic education curriculum structure (NERDC, 2008a: 6). It replaces Integrated Science of the old junior secondary education curriculum (NERDC, 2008b: 5). However, it now exists as one of the four (4) components of the Basic Science and Technology in the curriculum for junior secondary education (FRN, 2013: 25). Basic Science and Technology is one of the ten (10) compulsory subjects in the basic education curriculum (NERDC, revised 2012: iv). According to Oludipe (2012: 93), Basic Science was introduced by Nigerian Government for the following reasons:

1. It provides students at the junior secondary school level a sound basis for continuing science education either in single science subjects or further integrated science.
2. It enhances the scientific literacy of the citizenry.
3. It allows students to understand their environment in its totality rather than in fragments.
4. It allows the students to have general view of the world of science.
5. The processes of science serve as unifying factor for the various science subjects. It is necessary for the learner to know these processes through integrated approach of learning science.

2.2.2 Objectives of Basic Science

The objectives of the Basic Science are subsumed in the objectives of Basic Science and Technology Curriculum for junior secondary school. The objectives of Basic Science and Technology Curriculum include: To enable the learner to

(a) develop interest in science and technology;
(b) acquire basic knowledge and skills in science and technology;
(c) apply their scientific and technological knowledge and skills to meet societal needs;
(d) take advantage of the numerous career opportunities offered by science and technology;
(e) become prepared for further studies in science and technology;
(f) avoid drug abuse and related vices; and
(g) be safety and security conscious.

(NERDC, revised, 2012: vi).

2.2.3 Laboratory experiments in science education

A laboratory could be viewed as a space with or without physical boundaries where apparatuses and equipment are kept and used to conduct inquiry into the general principles and laws existing in nature. As an open space without physical boundaries or limitations, it is also known as a field. Hornby (2010: 829) saw a laboratory as "a room or building used for scientific research, experiments, testing, etc". Thus, a science laboratory could be a physical structure with store(s) for keeping science equipment, fragile apparatuses and consumable materials (such as reagents or chemical substances, batteries, among others) as well as a space with work-benches/tables and stools for sitting during investigation into the latent properties or truths about nature. It has provisions for utility like electricity, water and gas supply systems to facilitate the conduct of science experiments under minimal stress. Adegoke (2005: 117) defines a laboratory as "an assembly of useful tools and materials that need careful manipulation". Also, a laboratory could be a virtual environment in which case experiments are simulated on the internet or intranet or even recorded on the Video Compact Disc (VCD). This is otherwise known as electronic laboratory or e-lab. An electronic laboratory consists of interactive computerized software linked with sensitive connector endings called sensors, where models of apparatus and equipment for conducting science experiments are integrated with computers as measuring instruments to collect and analyze data (Al-Shaiey, 2006).

Ogunbowale (2012) corroborates Bates (1988) on rationale for the use of laboratory in science as:

(i) The science subject-matter is highly complex and abstract; therefore, laboratory activities are intended to concretize teaching and learning of science subject-matter.

(ii) Students need to participate in enquiry to appreciate the spirit and methods of science; thus, laboratory experiments should transcend confirmation of existing laws and theories but discovery of novel relationships between experimental variables.

(iii) Practical work is intrinsically interesting to students; thus, it should be child-centred and full of activities.

Shaheen and Khattab (2005:206) identified the objectives of electronic laboratory in science as:

a. Update laboratory work and its applications to keep pace with technological advances.
b. Take advantage of computer in employing scientific and educational software in the educational process.
c. Compensate for the shortfall in some laboratory equipment through the use of ready-made computer software.
d. Help students to deeply understand scientific concepts.
e. Correct many of the misconceptions held by students about science and technology.
f. Develop students' positive attitudes towards the study of science and the use of technology.

A science laboratory ensures that students experience science through experimentation. An experiment is a planned inquiry conducted to obtain new facts or to confirm/refute (or deny) results of previously preformed enquiry (Ogunkunle, 2011). It integrates so many scientific processes or methods and thereby develops appropriate desirable skills in young scientists. Little wonder, Alao (2001) describes a laboratory as a factory for developing scientific skills and attitudes.

Science laboratory activities (experiments) have been defined by Hofstein and Lunetta (2004:31) as "learning experiences in which students interact with materials and/or with models to observe and understand the material world". Tobin (1990:405) identified laboratory activities "as a way of allowing students to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science". Thus, laboratory activities include "minds-on" as well as "hands-on". They could be carried out in a physical or virtual/simulated environment. Whereas a physical laboratory in science contains real apparatus, equipment and materials for conducting real experiments using laboratory guide materials, only simulated experiments could be carried out in a virtual laboratory.

Laboratory experiments are usually conducted following the provisions of a laboratory manual or guide. According to the National Council of Education Research and Training (NCERT, 2014), a laboratory manual in science contains information carefully selected to familiarize learners with the general facilities, equipment, measuring instruments, chemicals, glassware and specimen available in a school science laboratory. It also provides information to the learners on the aim, theory, materials needed and steps to be taken in order to carry out an assigned experiment. It guides the learners on the observations to be made, how to state the results and draw conclusions from the results. This is corroborated by Mishra and Yadav (2013) who observed that experiments are usually motivated by the teacher or textbook; the students either watch (as it is the case in demonstrational experiments) or follow instructions contained in the laboratory manual; they are told which particular observation to focus on, and the inference is also told to them. Thus, laboratory experiments are restricted to confirmation of the aim(s) of the experiment as expressed in the conclusion from the experiment.

However, scientific inquiry transcends confirmation of existing laws and theories but discovery of novel relationship(s) between experimental variables (Ogunbowale, 2012). This may lead to the discovery of unexplored avenues of interest and investigation in science (Bybee, 2000). Thus, laboratory experiments should include making prediction(s) from conclusion(s) and further activities through which the prediction(s) could be investigated. Such predictions are usually anchored by the theory of the experiment (Millar, Tiberghien and Marechal, 2002). These are the features of an enriched laboratory guide material experiment.

Laboratory experiments could be demonstrational while providing short-spanned (about 20minutes) learning experiences to a large group of students. They could last for several weeks while they are called project works providing learning experiences, on individual basis or in small groups, to students. They consist of individual and/ or group activity, teacher demonstration and sometimes, project work. They provide scientific experiences which promote science education goals including the enhancement of students' understanding of concepts in science and its applications; scientific practical skills and problem – solving abilities; scientific 'habit of mind'; understanding of how science and scientists work; interest and motivation (Hofstein and Mamlok-Naaman, 2007). According to the National Association of Biology Teachers (NABT, 2005), science laboratory experiment, as a form of scientific inquiry, develops the basic skills of questioning, prediction, qualitative and quantitative observation, classification, inference, communication, among others. Also, it develops such integrated skills as identifying and controlling variables, generating procedures, planning strategies for testing hypotheses and answering questions, for collecting and interpreting appropriate data. Thus, laboratory experiments are basically science laboratory activities.

Isa (2007:103) defines practical work as "any teaching and learning activity which involves at some point the students in observing or manipulating real objects and materials". Practical work then involves gathering of materials for an experiment, setting up the experiment and collecting data through observations. Science practical incorporates science laboratory activities especially science laboratory experiments.

Kerr (1963) identify the following aims of practical work in science.

1. To encourage accurate observation and careful reading.
2. To promote simple common-sense, scientific methods of thought.
3. To develop manipulative skills.
4. To give training in problem-solving.
5. To fit the requirements of practical examination regulations.
6. To elucidate the theoretical work so as to aid comprehension.
7. To verify facts and principles already taught.
8. To be an integral part of the process of finding facts by investigation and arriving at principles.
9. To arouse and maintain interest in the subject.
10. To make biological, chemical and physical (scientific) phenomena more real through actual experience.

Trowbridge and Bybee (1990) listed eight goals for practical work in science. These are:

1. To develop skills in problem-solving through identification of problems, collection and interpretation of data, and drawing conclusions.
2. To develop skills in manipulating laboratory apparatus.
3. To establish systematic habits of record keeping.
4. To develop scientific attitudes.
5. To learn scientific methods of solving problems.
6. To develop self-reliance and dependability.
7. To discover unexplored avenues of interest and investigation.
8. To promote enthusiasm for the subject of science.

Bajah (1984:45-46) suggested that assessment formats in science practical work should include the following aspects of science laboratory activities / experiments.

a. Individual Activity
i. Willing to share ideas with others.
ii. Active in setting up apparatus and prompt write up.
iii. Takes pains in collecting data and attends to details.
iv. Introduces new and relevant ideas.
v. Honesty in recording of observations.
vi. Safety for others.
b. Group Activity
i. Works willingly with others.
ii. Does not dominate the group.
iii. Allows others to use apparatus.
c. Teacher Demonstration
i. Attentiveness
ii. Willingness to participate.
iii. Writes up promptly.
d. Project Work
i. Scientific methods used.
ii. Advancement in science.
iii. Ingenuity of construction.
iv. Originality.
v. Science relevance.
e. Psychomotor
i. Use of specific equipment.
ii. Ability to use apparatus.
iii. Care of apparatus.

The laboratory is a medium for instruction in science teaching and learning. It provides students with opportunities to engage in processes of investigation and inquiry. Thus, it is an environment which facilitates learning by doing. Bybee (2000) opined that science laboratories have potential to facilitate the learning of science concepts, processes and skills. This corroborates some objectives of using laboratory work in science teaching and learning as identified by Bates (1988). The objectives include facilitating the teaching and learning of skills, concepts, attitudes, cognitive abilities and understanding the nature of science.

However, the students and the teacher are often pre-occupied with technical and manipulative details rather than devoting their time and energy to meaningful, conceptually driven inquiry (Hofstein and Lunetta, 2004). Meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concepts (Tobin, 1990). Thus, students should be given sufficient time and opportunities for interaction with laboratory materials and equipment as well as reflect on (i.e. interpret) the data generated and collected.

Ogunkunle (2011:48) opined that successful conduct of a typical science laboratory experiment depends on the ability of a scientist to

i. identify problem situation(s);
ii. state the problem succinctly;
iii. formulate hypotheses;
iv. design the experiment;
v. plan the experiment;
vi. source the materials needed for the conduct of the experiment;
vii. organise the materials;
viii. uses the materials to collect relevant and adequate data;
ix. execute correctly the experimental procedures;
x. identify necessary precautions;
xi. take the precautions before, during and after the experiment in order to achieve good results;
xii. control extraneous variables;
xiii. organise the results of observation;
xiv. analyse the results of observation;
xv. interpret the results of observation;
xvi. discern relationships which exist between information obtained on adequately identified and controlled experimental variables;
xvii. draw correct and adequate inferences from the results of observation.

2.2.4 Learning together instructional strategy

Cooperative learning occurs when students/learners acquire knowledge from epxperiences which they gathered from performing learning activities/tasks with other students/learners in small groups/teams. It is a process in which students learn by working in small groups and helping each other's learning for the attainment of a common aim (Özsoy and Yildiz, 2004). It consists of instructional strategies which require the teacher to organise learners into small heterogeneous (mixed ability) groups/teams in order to perform a learning task and ensure that every member learn both from their individual and group/team experiences (http://www2.ed.gov/pubs/OR/ConsumerGuides/cooplearn.html). Slavin (1994) defines cooperative learning as instructional programmes in which students work in small groups to help one another master academic content.

Cooperative learning was developed and recommended for use in American schools by James Coleman in 1959 with the intention to facilitate positive ethnic relation and discourage observed competition which militates against increase in academic achievement in heterogeneous classrooms (Coleman, 1961). In 1981, cooperative learning was introduced to Australia by Joan Dalton, Julie Boyd, Sue Hill and Polly Eckert (Boyd, 2001). Cooperative learning has many instructional strategies. Examples of cooperative learning strategies are Student Team Learning (STL), Student-Teams-Achievement Division (STAD), Team-Games-Tournament (TGT), Cooperative Integrated Reading and Composition (CIRC), Peer-Assisted Learning Strategies (PALS), IMPROVE, Jigsaw, Learning Together (LT) and Group Investigation (GI) (Slavin, 1995).

Learning together (LT) instructional strategy, a family of cooperative learning, was developed in 1975 by David W. Johnson and Roger T. Johnson at the University of Minnesota (Bilesanmi-Awoderu and Oludipe, 2012). Johnson and Johnson (1991) identified five principles which underline effective use of learning together instructional strategy in a classroom situation. These include:

1. Positive Interdependence: setting group goals and ensuring full participation of all members in the group assignment through division of labour.
2. Face-to-Face Promotive Interaction: ensuring that students discuss, clarify and explain the content and procedures involved in the learning activities as well as critique one another's ideas and performance and provide appropriate feedback, scaffold/support, assistance and encouragement to members of their group.
3. Individual Accountability: ensuring that each student is held accountable for the performance of his/her assigned task(s) and learning as well as for assisting the whole group meet the learning goals.
4. Social Skills: establishing the development and use of effective communication, leadership, decision-making through compromise and negotiation, trust-building, friendship-development, conflict- and time-management.
5. Group Processing: ensuring that students reflect on which member actions were helpful and make decision about which actions to continue or change.

According to Slavin (1995), learning together instructional strategy involves students

1. working on learning task/assignment in heterogeneous groups of five members each;
2. having regular discussions within groups about how well they are working together;

3. during discussion, if students ask the teacher question, the teacher will refer such students to their groups to find answer;
4. after the group discussion, the group produce and submit a common report; and
5. receive praise and rewards based on the group report (scores are based on both individual performance and the success of the group, but individuals do not compete with one another).

In this study, each student in the five-member experimental stand group was required to lead the conduct of experiments on light and electricity for one glancing angle and E.M.F. of battery respectively. Each group member discussed his/her reading/measurement (one reading/measurement per member). All members of the group shared the readings /measurements to produce group report of the experiment conducted.

2.2.5 Computer technology and Simulation

Computer technology is "the technology of using computer and all its resources to process data and the information from one place to another" (Akanbi, 2005:56). It utilizes the principles and operations of communication technology. It had been found useful in data logging, graphical representation of data, creating CD-ROM databases, data analysis, high quality desktop publishing and promotion of links through worldwide web between scholars across the globe (Olawepo, 2001). Akanbi identified three areas of computer technology which are valuable in science teaching and learning. These are Computer-Based Instruction (CBI), Computer-Aided/Assisted Design (CAD) and Information Technology (IT). Some strategies of CBI which are commonly used to enhance the quality of teaching and learning in science and technology education are Computer-Assisted (or Aided) Instruction/Learning (CAI/CAL), Computer-Managed Instruction/Learning (CMI/CML) and Computer-Assisted (or Aided) Testing (CAT) (Ajewole, 2005b; Akanbi, 2005; Olawepo, 2001).

CAI/CAL is an automated instructional strategy in which the teacher packages instructional contents, on a given topic in the curriculum, sequentially in an instructional software (known as courseware) so that a computer is used to present the instruction to the learner in an interactive manner (Durowoju and Busari, 2012; Ogunwale and Akintoye, 2005; Ojeme and Umendu, 2004). The courseware contains learner-paced activities prepared with different colours using graphics mixed with sound. It incorporates diagnostic assessment which ascertain the initial competence level (in terms of the theoretical background knowledge relevant to the experiment which the learner is about to perform) of the learner in order to guide the learner to start learning at such a point that is appropriate to his/her entering behaviour. Also, it provides formative assessment at every stage of the instruction in order to enable the learners to take different learning routes and finish at different times. Akanbi and Adagunodo (2003) identified some features of a well- designed courseware to include: elements that motivate the learner, specified what is to be learned, prompt the learner to call or apply previous knowledge, provide new information, offer guidance and feedback, test comprehension and supply enriched remediation as well as accommodate individual learning style. According to Ajani and Konku (2012) and Onasoga (2012), a computer assisted programme is a computer software/application in which information that aids teaching and learning as well as encourages interaction is presented on computers in the form of tests or multimedia formats which include photographs, videos, animations, speech and music. CAI/CAL programmes could be used by either the teachers to supplement conventional instructional strategy or students independent of their teachers.

Ogunwale and Akintoye (2005:162) catalogue the following benefits which may accrue from using CAI/CAL: It allows for

a. learners' controlled instruction;
b. prompt feedback to the learner;
c. self-pacing instruction/learning;
d. adaptability of instruction to learner's entering behaviour;
e. random access facilities and facilities for revising and updating.

The following modes of CAI/CAL had been identified in literature: Tutorial, Discovery, Drill and Practice, Games, Simulation, Modelling, Information Handling, Problem Analysis and Dialogue (Ajewole, 2005a; Akanbi, 2005; Ogunwale and Akintoye, 2005; Olawepo, 2001).

Simulation as a mode of CAL entails students/learners working with a scale-down approximation of real life situation. It offers realistic practice without the expenses or hazards that would have been involved in real life. It provides interactive learning experience electronically by combining the principles and operations of simulator technology with ease of use and precision of video game industry (http://eonrealityblog.wordpress.com/terminology/simulationbasedlearningdefinition.htm).

According to McGraw-Hill Encyclopedia of Science and Technology (2002:507), simulation essentially consists of four processes and these are:

a. formulate (build) a valid model of a real world system;
b. develop operational scenarios of interest (from the real-world) that exercise the model;
c. analyze the output of these scenarios;
d. translate and project the model outputs back to real-world system.

Simulation software contains a model of a real-world system created for the purpose of studying certain dynamics and characteristics of the system. Akinsanya (2012) gave examples of software packages which are available for running computer-based simulation modelling as Monte Carlo simulation, Stochastic modelling, Multi-method modelling among others. According to McGraw-Hill Encyclopedia of Science and Technology (2002:507), the followings are some of the rationale for using simulations.

1. To predict outcomes of investigations.
2. To predict reliable solutions to most real-world systems whose operations are more stochastic and dynamic especially when analytical solutions seem either not feasible or impractical.
3. It gives room for multiple runs of the model under different conditions and therefore opportunity abounds to examine the variability of outcomes in addition to the average outcomes.
4. Simulation analysis promotes total solutions to challenges in systems operations.
5. It can bring together expertise, knowledge and information about a system and its operations.
6. It can be a very cost effective tool, especially in the design of new systems.

Most instructional and learning aids are static models wherein all data, relationships and variables were assumed to remain fairly constant over a given time period or planning horizon. On the other hand, simulation uses dynamic models wherein all data, relationships and variables are either in motion or constantly changing. Simulation models, thus, permit tracing through in time the dynamics and behaviour implicitly induced by the model's probabilistic and causal structure (Austin and Burns, 1985). Real objects like human beings, animals, automobiles, among others, could be used to simulate teaching and learning activities. However, computer-based simulation of complex, dangerous, expensive and time-consuming situations or systems variables' interactions is gradually replacing role playing by concrete/real objects in simulated learning.

Akanbi (2005) reported that computer-based simulation is one of the five modes of Computer Aided/Assisted Learning (CAL) identified by Aremu (2002). It is a scale-down approximation of real life situation which allows students' realistic practice without incurring the expenses or experience hazards that would have been involved in real life situation. Other modes of CAL are Tutorial, Discovery, Drill and Practice, and Gaming modes (Aremu, 2002 cited in Akanbi, 2005). Shelly, Cashman, Gunter and Gunter (2006) defined an educational computer simulation or a video game as a computerized model of real life that represents a physical or simulated process. These programs are unique because the user can cause things to happen, change the conditions, and make decisions based on the criteria provided to simulate real-life situations.

Computer-based simulation facilitates electronic learning through the internet, intranet, electronic storage devices such as CD-ROM, DVD, tapes (audio and video), interactive television, among others (Bates, 2005; Ogunleye, Oke and Adeoye, 2007). They are usually packaged as either stand-alone application packages or through the internet or intranet. According to Saka (2005), stand-alone applications are computer programmes that run without connection to electronic transmission. They are available on floppy disks, CD-ROM disks and laser disk with accompany disks. In stand-alone applications, many programmes have been designed for teaching and learning process.

Akanbi (2005) opined that simulation mode of Computer Assisted/Aided Learning (CAL) finds application in the area of laboratory experiments. This is because computer-based simulations are interactive programs which offer learners the opportunity to manipulate variables that affect the outcomes of their experience (Shelly, Cashman, Gunter and Gunter, 2006). Thus, simulated laboratory experiments could be regarded as applications of CAL in science practical classes/lessons. Whereas many Computer Assisted Instruction/Learning packages are available in the market in form of CD-ROM as Tutors and Tutorials on Biology, Chemistry, Physics, Mathematics and even Computer Science, simulations of laboratory experiments in form of CD-ROM are not common in the market especially in respect of Basic Science. However, customized in-house software could be developed for teaching and learning of Basic Science. It was achieved for conducting experiments on light electrical energy in this study.

2.2.6 Software development

The software package on simulated laboratory experiments predominantly benefits from Adobe Complete Suite (CS6). Images are mainly created fresh as vectors in Fireworks. This is the case for laboratory table, paper and mirror with holder. There are few instances of Bitmaps, like real pictures of drawing board, drawing pins and optical pins; bitmap images (pictures) are edited in Fireworks before being imported into Adobe Flash. Some of the images are sourced online and appropriate credit is given on credit page. Illustrator is alternative software for developing exportable vector images. Corel draw can edit and produce bitmap images, and also create vector images but it is limited in exporting vector formats. The digitally simulated laboratory experiment is a professional development of application which is made possible by the simultaneous use of various Adobe Creative Suites (CS) applications which are used for graphic development, computer animation, and application software development programs.

Adobe Creative Suite

Adobe Creative Suite (CS) is a software suite of graphic design, video editing, application development and web development applications developed by Adobe Systems. Each edition consists several Adobe applications, such as Photoshop, Acrobat, In Design, Premiere Pro or After Effects, Flash Professionals, Fireworks among others. The last version, Adobe Creative Suite 6 (CS6), was launched at a release event on April 23, 2012, and released on May 7, 2012. (*http://en.wikipedia.org/wiki/Adobe_Creative_Suite*)

In order to facilitate the perfection of the digitally simulated laboratory experiment, the following Adobe creative suite programs were used in its development: Adobe Fireworks; Adobe Flash Professional; Adobe Audition; and Adobe After Effect.

Adobe Fireworks

Adobe Fireworks (formerly Macromedia Fireworks) is a discontinued bitmap and vector graphics editor, which Adobe acquired in 2005. It was originally developed using parts of Macromedia xRes. Fireworks is made for web designers to rapidly creating website prototypes and application interfaces. Its features include slices and the ability to add hotspots. It is designed to integrate with other Adobe products such as Adobe Dreamweaver and Adobe Flash. It is available as either a standalone product or bundled with Adobe Creative Suite. Previous versions were bundled with Macromedia Studio.

On May 6, 2013, Adobe announced that Fireworks would be phased out, citing the increasing overlap in functionality with its other products such as Adobe Photoshop, Adobe Illustrator, and Adobe Edge. Adobe will continue to provide security updates and perhaps bug fixes for the current version of Fireworks, but does not plan to add any new features beyond what is in Fireworks CS6. (*http://en.wikipedia.org/wiki/Adobe_Fireworks*)

Adobe Flash Professional

It is a multimedia authoring and computer animation program developed by Adobe Systems. (*http://en.wikipedia.org/wiki/Adobe_Flash_Professional*). It was first released in 1996 as FutureSplash Animator and re-christened Macromedia Flash upon its acquisition by Macromedia. It was created to serve as the main authoring environment for the Adobe Flash platform, a vector-based platform for the creation of animated and interactive content.

Adobe Flash Professional is the successor of a software product known as FutureSplash Animator, a vector graphics and vector animations program released in May 1996. FutureSplash Animator was developed by FutureWave Software, a small software company whose first product, SmartSketch, was a vector-based drawing program for pen-based computers. In December 1996, Macromedia bought FutureWave, re-branded it and released FutureSplash Animator as Macromedia Flash v1.0. Adobe Systems acquired Macromedia in 2005. The move came as part of an effort to disassociate the program from Adobe Flash Player. Also, acknowledging its increased use for authoring HTML5 and video content, it was an effort to begin discouraging the use of Flash Player in favor of web standards-based solutions (*http://en.wikipedia.org/wiki/Adobe_Flash_Professional*).

Flash Professional is primarily used to design vector graphics, animation, and publish the same for websites, web applications, rich internet applications, and video games. The program also offers support for raster graphics, rich text, audio and video embedding, and Action Scriptscripting. Content may be published for Flash Player, Adobe AIR and more recently, HTML5, WebGL and spritesheets. (*http://en.wikipedia.org/wiki/Adobe_Flash_Professional*)

In this case, it was used to create vector images such as arrows, wire, movable mirror, pins, paper, drawing boards, plug, bulb, among others.

User interface

Fireworks' user interface is consistent with the rest of Adobe Creative Suite, similar to that of Adobe Photoshop. On Mac OS X, it is possible to display the application in multiple document interface mode or the standard viewing mode where all toolbars float freely on the screen. All the layers can be accessed from the Layers panel. Layers may be wider or taller than the image itself. However, the final image is produced by hiding those areas that exit image boundary.

Fireworks supports *guides* are horizontal or vertical lines that act like a real-world ruler to help drawing, content placement and image composition. A user may place one or more guides on the image at any time and use it as a visual aid. For instance, a guide is useful when a piece of text must be placed in line with another graphical item. Additionally, the user may enable the *snap* feature of the Fireworks, which causes objects (pieces of image, text or layers) drag to the vicinity of a guide to snap to it. (*http://en.wikipedia.org/wiki/Adobe_Fireworks*)

Adobe Audition

Adobe Audition (formerly Cool Edit Pro) is a digital audio workstation from Adobe Systems featuring both a multi-track, non-destructive mix/edit environment and a destructive-approach waveform editing view (*http://en.wikipedia.org/wiki/Adobe_Audition*). Syntrillium Software was founded in the early 1990s by Robert Ellison and David Johnston, both former Microsoft employees. Originally developed by Syntrillium as Cool Edit, the program was distributed as crippleware for Windows computers. The full version was useful and flexible, particularly for its time. Syntrillium later released Cool Edit Pro, which added the capability to work with multiple tracks, as well as other features.

Audio processing, however, was done in a destructive manner (at the time most computers were not powerful enough in terms of processor performance and memory capacity to perform non-destructive operations in real time). Cool Edit Pro v2 added support for real-time non-destructive processing. v2.1 added support for surround sound mixing and unlimited simultaneous tracks (up to the limit imposed by the actual computer hardware). Cool Edit also included plug-ins such as noise reduction and FFT equalization. (*http://en.wikipedia.org/wiki/Adobe_Audition*).

Adobe Audition was used to create background audio tracks for the digitally simulated laboratory experiments and to control sound effects and click sounds for the program.

Adobe After Effect

Adobe After Effects is a digital visual effects, motion graphics, and compositing application developed by Adobe Systems and used in the post-production process of filmmaking and television production. Among other things, After Effects can be used for keying, tracking, rotoscoping, compositing and animation. It also functions as a very basic non-linear editor, audio editor and media transcoder. (*http://en.wikipedia.org/wiki/Adobe_After_Effect*). Adobe After Effects is software primarily used for creating motion graphics and visual effects. It allows users to animate, edit, and compose media in 2D or 3D space with many different built-in tools and third party plug-ins which can be downloaded from the Internet depending on what type of plug-in the user is looking for. It also provides individual attention to variables like parallax and also user adjustable angles of observation. (*http://en.wikipedia.org/wiki/Adobe_After_Effect*).

Each individual media object like video clips, still images, audio clips among others runs on its own. In contrast, other Non-Linear Editing Systems use a system where individual media objects can occupy the same track as long as they do not overlap at the same time. This track-oriented system is more suitable for editing and can keep project files more simple. (*http://en.wikipedia.org/wiki/Adobe_After_Effect*). In this case Adobe After Effect (CS6) was used to create introductory graphic animation clip and transitional graphic effects in the developed software.

Finally, the package is available in Web based flash format (swf - shock wave format) and executable flash (.exe). This is because these flash-formats readily run on all desktops or laptops (system / browser).

2.2.7 Science process skills

Science Process Skills (SPS) are expertise needed by a scientist in order to effectively carry out scientific activities. They are the processing strategies which scientists bring to bear in solving problems (Champagne and Klopfer, 1981). Blough and Schwartz (1974) identified the dual role of science as problem-seeking and problem-solving. Thus, SPS are the ingenuity of a scientist which is called to play during the conduct of scientific enquiries. They are the fundamental capabilities (the rational and logical thinking skills) utilized in science (Esomonu and Onunkwo, 2004). They are the generalisable intellectual abilities/skills needed to learn the concepts and broad principles used in making inductive inferences; the underlying capabilities needed to practice and understand science (Gagné, 1965). They are appropriate to many science disciplines and reflective of true behaviour of scientists (Okeke, Akusoba and Okafor, 2004). They have potentials to increase students' achievement and scientific creativities (Aktamiş and Ergin, 2008).

The American Association for the Advancement of Science (AAAS) identified fourteen process skills (Livermore, 1964; Young, 1974) which are representative of scientific activities as described by the processes/methods of science. Ogunniyi (1986) described processes of science as what scientists do. In the Curriculum project, Science – A Process Approach (SAPA), the SPS are grouped into two types: Basic and Integrated SPS. The Basic (simple) SPS provide a foundation for learning the Integrated (more complex) SPS (Padilla, 1990). This is because the Integrated SPS make higher cognitive demands than the Basic SPS (Adey and Harley, 1986). According to Özgelen (2012), Basic SPS consist of observing, using space/time relationships, inferring, measuring, communicating, classifying and predicting while Integrated SPS include controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, formulating models and presenting information.

2.2.8. Factors affecting Future career interest in science

Blair, Jones and Simpson (1968) defined interest as a "feeling of like or dislike towards an activity". Also, it is a response by an individual which expresses his/her like/dislike or preference for and to participate in an event, activity or situation (Njoku, 2003). This position corroborated Dewey (1913) view that interest is an activity in which self and objects are unified under clear ends. According to Dewey, a person is genuinely interested in an object or idea only when the person perceives worthwhile goal(s)/end(s) in the object or idea; initiates activity which could help the person to attain the goal(s)/end(s); and becomes committed to the self-initiated activity until the goal(s)/end(s) is achieved. Thus, a child develops intellectual interest (interest in an academic subject) only when the child finds the activities in the subject interesting (Bae, 2015). There could be a spectrum of interests shown by an individual usually on a table of relative preference for persons, objects, events, situations or activities. Therefore, developing students' interest (intellectual interest) in science involves developing students' genuine interest in its activities which is inquiry through conduct of laboratory experiments.

Essuman (1986) cited in Njoku (2003) identified four types of interest, namely:

1. Expressed interest – is the verbal declaration of like or dislike or indifference in an object or activity.
2. Manifest interest – involves professing of interest in an activity and going ahead to participate in that activity.
3. Tested interest – refers to interest as measured by objective test which elicit the nature of interest possessed by the testee.
4. Inventoried interest – refers to an individual's performance on a large number of activities listed in an interest inventory.

One of the aims of practical work (laboratory activities) in science is to arouse and maintain interest in the subject (Kerr, 1963). Also, Trowbridge and Bybee (1990) identified promotion of enthusiasm (interest) for science as one of the goals for engaging students in practical work in science. These were corroborated by Ogunbowale (2012) view that practical work is intrinsically interesting to students as one of the rationale for the use of laboratory in science. Joju (2003:28) submitted that "Laboratory exercises offer both activity-oriented instruction type and medium for mutual students-teacher physical interactions". These fascinate and arouse students' interest in laboratory activities and science as a field of study. Consequently, students become regular and actively involved in the laboratory activities.

A career encompasses all the roles a person play during his/her lifetime. These include education, training, equipment, family, leisure activities and volunteer work among others (http://www.education.vic.gov.au/school/students/beyond/pages/what is a career?). The preference for activities in which one intends to be engaged in future especially with respect to science and science-related courses (future career interest in science) may be influenced by some of the following factors: gender-role stereotyping, informal science experience (Farenga and Joyce, 1999); future jobs expectation, job demands on science literacy (Wang and Staver, 2010); parental and family attitudes to science, teaching strategy, work experience and direct contact with those working in a particular industry, absence of career talk and inadequate career information on science-related options, family socio-economic status (Cooley, 1963; White and Harrison, 2012; Wyss, Heulskamp and Siebert, 2012).

The quality and type of background science experiences could affect students' future career interest in science. Bulunuz and Jarrett (2010) identified students' active participation in science clubs; regular interaction with classroom plants, pets and items in the classroom science museum as well as using basic science kits, apparatus and equipment to perform basic science experiments as some of the ways by which students could acquire formal/school science experiences. Also, they opined that background science experiences could be acquired informally through students' involvement in non-school science activities such as visits to science museums, nature centres, zoos, and aquaria. Furthermore, Farenga and Joyce (1999) submitted that informal science-related experiences could be provided to children at home through books, television programmes, zoos, museums, hobbies, clubs, web sites, and family vacations. Bulunuz and Jarrett observed that memories of elementary school science as well as quantity and importance of informal science experiences were responsible for the difference between pre-service elementary teachers' interest in science in the U.S.A. Also, Farenga and Joyce found that future science course selections of students in the 4th, 5th and 6th grades who were between the ages of 9 and 13 resemble later enrollment data of master's and doctoral candidates in New York.

Gender-role stereotyping and masculine image of science and technology education were identified as factors affecting students' interest in science. Njoku (2007:26) defines sex role stereotyping as "the socio-cultural classification of human activities by sex in line with what the society considers as appropriate for one sex or the other." Njoku noted that "the arbitrary arrogation of roles to either of the sexes has given rise to the masculine image of science and technology" (p.26). Thus, "males are helped to dominate science and technology activities both at school and professional levels while females experience formidable obstacles and conflicts in their efforts to participate in science and technology activities at both school and professional level" (Njoku and Okeke, 2003:127). "At the school level, females experience a lot of discouraging conditions that deter them from enjoying and achieving well in science and technology subjects" (Njoku, 2007:26). These led to observed low interest and aspiration, poor participation and under achievement of females in science and technology (Okeke, 1990 and Obianyo, 2000). Farenga and Joyce (1999) observed that gender-role stereotyping have adverse effects on females' selection of science courses. Specifically, they investigated the perception of grades 4,5 and 6 (between ages 9 and 13) students in New York who were exposed to a laboratory-based science programme as part of their regular classroom instruction and found that both boys and girls perceived physical science and technology-related courses appropriate subjects for boys and life sciences as appropriate subjects for girls.

Teaching strategy as a factor which could affect students' interests in science was captured by Opara and Elekalachi (2007) when they reported Jenkins (1997) as having observed that girls' interest in science and technology education increases when these can be related to their own concerns and priorities. They submitted that the application of indigenous technology in science teaching makes it more meaningful and thereby captivates the interest of boys and girls in the learning process. Alake (2007:15) opined that "the use of game stimulates student interest, enhances student participation, enhances creativity, curiosity and understanding, expands time of study, reduces and replaces boredom in the classroom giving room for continuity even at home." She then investigated the effect of Floor Puzzle Game (FPG) and gender on NCE Part I students' achievement in integrated science. She observed gradual development of students' interest in Integrated Science through the use of floor puzzle game. Also, Wyss, Heulskamp and Siebert (2012) found that the use of video interviews of professionals in science and science-related careers to provide accurate information about Science, Technology, Engineering and Mathematics (STEM) careers enhanced the desire and ability of sixth and eighth grade students in U.S. to pursue STEM careers.

Njoku (2003) isolated two factors which could affect students' interest in O' level Practical Chemistry activities. He noted that anticipated/expected reward(s) could arouse students' interest to take action or participate in activities which could make the students to earn such reward(s). Also, he submitted that desire to satisfy perceived need(s) could arouse individual's interest to take action or participate in activities that would lead to the satisfaction of the needs.

Other factors which affect students' interest in science include: gender (Osokoya, 2003), perceived level of risks involved in an activity and expressed fear to succeed or fail on the assignment.

2.3 Empirical review of literature

2.3.1 Studies on teaching and learning of Basic Science

One of the measures identified in the National Policy on Education to accomplish the goals of education in Nigeria and gain from its contribution to the national economy is "to ensure that teaching shall be practical, activity-based, experiential and IT supported" (FRN, 2013:15). Danmaigoro (2005) identified the following as factors that promote effective teaching and learning of science in schools: on the part of teachers, a good knowledge of the subject-matter, understanding of basic principles of child's development, ability to employ different effective teaching strategies and ability to adapt teaching to local situations (needs and realities) as well as on the part of learners, development of positive attitude towards and interest in science. Other characteristics include creation of conducive learning environment wherein there are well-equipped science laboratories and facilities for improvisation; realistic science curricula which contents are not overloaded vis-à-vis allotted time as well as good funding of science activities by educational administrators.

Schroeder, Scott, Haung, Tolson and Lee (2007) opined that science achievement of learners is dependent on the strategy employed to present the subject-matter. They identified the following strategies as having impacted positively on learners' achievement in science. These include relating learning to students' previous experiences, collaborative learning, varying the level and type of questions asked during lessons, using inquiry-based approaches that allow for hands-on manipulation of science material, employing a variety of assessment methods, and incorporating instructional technology into lessons. Thus, effective teaching of science requires that all components of science - cognitive science (products of science), affective science (scientific attitudes and ethics of science) as well as manipulative science (processes/methods of science) – are presented in an intelligible and comprehensible manner to bring about all round development in learners' cognitive, affective and psychomotor domains. Therefore, a blend of classroom theoretical instructions (leading to acquisition of appropriate, relevant and correct science contents) with adequate laboratory practical training (which ensures that desirable scientific attitudes, ethics and process skills are inculcated in learners) would produce teaching effectiveness in science classes.

2.3.2 Learning together instructional strategy and Students' achievement in Basic Science

Evidences abound in literature to show that learning together instructional strategy of cooperative learning have improved teaching and learning of Science, Technology and Mathematics. Gokkurt, Dundar, Soylu and Akgun (2012) conducted an investigation on the effects of learning together instructional strategy on ninth-grade Turkish students' achievement in Mathematics. They reported a significant better achievement of the experimental group than the traditional instructional strategy group in the subject. This corroborated the earlier findings of Özsoy and Yildiz (2004) that learning together instructional strategy is more effective than traditional strategy in improving Mathematics achievement of the seventh-grade Turkish pupils.

Furthermore, Campbell (2013) doctoral dissertation at the Walden University on a 6-week quantitative causal-comparative study on the effects of using learning together instructional strategy and direct instruction on a convenience sample of 38 fifth-grade students' achievement in Physical Science revealed that the experimental group scored significantly higher than the control group. Also, Bilesanmi-Awoderu and Oludipe (2012) observed significant effects of learning together and jigsaw II strategies of cooperative learning on immediate and delayed academic achievement of Ogun State junior secondary III (JSIII) students in Basic Science.

2.3.3 Learning together instructional strategy and Students' acquisition of Science process skills in Basic Science

Literature reviewed indicated that although group size played no significant role in the use of microcomputers to learn science process skills, cooperative learning enhanced their mastery. Specifically, Berge (2006) observed that cooperative learning using microcomputers with a file-management programme and structured activities promoted learning of science process skills by the seventh- and eighth-grade students in Michigan. Also, Bilgin (2006) investigated the effects of hands-on activities incorporating a cooperative learning strategy on eighth-grade students' science process skills and observed a significant better performance on post science process skills test of the students in the experimental group than students taught using teacher demonstration strategy.

2.3.4 Simulated laboratory experiments and Students' achievement in Basic Science

Achievement in science had been bedeviled by paucity/inadequacy and absence of teaching and learning resources in science laboratories in most Nigerian schools at all levels of education (Ogunbowale, 2012; Taiwo, Adeniji, and Muazu, 2012; Enwereonye, 2011; Bamidele, 2004; Fagbemi, 2004;). Nnorom (2012) observed that there were no Basic Science laboratories or laboratory facilities for teaching Basic Science in Anambra State owned secondary schools. This corroborated the earlier findings of Eya and Elechi (2011) on the non-availability of Basic Science laboratory rather the available facilities were found in Biology, Chemistry and Physics laboratories. Furthermore, they all reported that the available facilities were not being used by the teachers to teach Basic Science. These findings confirm the outcome of a survey conducted by Oriade (2008) which expressed lack of laboratory facilities and appropriate skills by the teachers to teach Basic Science practical in Bauchi state. This led to an abysmal performance of students in science in both school and public examinations (Bajulaiye, 2005; Haastrup, 2005). Many scholars suggested improvisation of science laboratory materials and equipments as a way out of the non-functioning and non-availability of functional resources (Enwereonye, 2011; Bajah, 1983). However, this has serious implications for the reliability and validity of experimental results in science. Improvised materials are usually limited in accuracy and precision.

According to Akanbi (2005), facilities in remote computer laboratories online could be used to teach Science and Mathematics topics especially science practical for which apparatus and equipment are either obsolete, non-functional, inadequate vis-à-vis students' population or not available in our science (physical) laboratories. However, the use of computers and internet to teach and conduct scientific investigations had been limited by some of the challenges associated with teachers' utilization of modern information and communication technology (ICT) based instruction in Nigeria. These include:

1. Inadequate expertise and skilled manpower capable of operating the modern ICT facilities.
2. Inadequate modern ICT facilities like computers especially in public schools due to underfunding by government.

3. Where the computers are available, they may lack the right software for learning. Also, the computers may not be properly maintained due to lack of qualified technicians.
4. Erratic and unreliable power supply which makes the use of the modern ICT components in form of electronics like computers near impossible.
5. High level of poverty and low level of literacy among Nigerians which hinders the possession of modern ICT components like computers, internet services, television among others, by parents for use at home by their children as an extension of the school learning.
6. Limited internet connectivity between the Internet Service Provider (ISP) and the user at most locations within the country (Onasoga, 2012; Piwuna and Scholar, 2010).

Therefore, the use of online science laboratory to teach science practical could be supplemented and/or replaced by the use of stand-alone software/application packages of simulated laboratory equipments obtained as downloads from the internet or developed and produced/generated locally.

Simulated Laboratory (SL) experiments are application of Computer Assisted/Aided Instruction to conducting experiments in the laboratory. This reduces the challenges of non-functioning and availability of materials and equipment in the science laboratories. Thus, improve the level of participation of students during science lesson especially during the conduct of laboratory experiments.

Simulated laboratory experiments have been shown to improve students' achievement in science. Kim (2007) found that 3D virtual reality simulated experiment significantly improved the achievement in science of 41 fifth-grade students more than the traditional 2D visuals. Geban, Askar and Özkan (2010) observed greater achievement of ninth-grade students who were taught Chemistry using computer-simulated experiment (CSE) strategy than those exposed to the conventional strategy. Huppert, Lomask and Lazarowitz (2010) concluded that simulated experiment produced significantly higher academic achievement of high school students in Biology than the "hands-on" experiment. Tüysüz (2010) observed a positive effect of the use of 16virtual experiments on the achievement in Chemistry of 341 ninth-grade state schools' students in Turkey than traditional teaching strategy. Kelly, Bradley and Gratch (2008) reported a significant positive effect of simulated laboratory experiments on students' achievement in undergraduate Physics courses more than the traditional laboratory experiments. Bartholomew, Oyedepo and Yusuf (2011) found that simulated laboratory experiments improved the achievement of higher national diploma students in Electronic Engineering more than the “hands-on” laboratory experiments.

Science educators have indicated that a blend of simulated and enriched laboratory guide material experiments produced better achievement in science than the use of any of the two modes alone. Jaakkola and Nurmi (2008) found that simulation - laboratory (physical) combination environment produced significantly greater learning gains in the conceptual understanding of simple electricity by elementary school students than the use of either simulation or laboratory activities alone. Zacharia (2007) observed more conceptual understanding of electric circuits by the pre-service elementary school teachers (i.e. undergraduates) when exposed to a combination of Real Experimentation (RE) and Virtual Experimentation (VE) than either of the strategies. Olympiou and Zacharia (2012) concluded that a blended combination of Physical Manipulatives (PM) and Virtual Manipulatives (VM) enhanced undergraduate students’ conceptual understanding of “Light and Colour” in introductory Physics than either PM or VM alone.

However, some findings revealed no significant difference in achievement of students taught using simulated and enriched laboratory guide material experiments. Başer and Durmuş (2010) found no significant difference in the conceptual understanding of Direct Electric Current (DCE) in Physics for pre-service elementary school teachers (undergraduates) taught in a Virtual Laboratory Environment (VLE) and Real Laboratory Experiment (RLE). Bayrak, Kanli and Ignec (2007) reported no significant difference in achievement of ninth-grade students who were taught electric circuit using computer based learning and laboratory based learning strategies.

2.3.5 Simulated laboratory experiments and Students’ acquisition of Science process skills in Basic Science

Reports showed that simulated laboratory experiments promoted acquisition of science process skills of students at various levels of education across the globe. Lazarowitz and Huppert (2014) determined the impact of computer-assisted learning (CAL) used in classroom-laboratory instruction on tenth-grade students’ mastery of science process skills in microbiology and concluded that the students exposed to simulation software performed significantly better on three science process skills than the classroom-laboratory instruction group. The skills were graph communication, interpreting data and controlling variables. The result corroborates the earlier findings of Huppert, Lomask and Lazarowitz (2010). Yang and Heh (2007) observed that the use of Internet Virtual Physics Laboratory (IVPL) instruction produced significantly higher posttest mean score in science process skills in Physics among the tenth-grade students in Taiwan than the traditional laboratory instruction.

Saat (2004) investigated the process of acquiring an integrated science process skill of controlling variables by the fifth-grade children in a web-based learning environment and observed that the children acquired the skill in three phases starting from the phase of recognition, through the phase of familiarisation to the phase of automation. The researcher submitted further that the web-based instructional material must provide declarative knowledge, concrete visualisation and opportunities for practice in order to take the children through the three stages. Leonard (2006) compared the use of an interactive computer/videodisc learning package to the conventional laboratory approach to teach respiration and biogeography in undergraduate Biology. He found that although the use of interactive videodisc was statistically significant more time efficient than the use of conventional laboratory, there was no statistically significant difference between the two approaches for students' level of acquisition of science process skills.

2.3.6 Enriched laboratory guide material experiments and Students' achievement in Basic Science

Studies showed that enriched laboratory guide material experiments enhanced students' achievement in science. Ogunkola and Bilesanmi-Awoderu (2000) employed the non-randomized control group pretest – posttest quasi-experimental design with a 2x2x2 factorial matrix to investigate the effectiveness of laboratory-based and lecture strategies on students' achievement in Biology. They reported that students taught using laboratory-based strategy performed significantly more than those taught by lecture strategy. Ertepinar and Geban (2006) found that eighth-grade students exposed to investigative-oriented laboratory activities performed significantly better in science than those exposed to worksheet-oriented laboratory activities. Okebukola and Ogunniyi (2006) observed that science laboratory experiments which were conducted using mixed ability group enhanced achievement and acquisition of practical skills by junior secondary class three students than those performed individually. Also, they reported that there was no significant difference in achievement and acquisition of practical skills between competitive and individualistic groups.

Furthermore, Freedman (1998) found a significantly higher students' achievement in science for hands-on laboratory instruction than the conventional instructional strategy. Dechsri, Jones and Heikkinen (1998) observed that a Chemistry manual enriched with pictures or diagrams improved university students' achievement in general Chemistry course than the Chemistry laboratory without pictures or diagrams enrichment. Okeke (2012) reported a significant better achievement in Agricultural Science for JSII students of Onitsha North Local Government Educational zone of Anambra State exposed to laboratory experiment strategy than those taught without laboratory facilities.

2.3.7 Enriched laboratory guide material experiments and Students' acquisition of Science process skills in Basic Science

Science practical which essentially consists of performing experiments in and outside the laboratory focus on familiarising the learners with the basic tools and techniques used by scientists during investigations; as well as developing science process skills in the learners. The details of such activities are provided in a science laboratory manual or guide. However, there was no laboratory guide material at the basic education level. Although, the NERDC Basic Science and Technology curriculum (revised, 2012) suggests teacher's and students' activities as well as teaching and learning resources, it did not specify the experiment, identify its aim nor provide the procedure for conducting it. Thus, Basic Science teachers would have to make use of the contents of "Activity" suggested in Basic Science textbooks, especially the Science Teachers' Association of Nigeria Nigerian Basic Science Project Pupils' Textbook, in order to conduct experiment. Unfortunately, the activity did not identify the aim of the experiment nor follow the conventional organisational mode contained in the laboratory guide material.

Consequently, most Basic Science teachers do not deem it fit to take students through many of the activities. They teach only the science contents with little lecture-demonstration type of experiment. Therefore, there is a dire need to design ELGM suitable for use in Basic Science classes. This is because it identifies the experiment, its aim and contains the experimental procedure that will make students to experience science through the conduct of such experiment. ELGM presents Basic Science as a subject with two inseparable components (theory and practical) and thereby it extols the important roles of experimentation in generating the science contents (the products of science).

Literature had shown that ELGM experiments could enhance students' acquisition of science process skills. Feyzioğlu (2009) observed a significant positive linear relationship between six science process skills taught in a laboratory application and efficient laboratory use of newly admitted students in general Chemistry in Turkish university. These were skills used in the identification of problem; identification of variables and experiment design; observation, assessment, and data collection; classification; processing and visual representation of data obtained; interpretation and evaluation.

Jeenthong, Ruenwongsa and Sriwattanarotha (2013) found that laboratory experiments enhanced learning of Integrated Science process skills among Thailand high school students than the traditional lecture strategy. Bilgin (2006) investigated the effects of hands-on activities incorporating a cooperative learning strategy on eighth-grade students' science process skills and observed a significant better performance on post science process skill test of students in the experimental group than students taught using teacher demonstration strategy. Hirça (2013) found no significant improvement in the science process skills of prospective science and technology teachers exposed to hands-on laboratory experiments in Physics. The skills were observing, providing explanations, predicting, making an inquiry and forming logic.

2.3.8 Gender and Students' achievement in Basic Science

Research reports indicated divergent results on the influence of gender on males and females achievement in science. Nworgu (2005) observed that students who were taught science by gender sensitised science teachers performed significantly better than those taught by non-gender sensitised teachers. Instructional environments that utilise a variety of strategies and employ pedagogical strategies that address different learning styles have proved to encourage female achievement in science classrooms (Schroeder, Scott, Tolson, Haung and Lee, 2007).

Mishra and Yadav (2013) observed that girls performed significantly better than boys in the knowledge based items of science when taught using activity based strategy in India class VII high school. Farooq, Chaundhry, Shafiq and Berhanu (2011) undertook a t-test comparison of the academic performance of 300males and 300females in the ninth-grade annual examination (conducted by the Board of Intermediate and Secondary Education, Lahore) of secondary school students from different socio-economic and backgrounds in the metropolitan city of Pakistan. They observed that girls performed significantly better than boys in English and Mathematics as well as in the overall achievement scores. Nnadi (2002) reported that female students performed significantly better than their male counterparts in science.

Trends in International Mathematics and Science Study (TIMSS) reported that in 2007, males performed significantly higher than females overall in science, scoring higher in Biology, Physics, and Earth Science. Also, TIMMS showed no measurable difference in the average science scores of the U.S. eight-grade males and females in Chemistry. These reports corroborated the 1995, 1999 and 2003 TIMSS reports that males out performed females in science (Gonzales, Guzman, Partelow, Pahlke, Jocelyne, Kastberge, et. al., 2004). Okafor (2007) and Ige and Arowolo (2003) found that male students performed better than female students in science.

Several studies indicated no significant difference between achievement of males and females in science. Specifically, Huppert, Lomask and Lazarowitz (2010) found no gender difference in achievement of tenth-grade Biology students exposed to simulated experiment. Yusuf and Afolabi (2010) concluded that achievement in Biology of students in private secondary schools in Oyo town and Ibadan city, Nigeria who were taught using CAI was not sensitive to gender. Murugan and Jaseena (2010) reported no significant gender difference in achievement of secondary school students exposed to online CAI as a supplementing strategy in science. Iravani and Delfechresh (2011) observed no gender difference in achievement of eighth-standard students of higher primary school in Ahwaz city in Iran who were taught science subjects using CAI software package. Adigun and Zosu (2012) concluded that there was no significant difference between the mean performance of male and female junior secondary three (JSIII) students exposed to computer assisted instruction (CAI) in Basic Technology. Oludipe (2012) employed a quasi-experimental research design to investigate gender difference in science achievement among junior secondary three (JSIII) students in Ogun State, Nigeria using a jigsaw II cooperative learning strategy to teach energy and force in Integrated Science. It was discovered that there was no significant difference in the academic achievement of male and female students at the pretest, posttest and delayed posttest levels respectively. Durowoju and Busari (2012) used a quasi-experimental pretest-posttest control group design to investigate the effect of computer assisted instruction (CAI) and problem-solving instructional strategies on students' achievement in Integrated Science. They observed no significant difference in the achievement of 120 males and females randomly selected junior secondary II students of Ogun State in Integrated Science.

2.3.9 Gender and Students' acquisition of Science process skills in Basic Science

Literature reviewed revealed gender parity in the level of acquisition of most science process skills investigated by scholars. Huppert, Lomask and Lazarowitz (2010) observed no significant gender difference in the level of mastery of science process skills by tenth-grade students who were exposed to the computer simulated experiment on "The Growth Curve of Microorganisms" in Biology. Also, Lazarowitz and Huppert (2014) found no significant gender difference in the mastery of science process skills by tenth-grade students in Israel who were taught "The Growth Curve Microorganism" using computer simulation software in the classroom-laboratory instruction setting. However, Raj and Devi (2014) observed significant difference in the level of acquisition of observing skills by males and females. They reported further that IXth-standard students who were exposed to hands-on experiments in India schools did not differ significantly in their level of acquisition of the following process skills: measuring, classifying, inferring, predicting and communicating.

2.3.10 Future career interest in science and Achievement in Basic Science

One of the reasons adduced in literature for poor achievement of students in science is the nature of their future career interest in science (Adodo and Gbore, 2012). Although, Osokoya (2003) observed a statistically low positive correlation of 0.08 between career aspiration and students' achievement in Chemistry, students' belief that science subject will lead them into fulfillment of their life ambition could propel them to do well in the subject. Park, Khan and Petrina (2009) observed that future course selection and career aspirations related to science significantly improved students' achievement in science in a computer-assisted instruction in Korean K-12 curriculum. Odetoyinbo (2004) found a non-significant contribution of students' intended career to JSIII students' achievement in Integrated Science in Oyo State.

2.3.11 Future career interest in science and Students' acquisition of Science process skills in Basic Science

Future career interest in science is determined by future career prospect (Oloruntegbe and Aganga, 2001). Many students are ignorant of potential employment that uses science (jobs demands on science literacy and expected jobs in the future if they offer science subjects). Also, White and Harrison (2012) opined that many students in the United Kingdom schools generally enjoy their studies of science from a young age but are turned off as science gets more demanding compared with their other subjects. Thus, they see science as difficult and uncreative for developing transferrable skills such as technical competence, numeracy, analytical and problem-solving,

Farenga and Joyce (1999) observed that many students in grades 4, 5 and 6 who were between the ages of 9 and 13 prefer to study life sciences to physical sciences. Specifically, they reported that four out of five (80%) life science courses favoured female participation whereas all (100%) physical science courses favoured male participation. Therefore, Biology and related courses could promote acquisition of science process skills in females while physical sciences (Chemistry and Physics) and related courses could enhance acquisition of science process skills in males.

2.4 Appraisal of literature review

Laboratory experiment promotes peer-assisted learning, students' achievement and acquisition of science process skills. Science process skills are useful in everyday decision-making process and facilitate scientific discoveries and technological breakthroughs. The literature review indicated that the absence of Basic Science laboratory and laboratory guide material in most public schools as well as inadequate apparatus and equipment in Biology, Chemistry and Physics laboratories which could serve as viable alternatives reduced the students' opportunity to engage in the conduct of Basic Science practical. Reports showed that there is no known effort among science educators in Nigeria to provide alternative means of conducting Basic Science practical through the use of simulated and enriched laboratory guide material experiments. This present study developed stand-alone simulated laboratory experiments software and enriched laboratory guide material experiments in Basic Science.

Studies revealed that simulated and enriched laboratory guide material experiments had impact on students' achievement and acquisition of science process skills in other subjects/disciplines than Basic Science as they were performed among the senior secondary, higher national diploma and university students. The literature review indicated that productive cooperative learning interactions could be promoted among students in a school laboratory than in a conventional classroom environment. Specifically, learning together, a family of cooperative learning was reported by scholars to contribute to students' acquisition of the science process skills. Hence, the choice of learning together environment for the conduct of the simulated laboratory and enriched laboratory guide material experiments in this study.

Research findings showed that males performed better than females, females achieved more than males and no gender disparity in students' achievement in science. Hence, the divergent reports necessitated further research on gender effects on learning outcomes in Basic Science. The literature review revealed that future career interest in science could propel students to do well in the subject. Males show more interest in science than females. For students between ages 9 and 13, females prefer life science while males have affinity for studying physical science and their future career interest determined later enrolment in science-related disciplines. Basic Science is taught to students between ages 12 and 15 and this prompted the inclusion of future career interest in science subjects in the study.

CHAPTER THREE
METHODOLOGY

This chapter discusses research design, variables of the study, selection of participants and topics, research instruments, research procedure and methods of data analysis.

3.1 Research design

This study adopted the pretest-posttest control group quasi-experimental design with a 3x2x2 factorial matrix. The design is represented schematically as follows:

Experimental Group 1 (E_1) = O_1 X_1 O_2

Experimental Group 2 (E_2) = O_3 X_2 O_4

Control Group 3 (C) = O_5 X_3 O_6

Where

X_1 = Simulated laboratory experiments

X_2 = Enriched laboratory guide material experiments

X_3 = Conventional (expository) laboratory experiments

O_1, O_3 and O_5 = Pretest scores for the three groups respectively

O_2, O_4 and O_6 = Posttest scores for the three groups respectively

3.2 Variables of the study

The following are variables of the study:

A. Independent variable: This is instructional strategy manipulated at three levels:

i. Simulated Laboratory (SL) experiments

ii. Enriched Laboratory Guide Material (ELGM) experiments

iii. Conventional (Expository) Laboratory (CEL) experiments

B. Moderator Variables:

i. Gender: This is at two levels:

a. Male b. Female

ii. Future Career Interest in Science (FCISQ): This is at two levels:

a. Science-related b. Non-science related

C. Dependent Variables: These are learning outcomes namely:

i. Students' achievement in Basic Science

ii. Students' acquisition of Science process skills in Basic Science

The 3x2x2 factorial matrix of the research design is depicted in Table 3.1.

Table 3.1: 3x2x2 Factorial matrix

Treatment	Future career interest in science	Gender	
		Male	Female
Simulated laboratory experiments	Science-related		
	Non-science related		
Enriched laboratory guide material experiments	Science-related		
	Non-science related		
Conventional (expository) laboratory experiments	Science-related		
	Non-science related		

3.3 Selection of participants

Six public secondary schools were purposively selected for the study using the following criteria:

1. Availability of a functional Computer laboratory each. The National Science Teachers Association (NSTA, 1999) identifies functional Computer laboratory as one which has sufficient computers available for simultaneous use by groups of three or four students (http://www.nsta.org/about/positions/computers aspx).
2. Availability of a well-equipped Physics laboratory which could be used to perform Basic Science experiments on light and electrical energy.
3. Availability of conventional (expository) laboratory facilities for conducting Basic Science experiments in light and electrical energy.
4. All selected schools were co-educational.
5. All selected schools had not taught light and electrical energy to their students at the junior secondary level.
6. Two schools were not selected from the same Local Government Education Area.

One intact class of junior secondary three (JSIII) was randomly selected in each of the schools and assigned to experimental treatments such that two intact classes were used for each of the treatment groups. Therefore, a total of two hundred and seventy-seven students and six research assistants were involved in the study. The junior secondary class three was used because light and electrical energy have been planned for teaching in Basic Science in the class by the Nigerian Educational Research and Development Council (NERDC) since 2006 and reiterated in 2012.

3.4 Selection of topics taught

Experiments on reflection of light as well as relationship between potential difference and electric current were purposively selected for this study. Preliminary survey among Basic Science teachers in Oyo State have shown that light and electrical energy are among the perceived difficult topics of the NERDC Basic Science curriculum which are either not or poorly taught by the teachers. The two topics are under the theme: "You and Energy" in JSIII.

3.5 Research instruments

Seven instruments were used for the study. These are

1. Instructional Guide on Simulated Laboratory (IGSL) experiments.
2. Instructional Guide on Enriched Laboratory Guide Material (IGELGM) experiments.
3. Instructional Guide on Conventional (Expository) Laboratory (IGCEL) experiments.
4. Achievement Test in Basic Science (ATBS).
5. Science Process Skills Test in Basic Science (SPSTBS).
6. Future Career Interest in Science Questionnaire (FCISQ).
7. Research Assistants Training Evaluation Scale (RATES).

3.5.1 Instructional Guide on Simulated laboratory (IGSL) experiments

The IGSL experiments contain step by step instruction on the use of the Simulated Laboratory Experiments Software (SLES) to conduct laboratory experiments on reflection of light and relationship between potential difference and electric current. The steps fall into six stages: introduction, discussion of basic concepts relevant to each experiment, demonstration of the experiment by the facilitator (teacher), group performance of the experiment by the students, deduction of novel relationship(s) between experimental variables, and report writing.

The SLES is a stand-alone computer simulation which was used to perform virtual experiments on reflection of light as well as relationship between potential difference and electric current. The SLES was developed as a collaborative effort of the researcher, an architect and a software developer. Its copies are replicated on DVD as stand-alone software package in order to solve the challenge of internet connectivity usually associated with the use of online virtual experiments. Also, it was developed specifically for the conduct of Basic Science experiments at the basic education level.

The virtual experiment on reflection of light (experiment one) consists of main experiment (verification of the relationship between angles of incidence and reflection of light) and activity (which was carried out by the students to investigate and confirm their generalization). The virtual experiment on the relationship between potential difference and electric current (experiment two) consists of the main experiment (verification of relationship between potential difference and electric current for one resistor); activity I (which was conducted by the students to investigate and confirm the extension of the relationship to two resistors connected in series) and activity II (which was performed by the students to investigate and confirm the extension of the relationship to two resistors connected in parallel). The SLES was given to some lecturers in the educational technology unit of the Department of Teacher Education, University of Ibadan; some Basic Science teachers and some Computer Science teachers on the basic education programme in Oyo State to ascertain the adequacy and suitability of the SLES (content validity).

3.5.2 Instructional Guide on Enriched Laboratory Guide Material (IGELGM) experiments

The IGELGM experiments contain steps taken in the use of ELGM to conduct laboratory experiments on reflection of light and relationship between potential difference and electric current using physical laboratory apparatus. The steps fall into six stages: introduction, discussion of basic concepts relevant to each experiment, demonstration of the experiment by the facilitator (teacher), group performance of the experiment by the students, deduction of novel relationship(s) between experimental variables, and report writing.

3.5.3 Instructional Guide on Conventional (Expository) Laboratory (IGCEL) experiments

This guide shows the instructional strategy for the control group. Its procedural steps were grouped into five stages: introduction, discussion of basic concepts relevant to each experiment, demonstration of the experiment by the facilitator (the teacher), group performance of the experiment by the students and report writing.

3.5.4 Achievement Test in Basic Science (ATBS)

This is an achievement test which contains questions constructed by the researcher. The questions are of parallel standard to those constructed, validated and used for the conduct of the Basic Education Certificate Examination (BECE). The researcher developed the instrument because ATBS is based on theories of experiments conducted by the students whereas BECE contains topics in the NERDC Basic Science curriculum for junior secondary. It consists of 40 (20 items from each of light and electrical energy) multiple choice items, each item having four options: a, b, c, d. Each correct option is allotted one mark.

The achievement test sought information on the amount of theoretical knowledge acquired by the students in relation to light and electrical energy of JSIII section of the Nigerian Educational Research Development Council (NERDC, revised 2012) curriculum for Basic Science. The blue-print for the construction of ATBS was in accordance with Okpala, Onocha and Oyedeji (1987) in which the six levels of Bloom's taxonomy of educational objectives were reduced to three levels. The blue-print is contained in Table 3.2.

Table 3.2: Blue-print for Achievement Test in Basic Science (ATBS)

S/N	Science contents	Behavioural objectives			Total
		Remembering	Understanding	Thinking	
1	Reflection of Light	1,12,13,15,16, 17,18,19	2,3,4,5,6,7,8,9, 10	11,14,20	**20**
2	Electric Cell and electric Circuits	21,22,23,24,25, 26,27,28,29	33,34,36,37,38	30,31,32,35,39, 40	**20**
Total		**17**	**14**	**09**	**40**

The instrument was given to some lecturers in the Science education unit of the Department of Teacher Education, University of Ibadan, Ibadan and some practicing Basic Science teachers in order to establish its content validity, objectivity of its scoring key and clarity of its items. The instrument was administered to JSIII students who did not participate in the study. The reliability index of 0.87 was obtained using Kuder-Richardson formula 20 (KR-20).

3.5.5 Science Process Skills Test in Basic Science (SPSTBS)

This instrument was used to assess the level to which the students have acquired some science process skills during the conduct of Basic Science laboratory experiments. Science process skills test in Basic Science (SPSTBS) was adapted from Dillashav and Okey (1980) "A Test of the Integrated Science Process Skills for Secondary Science Students" with a reliability coefficient of 0.84 for the ninth-grade students in Boston. SPSTBS contains 21 multiple-choice items, each having four options: a, b, c, d. Each correct option is allotted one mark.

The instrument was designed to assess three basic science process skills and four integrated science process skills inherent in the conduct of experiments on reflection of light as well as relationship between potential difference and electric current. The distribution of items on SPSTBS is contained in Table 3.3.

Table 3.3: Items distribution on Science Process Skills Test in Basic Science (SPSTBS)

S/N	Experiments	Serial numbers of items							Total
		Basic skills			Integrated skills				
		A	B	C	D	E	F	G	
1.	Reflection of light	1,3	4,5	20	8,9, 10,11	12,13	16	18	**13**
2.	Relationship between potential difference and electric current	2	6,7	21	-	14,15	17	19	**08**
Total		**03**	**04**	**02**	**02**	**04**	**02**	**02**	**21**

A – Classifying; B – Measuring; C – Predicting;
D – Defining variables operationally; E – Identifying experimental variables;
F – Presenting information (Organising); G – Interpreting data (Describing relationships between variables)

The instrument was given to some lecturers in the Science education unit of the Department of Teacher Education, University of Ibadan, Ibadan and some practicing Basic Science teachers in order to establish its content validity, objectivity of its scoring key and clarity of its items. The instrument was administered to JSIII students who did not participate in the study. The reliability index of 0.72 was obtained using Kuder-Richardson formula 20 (KR-20).

3.5.6 Future Career Interest in Science Questionnaire (FCISQ)

This instrument was used to collect information on the type of profession / course of study learners hope to go into after schooling. It consists of two sections, A and B. Section A contains learners' personal data. Section B is a checklist of some professions, mostly with scientific inclination. The list was adapted from Osokoya

(2003) Student Career Aspiration (SCA) and guided by the 2015/2016 eBronchure of the Joint Admissions and Matriculation Board (JAMB). The instrument is a list of thirty-eight (38) professions/courses of study, from which the learner indicated the preferred future career. The validated FCISQ was administered to students in the sampled schools and this was interpreted as shown in Table 3.4 in order to classify student's future career interest as science-related or non-science related.

Table 3.4: Interpretation of students' responses on FCISQ

Future career inclination	**Profession/Course of study**	**Ordinary Level requirements for admission into Nigeria university (excluding English and Mathematics)**
Science-related	Medicine, Veterinary Medicine, Dentistry, Nursing, Pharmacy, Biochemistry, Science Laboratory Technology	All of Biology, Chemistry and Physics
	Agriculture, Microbiology, Food Science and Technology, Food Science, Food Technology, Petroleum Engineering, Chemical Engineering, Computer Engineering, Aeronautic Engineering, Mechanical Engineering, Automobile Engineering, Electrical Engineering, Electronic Engineering, Civil Engineering, Architecture, Building Construction, Building Technology, Computer Science	Any two of Biology, Chemistry and Physics as applicable to the course of study
	Teaching, Mathematics, Statistics	Any one of Biology, Chemistry and Physics as applicable to the course of study
Non-science related	Business/Trading, Salesmanship, Marketing, Accountancy, Banking and Finance, Business Administration, Economics, Law, Mass Communication, Theatre/Performing Art.	None of Biology, Chemistry and Physics

The instrument was given face-validity by some experts in the Faculty of Education, University of Ibadan. FCISQ was administered twice, to JSIII students who would not take part in this study, with a time lag of two weeks between the two administrations. The test-retest reliability index of 0.99 was obtained for the instrument using Cronbach's Alpha formula.

3.5.7 Research Assistants Training Evaluation Scale (RATES)

Six Basic Science teachers were trained as research assistants for this study. There was one research assistant in each of the six junior secondary schools selected for the study. Thus, two research assistants were trained on the use of instructional guide for each of the three strategies to conduct laboratory experiments on reflection of light as well as relationship between potential difference and electric current. Each research assistant was required to use the assigned strategy to conduct laboratory experiment and obtain data. The performance of each research assistant on the task was evaluated using appropriate/ relevant assessment sheets contained in the appendices XI, XII and XIII.

3.6 Research procedure

3.6.1 Visit to the sampled schools

The six junior secondary schools selected for the study were visited by the researcher with letter of introduction from the Department of Teacher Education, University of Ibadan, Ibadan. The researcher discussed the object of the study with the principal, Basic Science teacher and laboratory technician in the schools. Schools visitation lasted one week.

3.6.2 Training of participating Basic Science teachers and other research assistants

The researcher conducted training for participating Basic Science teachers and other research assistants (laboratory technicians) on the use of instruments appropriate to each secondary school based on the instructional strategy group to which each school belong. Two days were spent by the researcher in each of the six schools. Thus, a period of two weeks was spent on the training of the participating Basic Science teachers and other research assistants. The participating Basic Science teachers and other research assistants were requested to demonstrate the conduct of the two experiments using the appropriate instructional strategy. They were assessed by the researcher using the assessment sheet for evaluating research assistants as applicable to each of them.

3.6.3 Administration of pretest

Participating Basic Science teachers were given the following evaluation instruments to administer to participating students.

1. Achievement Test in Basic Science (ATBS).
2. Science Process Skills Test in Basic Science (SPSTBS)
3. Future Career Interest in Basic Science Questionnaire (FCISQ).

The FCISQ and the SPSTBS were administered before the ATBS. This was to prevent the influence of the test on the participating students' responses to FCISQ items and level of acquisition of science process skills. Pretest took a period of one week.

3.6.4 Treatment phase

For seven weeks, the experimental groups were exposed to the treatments while the control group was exposed to the conventional (expository) laboratory experiments by the trained participating Basic Science teachers and other research assistants. Table 3.5 below summarises the work plan for the research procedure.

Table 3.5: Summary of work plan for the research procedure

S/N	Activity	Duration/weeks
1.	Identification of sample and visit to the selected schools	1
2.	Training of participating Basic Science teachers and other research assistants (laboratory technicians/assistants)	2
3.	Administration of the pretest (FCISQ, SPSTBS and ATBS) to all the participants in the experimental and control groups.	1
4.	Treatment of the experimental groups with SL and ELGM experiments while the control group was exposed to CEL experiments.	7
5.	Administration of posttest (SPSTBS and ATBS) to all groups in the experimental and control groups.	1
Total		12

3.6.5 Procedure for presenting the strategies

The laboratory experiments were combined with learning together instructional strategy.

3.6.5.1 Experimental group 1

This group conducted experiments on reflection of light as well as relationship between potential difference and electric current using the following steps.

Step1: Teacher introduced the aim of the experiment.

Step2: Teacher revised basic concepts relevant to the experiment.

Step3: Teacher drilled the students on how to boot the personal computer (PC).

Step4: Teacher led the students to open the simulated laboratory experiments file on the PC and selected the experiments as required.

Step5: Teacher demonstrated how to conduct the simulated laboratory experiment to the students.

Step6: Students were grouped in fives and each group was assigned to a PC. Each member of the group performed the SL experiments for only one angle of incidence and only one E.M.F. value of the battery and took readings.

Step7: Students in each group used members' observations on their tables of readings.

Step8: Students discussed their readings in order to confirm the aim of the experiment.

Step9: Students made further deduction(s)/inference(s) from the experimental results.

Step10: Students jointly conducted further SL experiments involving a change of variables in order to investigate and verify their deduction(s)/inference(s).

Step11: Students discussed their findings within the group.

Step12: Students wrote individual report of the experiment.

3.6.5.2 Experimental group 2

This group conducted laboratory experiments on reflection of light as well as relationship between potential difference and electric current using the following steps.

Step1: Teacher introduced the aim of the experiment.

Step2: Teacher revised basic concepts relevant to the experiment.

Step3: Teacher demonstrated how to assemble the apparatus for the experiment.

Step4: Teacher led the students to identify the apparatus needed for the experiment.

Step5: Teacher led the students to assemble the apparatus for the experiment.

Step6: Teacher drilled the students on the experimental set-up (Ask the students to assemble the apparatus for the experiment).

Step7: Students were grouped in fives and each group was assigned to an experimental stand. Each member of the group followed the experimental procedures as contained in the enriched laboratory guide material to perform the experiment (collect data and tabulate readings) for only one angle of incidence and only one E.M.F. value of the battery.

Step8: Students in each group used members' observations on their tables of readings.

Step9: Students discussed their readings in order to verify the aim of the experiment.

Step10: Students made further deduction(s)/inference(s) from the experimental results.

Step11: Students jointly conducted further experiments involving a change of variables in order to investigate and verify their deduction(s)/inference(s).

Step11: Students discussed their findings within the group.

Step13: Students wrote individual report of the experiment.

3.6.5.3 Control group

This group conducted laboratory experiments on light as well as relationship between potential difference and electric current using the following steps.

Step1: Teacher introduced the aim of the experiment.

Step2: Teacher revised basic concepts relevant to the experiment.

Step3: Teacher demonstrated the experiment.

Step4: Teacher led the students to identify the apparatus needed for the experiment.

Step5: Teacher led the students to assemble the apparatus for the experiment.

Step6: Teacher drilled the students on the experimental set-up (Ask the students to assemble the apparatus for the experiment).

Step7: Students were grouped in fives and each group was assigned to an experimental stand. Each member of the group performed the experiment (collect data and tabulate readings) for only one angle of incidence and only one E.M.F. value of the battery.

Step8: Students in each group used members' observations on their tables of readings.

Step9: Students discussed their readings in order to verify the aim of the experiment.

Step10: Students wrote individual report of the experiment.

3.6.5.4 Administration of the posttest

At the end of the treatment period, the posttest was administered to all the groups (two experimental groups and one control group). The posttest instruments are ATBS and SPSTBS.

3.7 Method of data analysis

The data were analysed using analysis of covariance (ANCOVA) with the pretest scores as covariates to test the hypotheses. Analysis of covariance was used to bring out / identify the initial group differences. Also, estimated marginal means (EMM) were computed in order to detect differences between the pretest and posttest mean scores for different groups. Scheffé post-hoc analysis was employed to determine the direction of significance and to estimate the amount of variation as a result of the independent variable. All the hypotheses were tested at $p<.05$ level of significance.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results of data analysis as well as the discussion of findings. The data collected were subjected to analysis of covariance (ANCOVA) in order to test the hypotheses at 0.05 level of significance.

4.1 Testing the null hypotheses

4.1.1 H_0 1(a): There is no significant main effect of treatment on students' achievement in Basic Science.

Table 4.1: Summary of ANCOVA of posttest achievement scores in Basic Science by Treatment, Gender and Future career interest in science

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Corrected model	2582.488[a]	12	215.207	7.057	.000	.243
Intercept	60610.594	1	60610.594	1987.608	.000	.883
Pre-achievement	279.592	1	279.592	9.169	.003	.034
Main effect						
Treatment	1578.072	2	789.036	25.875	.000*	.164
Gender	.300	1	.300	.010	.921	.000
Future career interest in science	124.263	1	124.263	4.075	.045*	.015
2-way interaction						
Treatment x Gender	70.545	2	35.272	1.157	.316	.009
Treatment x Future career interest in science	63.858	2	31.929	1.047	.352	.008
Gender x Future career interest in science	5.230	1	5.230	.171	.679	.001
3-way interaction						
Treatment x Gender x Future career interest in science	3.360	2	1.680	.055	.946	.000
Residual (Error)	8050.479	264	30.494			
Total	157304.000	277				
Corrected total	10632.968	276				

a. R squared = .243 (Adjusted R squared = .208) *Significant at p<.05

Table 4.1 indicates that there was significant main effect of treatment on students' achievement in Basic Science ($F_{(2,264)}$=25.88, $p<.05$; partial η^2 =.164). This implies that the treatment had significant main effect on students' posttest mean achievement score in Basic Science and the effect size is 16.4%. Therefore, hypothesis 1(a) is rejected. In order to determine the posttest mean scores of the groups, the estimated marginal means were computed and these are presented in Table 4.2.

Table 4.2: Estimated marginal means of posttest achievement scores in Basic Science by Treatment groups

Group	N	Mean	Std. error	95% confidence interval	
				Lower bound	Upper bound
Treatment I(SL)	110	19.395[a]	.551	18.311	20.479
Treatment II(ELGM)	60	24.907[a]	.957	23.022	26.791
Treatment III(CONTROL/CEL)	107	24.771[a]	.614	23.562	25.981

a. Covariates appearing in the model are evaluated at pre-Achievement score= 3.4152

Table 4.2 shows that the enriched laboratory guide material experiment group obtained the highest posttest achievement mean score (24.91) in Basic Science followed by the control/conventional (expository) laboratory experiment group (24.77) and the simulated laboratory experiment group (19.40) respectively. This implies that students exposed to the enriched laboratory guide material experiment in Basic Science performed better than those exposed to the conventional (expository) laboratory experiment and simulated laboratory. Furthermore, the sources of the significant effect of treatment on achievement in Basic Science were traced using Scheffé post-hoc test as shown in Table 4.3.

Table 4.3: Scheffé post-hoc analysis of Treatment on students' achievement in Basic Science

Group	N	Mean	SL	ELGM	CONTROL /CEL
1. Treatment I (SL)	110	19.395		*	*
2. Treatment II (ELGM)	60	24.907	*		
3. Treatment III (CONTROL/CEL)	107	24.771	*		

*Pairs of groups significantly different at p<.05

Scheffé post-hoc test on Table 4.3 indicates that the posttest achievement mean score (19.40) of students exposed to SL was significantly different from the mean score (24.91) of those exposed to ELGM. Also, the posttest achievement mean score (19.40) of students in the SL group was significantly lower than the mean score (24.77) of the CEL. Thus, the significant differences of the treatment on students' achievement exist between pairs of SL and ELGM as well as SL and CEL. This implies that each of the ELGM and CEL is significantly more effective in enhancing students' achievement in Basic Science than SL.

H_0 1(b): There is no significant main effect of treatment on students' acquisition of science process skills in Basic Science.

Table 4.4: Summary of ANCOVA of posttest Science process skills' acquisition scores in Basic Science by Treatment, Gender and Future career interest in science

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Corrected model	536.236[a]	12	44.686	8.471	.000	.278
Intercept	9386.701	1	9386.701	1779.366	.000	.871
Pre-Science process skills	8.409	1	8.409	1.594	.208	.006
Main effect						
Treatment	269.151	2	134.576	25.510	.000*	.162
Gender	9.008	1	9.008	1.708	.192	.006
Future career interest in science	92.948	1	92.948	17.619	.000*	.063
2-way interaction						
Treatment x Gender	3.494	2	1.747	.331	.718	.003
Treatment x Future career interest in science	4.552	2	2.276	.431	.650	.003
Gender x Future career interest in science	.425	1	.425	.081	.777	.000
3-way interaction						
Treatment x Gender x Future career interest in science	10.277	2	5.138	.974	.379	.007
Residual (Error)	1392.680	264	5.275			
Total	58627.000	277				
Corrected total	1928.917	276				

a. R squared = .278 (Adjusted R squared = .245) *Significant at p<.05

The results presented in Table 4.4 show that there was a significant main effect of treatment on students' acquisition of science process skills in Basic Science ($F_{(2,264)}$=25.51, p<.05; partial η^2 = .162). This implies that the treatment had significant main effect on students' posttest science process skills score in Basic Science, with an effect size of 16.2%. Therefore, hypothesis 1(b) is rejected. In order to determine the posttest mean scores of the groups, the estimated marginal means were computed and these are presented in Table 4.5.

Table 4.5: Estimated marginal means of posttest Science process skills' acquisition scores in Basic Science by Treatment groups

Group	N	Mean	Std. error	95% confidence interval	
				Lower bound	Upper bound
Treatment I(SL)	110	15.001[a]	.233	14.542	15.461
Treatment II(ELGM)	60	14.656[a]	.391	13.885	15.427
Treatment III(CONTROL/CEL)	107	12.591[a]	.256	12.087	13.094

a. Covariates appearing in the model are evaluated at Pre-Science process skills' acquisition score= 5.8700

Results from Table 4.5 reveal that the simulated laboratory experiment group obtained the highest posttest mean score (15.00) followed by the enriched laboratory guide experiment (14.66) and the conventional (expository) laboratory experiment group (12.59) respectively. This implies that students exposed to simulated laboratory experiment in Basic Science acquired more science process skills than those exposed to enriched laboratory guide material and conventional (expository) experiments. Furthermore, the sources of the significant effect of treatment on science process skills' acquisition in Basic Science were traced using Scheffé post-hoc test as shown in Table 4.6.

Table 4.6: Scheffé post-hoc analysis of Treatment on students' Science process skills' acquisition in Basic Science

Group	N	Mean	SL	ELGM	CONTROL /CEL
1. Treatment I (SL)	110	15.001			*
2. Treatment II (ELGM)	60	14.656			*
3. Treatment III (CONTROL/CEL)	107	12.591	*	*	

*Pairs of groups significantly different at p<.05

Scheffé post-hoc test on Table 4.6 shows that the posttest science process skills' acquisition mean score (15.00) of the SL group was significantly different from the mean score (12.59) of the CEL group. Also, the posttest science process skills' acquisition mean score (14.66) of students in the ELGM group was significantly higher than the mean score (12.59) of the CEL. Thus, the significant differences of the treatment on students' science process skills' acquisition exist between pairs of SL and CEL as well as ELGM and CEL. This implies that each of the SL and ELGM is significantly more effective in enhancing students' acquisition of science process skills in Basic Science than CEL.

4.1.2 H_0 2(a): There is no significant main effect of gender on students' achievement in Basic Science.

Table 4.1 indicates that there was no significant main effect of gender on students' achievement in Basic Science ($F_{(1,264)}$=.010, p<.05). This implies that gender had no significant main effect on students' posttest achievement mean score in Basic Science. Therefore, hypothesis 2(a) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.7.

Table 4.7: Estimated marginal means of achievement scores in Basic Science by Gender

Group	N	Mean	Std. error	95% confidence interval	
				Lower bound	Upper bound
1. Male	130	23.066[a]	.651	21.785	24.347
2. Female	147	22.983[a]	.524	21.951	24.015

a. Covariates appearing in the model were evaluated at Pre-Science process skills' acquisition score= 3.4152

Table 4.7 shows that male students have higher posttest achievement mean score (23.07) than female students (22.98) in Basic Science..

H_0 2(b): There is no significant main effect of gender on students' acquisition of science process skills in Basic Science.

Table 4.4 reveals that there was no significant main effect of gender on students' acquisition of science process skills in Basic Science ($F_{(1,264)}$=1.71, p<.05). This implies that gender had no significant main effect on students' posttest acquisition of science process skills in Basic Science. Therefore, hypothesis 2(b) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.8.

Table 4.8: Estimated marginal means of posttest Science process skills' acquisition scores in Basic Science by Gender

Group	N	Mean	Std. error	95% confidence interval	
				Lower bound	Upper bound
1. Male	130	14.309[a]	.269	13.779	14.839
2. Female	147	13.856[a]	.218	13.427	14.286

a. Covariates appearing in the model were evaluated at Pre-Science process skills' acquisition score= 5.8700

Table 4.8 shows that male students have higher posttest science process skills' acquisition mean score (14.31) than female students (13.86).

4.1.3 H_0 3(a): There is no significant main effect of future career interest in science on students' achievement in Basic Science.

Table 4.1 reveals that there was a significant main effect of future career interest in science on students' achievement in Basic Science ($F_{(1,264)}=4.08$, $p<.05$; partial $\eta^2=.015$). This implies that the future career interest in science had a significant main effect on students' posttest achievement mean score in Basic Science, with an effect size of 1.5%. Therefore, hypothesis 3(a) is rejected. In order to determine how the groups performed, the Estimated Marginal Means were computed and these are presented in Table 4.9.

Table 4.9: Estimated marginal means of posttest achievement scores in Basic Science by Future career interest in science groups

Group	N	Mean	Std. error	95% confidence interval	
				Lower bound	Upper bound
1. Science-related	197	23.865[a]	.408	23.061	24.668
2. Non-science related	80	22.184[a]	.728	20.751	23.616

a. Covariates appearing in the model were evaluated at Pre-achievement score= 3.4152

Table 4.9 indicates that students with science-related future career interest in science group had higher posttest achievement mean score (23.87) in Basic Science than the non-science related group (22.18). This implies that students in the science-related future career interest in science group performed better than those in the non-science related group.

H_0 3(b): There is no significant main effect of future career interest in science on students' acquisition of science process skills in Basic Science.

Table 4.4 shows that there was a significant main effect of future career interest in science on students' acquisition of science process skills in Basic Science ($F_{(1,264)}$=17.62, $p<.05$; partial η^2 =.063). This implies that the future career interest in science had a significant main effect on students' acquisition of science process skills posttest mean score in Basic Science, with an effect size of 6.3%. Therefore, hypothesis 3(b) is rejected. In order to determine how the groups performed, the Estimated Marginal Means were computed and these are presented in Table 4.10.

Table 4.10: Estimated marginal means of posttest Science process skills' acquisition scores in Basic Science by Future career interest in science groups

Group	N	Mean	Std. error	95% confidence interval	
				Lower bound	Upper bound
1. Science-related	197	14.809[a]	.169	14.476	15.143
2. Non-science related	80	13.356[a]	.302	12.762	13.951

a. Covariates appearing in the model were evaluated at Pre-Science process skills' acquisition score= 5.8700

Table 4.10 reveals that students with science-related future career interest in science group had higher posttest science process skills acquisition mean score (14.81) in Basic Science than the non-science related group (13.36). This implies that students in the science-related future career interest in science group acquired more science process skills than those in the non-science related group.

4.1.4 H_0 4(a): There is no significant interaction effect of treatment and gender on students' achievement in Basic Science.

Table 4.1 indicates that there was no significant 2-way interaction effect of treatment and gender on students' achievement in Basic Science ($F_{(2,264)}$=1.16, $p<.05$). Therefore, hypothesis 4(a) is not rejected. In order to determine how the groups performed, the Estimated Marginal Means were computed and these are presented in Table 4.11.

Table 4.11: Estimated marginal means of posttest achievement scores in Basic Science by Treatment and Gender

Groups		N	Mean	Std. error	95% confidence interval	
Treatment	Gender				Lower bound	Upper bound
1. Treatment I (SL)	Male	57	19.959[a]	.787	18.410	21.509
	Female	53	18.830[a]	.771	17.313	20.347
2. Treatment II (ELGM)	Male	23	25.141[a]	1 .541	22.107	28.174
	Female	37	24.673[a]	1.109	22.490	26.856
3. Treatment III (CONTROL/CEL)	Male	50	24.097[a]	.915	22.295	25.899
	Female	57	25.446[a]	.817	23.837	27.055

a. Covariates appearing in the model are evaluated at Pre-achievement score= 3.4152

Table 4.11 reveals that male students had higher posttest achievement mean score in Basic Science (19.96 > 18.83 and 25.14 > 24.67) than female students for simulated laboratory experiment and enriched laboratory guide material experiment respectively. However, female students had higher posttest achievement mean score in Basic Science (25.45 > 24.10) than male students in conventional (expository) laboratory experiment group.

H_0 4(b): There is no significant interaction effect of treatment and gender on students' acquisition of science process skills in Basic Science.

Table 4.4 shows that there was no significant 2-way interaction effect of treatment and gender on students' acquisition of science process skills in Basic Science ($F_{(2,264)}$=.33, p<.05). Therefore, hypothesis 4(b) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.12.

Table 4.12: Estimated marginal means of posttest Science process skills scores in Basic Science by Treatment and Gender

Groups		N	Mean	Std. error	95% confidence interval	
Treatment	Gender				Lower bound	Upper bound
1. Treatment I (SL)	Male	57	15.342[a]	.327	14.697	15.986
	Female	53	14.661[a]	.330	14.011	15.311
2. Treatment II (ELGM)	Male	23	14.651[a]	.632	13.406	15.895
	Female	37	14.662[a]	.461	13.755	15.568
3. Treatment III (CONTROL/CEL)	Male	50	12.935[a]	.381	12.185	13.685
	Female	57	12.249[a]	.339	11.538	12.015

a. Covariates appearing in the model are evaluated at Pre-Science process skills' acquisition score = 5.8700.

Table 4.12 indicates that male students had higher posttest mean scores in science process skills' acquisition in Basic Science (15.34 > 14.66 and 12.94 > 12.25) than female students for simulated laboratory experiment and conventional (expository) laboratory experiment groups respectively. However, female students had higher posttest mean scores in science process skills' acquisition in Basic Science (14.66 > 14.65) than male students in the enriched laboratory guide experiment group.

4.1.5 H_0 5(a): There is no significant interaction effect of treatment and future career interest in science on students' achievement in Basic Science.

Table 4.1 indicates that there was no significant 2-way interaction effect of treatment and future career interest in science on students' achievement in Basic Science ($F_{(2,264)}$=1.05, p<.05). Therefore, hypothesis 5(a) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.13.

Table 4.13: Estimated marginal means of posttest achievement scores in Basic Science by Treatment and Future career interest in science groups

Groups		n	Mean	Std. error	95% confidence interval	
Treatment	Future career interest in science				Lower bound	Upper bound
1. Treatment I (SL)	Science-related	70	20.996[a]	.665	19.687	22.304
	Non-science related	40	17.794[a]	.879	16.063	19.525
2. Treatment II (ELGM)	Science-related	48	25.116[a]	.829	23.484	26.749
	Non-science related	12	24.697[a]	1.706	21.339	28.056
3. Treatment III (CONTROL/CEL)	Science-related	79	25.482[a]	.628	24.244	26.719
	Non-science related	28	24.061[a]	1.055	21.985	26.137

a. Covariates appearing in the model are evaluated at Pre-achievement score= 3.4152

Table 4.13 reveals that students with science-related future career interest in science had higher posttest achievement mean scores in Basic Science (21.00 > 17.79; 25.12 > 24.70 and 25.48 > 24.06) than those with non-science related future career interest in science for simulated, enriched laboratory guide material and conventional (expository) laboratory experiment groups respectively.

H_0 5(b): There is no significant interaction effect of treatment and future career interest in science on students' acquisition of science process skills in Basic Science.

Table 4.4 shows that there was no significant 2-way interaction effect of treatment and future career interest in science on students' acquisition of science process skills in Basic Science ($F_{(2,264)}$=.43, p<.05). Therefore, hypothesis 5(b) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.14.

Table 4.14: Estimated marginal means of posttest Science process skills scores in Basic Science by Treatment and Future career interest in science groups

Groups		**N**	**Mean**	**Std. error**	**95% confidence interval**	
Treatment	**Future career interest in science**				**Lower bound**	**Upper bound**
1. Treatment I (SL)	Science-related	70	15.897[a]	.278	15.349	16.444
	Non-science related	40	14.106[a]	.370	13.378	14.834
2. Treatment II (ELGM)	Science-related	48	15.131[a]	.339	14.463	15.799
	Non-science related	12	14.181[a]	.705	12.793	15.568
3. Treatment III (CONTROL/CEL)	Science-related	79	13.400[a]	.261	12.887	13.913
	Non-science related	28	11.782[a]	.439	10.918	12.137

a. Covariates appearing in the model are evaluated at Pre-Science process skills' acquisition score = 5.8700.

Table 4.14 indicates that students with science-related future career interest in science had higher posttest mean scores in science process skills' acquisition in Basic Science (15.90 > 14.11; 15.13 > 14.18 and 13.40 > 11.78) than those with non-science related future career interest in science for simulated laboratory, enriched laboratory guide material and conventional (expository) laboratory experiment groups respectively.

4.1.6 H_0 6(a): There is no significant interaction effect of gender and future career interest in science on students' achievement in Basic Science.

Table 4.1 indicates that there was no significant 2-way interaction effect of gender and future career interest in science on students' achievement in Basic Science ($F_{(1,264)}$=1.17, p<.05). Therefore, hypothesis 6(a) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.15.

Table 4.15: Estimated marginal means of posttest achievement scores in Basic Science by Gender and Future career interest in science

Groups		N	Mean	Std. error	95% confidence interval	
Future career interest in science	**Gender**				**Lower bound**	**Upper bound**
1. Science-related	Male	96	23.732[a]	.606	22.538	24.926
	Female	101	23.997[a]	.559	22.896	25.099
2.Non-science related	Male	34	22.399[a]	1.148	20.138	24.660
	Female	46	21.969[a]	.891	22.214	23.724

a. Covariates appearing in the model are evaluated at Pre-achievement score= 3.4152

Table 4.15 reveals that female students with science-related future career interest in science had higher posttest achievement mean scores in Basic Science than their male counterparts in the same group (24.00 > 23.73). However, male students with non-science related future career interest in science had higher posttest achievement mean scores in Basic Science than male students in the same group (22.45 > 21.97).

H_0 6(b): There is no significant interaction effect of gender and future career interest in science on students' acquisition of science process skills in Basic Science.

Table 4.4 shows that there was no significant 2-way interaction effect of gender and future career interest in science on students' acquisition of science process skills in Basic Science ($F_{(1,264)}$=.08, p<.05). Therefore, hypothesis 6(b) is not rejected. In order to determine how the groups performed, the estimated marginal means were computed and these are presented in Table 4.16.

Table 4.16: Estimated marginal means of posttest Science process skills' acquisition scores in Basic Science by Gender and Future career interest in science

Groups		N	Mean	Std. error	95% confidence interval	
Future career in science	Gender				Lower bound	Upper bound
1. Science-related	Male	96	15.085[a]	.248	14.597	15.572
	Female	101	14.534[a]	.231	14.079	14.989
2.Non-science related	Male	34	13.533[a]	.478	12.593	14.474
	Female	46	13.179[a]	.370	12.451	13.907

a. Covariates appearing in the model are evaluated at Pre-Science process skills' acquisition score = 5.8700.

Table 4.16 indicates that male students with science-related future career interest in science and those with non-science related future career interest in science had higher posttest mean scores in science process skills' acquisition in Basic Science (15.09 > 14.53 and 13.53 > 13.18) than their respective female counterparts.

4.1.7 H_0 7(a): There is no significant interaction effect of treatment, gender and future career interest in science on students' achievement in Basic Science.

Table 4.1 reveals that there was no significant 3-way interaction effect of treatment, gender and future career interest in science on students' achievement in Basic Science ($F_{(2,264)}$=.06, p>.05). Therefore, hypothesis 7(a) is not rejected.

H_0 7(b): There is no significant interaction effect of treatment, gender and future career interest in science on students' acquisition of science process skills in Basic Science.

Table 4.4 shows that there was no significant 3-way interaction effect of treatment, gender and future career interest in science on students' acquisition of science process skills in Basic Science ($F_{(2,264)}$=.97, p<.05). Therefore, hypothesis 7(b) is not rejected.

4.2 Discussion of results

4.2.1 Effect of Treatment on Students' achievement in Basic Science

The findings of this study revealed that simulated laboratory and enriched laboratory guide material experiments had significant main effect on students' achievement in Basic Science. The enriched laboratory guide material experiments proved superior to the conventional (expository) laboratory experiments due to its additional activities which enabled the students to explore further (investigate their predictions/extrapolations of results) in order to discover other relationships between the experimental variables. For example, students in the ELGM experiments group were made to discover the angle of incidence from the glancing angle and they were made to extrapolate and investigate the relationship between angles of incidence and reflection to angle 90^0. These were not included in the conventional (expository) laboratory experiments. The finding is in line with the finding of Dechsri, Jones and Heikkinen (1998) that a Chemistry manual enriched with pictures or diagrams improved university students' achievement in the general Chemistry course than the Chemistry laboratory manual without pictures or diagrams enrichment.

Furthermore, the findings of this study revealed that both the enriched laboratory guide material experiments and conventional (expository) laboratory experiments enhanced students' achievement in Basic Science than the simulated laboratory experiments. This is because basic computer proficiency is required to operate simulated laboratory experiment and students needed some time to practice in order to gain mastery on the use of computer. Computer ability is not necessary for the students to conduct the ELGM and CEL experiments. The finding negates existing findings which established effectiveness of the computer-simulated experiments over the conventional (expository) instructional strategy (Geban, Askar and Özkan, 2010; Tüysüz, 2010; Kim, 2007). Also, it contradicts the observations of Batholomew, Oyedepo and Yusuf (2011) and Huppert, Lomask and Lazarowitz (2010) that simulated laboratory experiments improved students' achievement in science than the hands-on laboratory experiments. It did not agree with the results of Pyatt and Sims (2007) that simulated laboratory experiments produced higher achievement than hands-on laboratory experiments while the conventional (expository) laboratory experiments recorded least among high school students.

4.2.2 Effect of Treatment on Students' acquisition of Science process skills in Basic Science

The results obtained in this study indicated that simulated laboratory and enriched laboratory guide material experiments had significant effect on students' acquisition of science process skills in Basic Science. The two modes of laboratory experiments enhanced students' acquisition of science process skills in Basic Science better than the conventional (expository) laboratory experiments. This is because students are well guided in the conduct of experiments through the procedure provided on the note field in the SL software and ELGM. Also, SL software is interactive such that correct operations are rewarded with the opportunity to continue to perform the experiment while students were unable to proceed with the experiment when incorrect operations were made on the software. Thus, the two modes of laboratory experiment engaged students more in inquiry-based activities which improved acquisition and retention of science process skills than the conventional (expository) laboratory experiments.

These findings are in agreement with the result obtained by Berge (2006) that cooperative learning using microcomputers with a file-management programme and structured activities promoted learning of science process skills by the seventh- and eight-grade students in Michigan. Also, the findings corroborate the observation of Bilgin (2006) that hands-on activities incorporating a cooperative learning strategy improved eighth-grade students' science process skills than teacher demonstration (conventional) strategy. The findings further strengthen. Activity-oriented instruction type and mutual teacher physical interactions (Joju, 2003) which are the features of the simulated and enriched laboratory guide material experiments are not adequate in the conventional (expository) laboratory experiments. These improved acquisition of science process skills (Feyzioğlu, 2009) which are retained by the students for a longer time than the cognitive knowledge (Akinbobola and Afolabi, 2010).

4.2.3 Effect of Gender on Students' achievement and acquisition of Science process skills in Basic Science

This study had shown that students' achievement and acquisition of science process skills in Basic Science were not gender sensitive. Thus, gender did not significantly determine students' success or their level of acquisition of science process skills in Basic Science. These findings did not support the research reports of

Mishra and Yadav (2013) and Nnadi (2002) that girls were significantly superior to boys in science achievement. They also contradict the result obtained by Benningfield (2013) and the reports of the International Mathematics and Science Study (TIMSS) that males outperformed females in science in 1995, 1999 and 2003 (Gonzales, Guzman, Partelow, Pahlke, Jocelyne, Kastberge, et.al., 2004). However, the findings are in line with Oludipe (2012) observation of gender parity in Integrated Science achievement and the report of Huppert, Lomask and Lazarowitz (2010) of no gender difference in the level of mastery of science process skills.

4.2.4 Effect of Future career interest in science on Students' achievement and acquisition of Science process skills in Basic Science

The findings of this study showed that future career interest in science had significant effect on students' achievement and acquisition of science process skills in Basic Science. The effect size was smaller for students' achievement than acquisition of science process skills in Basic Science. This is because science process skills acquired are usually retained by the students for a longer time than the cognitive knowledge (Akinbobola and Afolabi, 2010).

Science-related future career interest improved students' achievement and acquisition of science process skills in Basic Science more than non-science related future career interest in science. This is because the belief that Basic Science will help in the realization of life ambition encouraged students with science-related future career interest to perform better than those with non-science related future career interest. Also, anticipated/expected reward(s) in science-related future career (e.g. job prospects and job demands on science) aroused students' interest to participate in and learn science process skills in Basic Science (Wang and Staver, 2010; Njoku, 2003) and acquisition of science process skills increased students' achievement and scientific creativities (Aktamiş and Ergin, 2008). This is in line with the result obtained by Odetoyinbo (2004) that students' intended career contributed to JSIII students' achievement in Integrated Science in Oyo State. Also, it strengthens the observation by Osokoya that career aspiration and students' achievement in Chemistry were positively related.

4.2.5 Interaction effect of Treatment and Gender on Students' achievement and acquisition of Science process skills in Basic Science

Findings from the study revealed that the 2-way interaction effect of treatment and gender on students' achievement and acquisition of science process skills in Basic Science was not significant. This implies that there was no significant gender disparity in the achievement and acquisition of science process skills of students across treatment groups. Gender equality in students' achievement in Basic Science when taught using the simulated laboratory experiments was in agreement with the findings of Durowoju and Busari (2012) that there was no significant difference in the achievement of males and females in the junior secondary two (JSII) who were taught Integrated Science using computer assisted instruction (CAI) in Ogun State. This confirms the result of Adigun and Zosu (2012) that there was no significant difference in the mean performance of male and female junior secondary three (JSIII) students exposed to computer assisted instruction (CAI) in Basic Technology.

4.2.6 Interaction effect of Treatment and Future career interest in science on Students' achievement and acquisition of Science process skills

Analysis of results obtained from the study indicated that the 2-way interaction effect of treatment and future career interest in science on students' achievement and acquisition of science process skills in Basic Science was not significant. Although, students with science-related future career interest performed better and acquired science process skills more than their non-science related counterparts in all treatment groups, the combined effect of treatment and future career interest in science was not significant. This implies that students' preference for career which are related or not-related to science did not influence their achievement and acquisition of science process skills in Basic Science. This is because laboratory experiments generally stimulate students' interest and motivate them to learn science (Ogunbowale, 2012 and Hofstein and Lunetta, 2004). Also, simulated laboratory experiments were observed by Ahmad (2010) to be more effective in the development of science process skills and enhanced Physics achievement than the conventional laboratory experiments in Turkey. This contradicts the results obtained by Park, Khan and Petrina (2009) that future course selection and career aspirations related to science significantly improved students' achievement in science using computer assisted instruction in Korea.

4.2.7 Interaction effect of Gender and Future career interest in science on Students' achievement and acquisition of Science process skills in Basic Science

The interaction effect of future career interest in science and gender on students' achievement and acquisition of science process skills in Basic Science was found not to be significant. Thus, future career interest in science of males and females did not determine their achievement and acquisition of science process skills in Basic Science. However, females with Science-related future career interest in science achieved more than their male counterparts in Basic Science whereas males with non-science related future career interest in science performed better than their female counterparts in the subject.

Furthermore, males with science-related and non-science related future career interest in science acquired science process skills in Basic Science more than females. Thus, future career interest in science and gender did not mutually influence the students' achievement and acquisition of science process skills in Basic Science to produce joint effects. This is because of increased female participation in Science and Technology in spite of the gender-role stereotypes that boys excel in Mathematics and Science whereas girls are superior in language arts and writing. A child develops intellectual interests (i.e. interest in academic subject) only when the child finds the activities interesting (Bae, 2015) and practical work is intrinsically interesting to the students (Ogunbowale, 2012).

4.2.8 Interaction effect of Treatment, Gender and Future career interest in science on Students' achievement and acquisition of Science process skills in Basic Science

The findings from this study indicated that the 3-way interaction effect of treatment, gender and future career interest in science was not significant on students' achievement and acquisition of science process skills in Basic Science. In other words, the effect of treatment did not depend on the interaction between gender and future career interest in science of students. This is because laboratory experiments engage students in scientific activities which the students found interesting and enjoyable. The use of ICT gadgets in science instruction helps to increase students' interest, facilitate clearer thinking and developing skills with data (Newton and Rogers, 2003 ; Ayogu, 2002 and Osborne and Collins, 2000). Similar results were obtained by Okeke (2012) that students taught using laboratory experiments developed interest and achieved more in Agricultural Science than those taught using conventional (expository) instructional strategy without laboratory facilities.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary of findings from the study, conclusion and recommendations.

5.1 Summary of findings

The findings of this study are summarised as follow:

1. There was a significant effect of treatment (SL, ELGM and CEL) on students' achievement and acquisition of science process skills in Basic Science.
2. There was no significant effect of gender (male and female) on students' achievement and acquisition of science process skills in Basic Science.
3. There was a significant effect of future career interest in science (science- and non- science related) on students' achievement and acquisition of science process skills in Basic Science.
4. There was no significant effect of interaction of treatment and gender on students' achievement and acquisition of science process skills in Basic Science.
5. There was no significant effect of interaction of treatment and future career interest in science on students' achievement and acquisition of science process skills in Basic Science.
6. There was no significant effect of interaction of gender and future career interest in science on students' achievement and acquisition of science process skills in Basic Science.
7. There was no significant effect of interaction of treatment, gender and future career interest in science on students' achievement and acquisition of science process skills in Basic Science.

5.2 Conclusion

This study revealed that simulated laboratory and enriched laboratory guide materials experiments were effective in making students experience science through the conduct of inquiry-based participatory laboratory experiments in Basic Science. Thus, simulated laboratory experiment offers a viable alternative to the use of hands-on laboratory experiment in order to teach Basic Science effectively especially in schools where there are no functional science laboratories. However, schools with well-equipped laboratory could enrich their practical lessons through the use of the enriched laboratory guide material experiments.

Future career interest in science could propel students to do well in science subjects. This is evident in greater achievement and acquisition of science process skills in Basic Science of students in the science-related than those in the non-science related future career interest. Simulated laboratory and enriched laboratory guide material experiments provide discovery-oriented activities which arouse and sustain students' interest in and promote conceptual understanding in Basic Science. It could be concluded that the two modes of laboratory experiment could be facilitative of improved students' achievement and acquisition of science process skills in Basic Science.

5.3 Implications of findings

From the study, some pedagogical implications could be drawn as follows:

First, the teaching of Basic Science needs to actively engage students to work together especially during the conduct of laboratory experiments.

Second, simulated laboratory and enriched laboratory guide materials experiments are indispensable tools for teaching Basic Science.

Third, effective laboratory experiments require that students are given ample opportunity to verify existing theories and laws, discover and confirm new relationships between experimental variables. This will stimulate students' interest, enhance acquisition of science process skills, equip them adequately for future studies especially practical and improve their achievement in science subjects. Therefore, more time is needed on the time-table in order to teach Basic Science through the use of simulated laboratory and enriched laboratory guide material experiments.

Fourth, the effectiveness of simulated laboratory and enriched laboratory guide material experiments in the teaching of light and electrical energy implies that the packages need to be developed for teaching other topics in the Basic Science curriculum.

Fifth, development and utilization of simulated laboratory and enriched laboratory guide material experiments could compensate for lack of and inadequate science laboratories in schools.

Sixth, simulated laboratory and enriched laboratory guide material experiments are effective at improving achievement and acquisition of science process skills of students in Basic Science notwithstanding the gender.

Seventh, the significant effects of future career interest in science on students' learning outcomes imply that it is an important factor to be considered in planning and delivery of Basic Science practical. This will assist Basic Science teachers to encourage students with non-science related future career interest to participate actively and benefit immensely from the conduct of laboratory experiments.

5.4 Recommendations

Based on the findings of this study, the following recommendations are hereby made.

The simulated laboratory and enriched laboratory guide material experiments are recommended to Basic Science teachers for teaching the practical components of the subject. This will encourage students to use their initiatives to conduct laboratory experiments, identify concepts, correct their misconceptions and thereby construct knowledge while working in groups. Also, it will enhance achievement and promote acquisition of science process skills in Basic Science.

Government and relevant professional bodies like the Science Teachers' Association of Nigeria (STAN) should organize seminars, workshops and conferences for practicing Basic Science teachers on the importance and use of simulated and enriched laboratory guide material experiments to teach the subject.

Stake-holders in science education like Old Students' Associations and Parents Teachers' Associations of various secondary schools and philanthropists should support Government to provide functional computers and science laboratories to facilitate teaching - learning of Basic Science through simulated laboratory and enriched laboratory guide material experiments.

Government should sponsor the development, mass production and distribution of simulated laboratory experiments software in other topics in Basic Science curriculum.

The Nigerian Educational Research Development Council (NERDC) should collaborate with the Science Teachers' Association of Nigeria (STAN) to develop appropriate enriched laboratory guide materials for the conduct of Basic Science experiments by the students. Copies of the materials should be made available to schools for use by the students under the guidance of their teachers.

The National Examination Council (NECO) as well as the Assessment and Evaluation section of State Ministries of Education responsible for the conduct and award of Junior Secondary Certificate and Basic Education Certificate respectively should incorporate practical work into Basic Science examinations. This will promote the use of laboratory experiments in the teaching of Basic Science in schools.

The use of simulated and enriched laboratory guide material experiments to teach Basic Science calls for more time allocation. Therefore, provision (three consecutive periods of forty minutes each) should be made on the time-table to accommodate the teaching of Basic Science practical.

5.5 Contributions to knowledge

The findings of this study revealed that the use of simulated laboratory and enriched laboratory guide material experiments to teach Basic Science have great potentials for enhanced students' achievement and acquisition of science process skills in the subject.

Furthermore, the study developed customized stand-alone software of simulated laboratory experiments for the teaching and learning of Light and Electrical Energy in Basic Science. These are viable virtual alternatives for teaching Basic Science concepts through laboratory experiment modes especially where there are no functional physical science laboratories.

In addition, the study developed enriched laboratory guide material experiments in light and electrical energy to facilitate effective teaching and learning of Basic Science practical where there are functional science laboratories.

The study has shown that laboratory experiments could be performed outside the laboratory environment.

5.6 Limitations to the study

The following are some of the challenges encountered in the study.

The rigid pattern of school time-table and quantum of laboratory activities to be performed made it quite difficult to convince school heads to allow the research endeavour.

Also, most Basic Science teachers are graduates of Agriculture, Biology, Chemistry and Health Science who employed the services of Physics graduate teachers in the senior secondary to teach Basic Science topics which are of Physics extraction.

Moreover, the co-curricula activities of the schools like preparation for the annual inter-house sports competition and "Asa" (i.e. culture) day altered the schedule for the laboratory experiments.

Additionally, the average Nigerian teacher has an over-loaded time-table which gives little or no room for experimenting with new instructional strategies.

Despite these limitations, the findings of this study would contribute to existing knowledge in the pedagogy of science in Nigeria and the world at large.

5.7 Suggestions for further study

Further research could focus on the use of each/both simulated laboratory and enriched laboratory guide material experiments to teach other properties of light than reflection at plane surface and other forms of energy than light and electrical energy in Basic Science.

The study was carried out using students' future career interest in science and gender as moderating variables, other moderating variables such as teachers' qualifications and teaching experience could also be used to replicate the study.

REFERENCES

Abe, C.V. 1995. A causal model of some socio-psychological variables as determinants of achievement in secondary school studies. A Ph.D. Thesis. Institute of Education, University of Ibadan, Ibadan.

Aboki, B.T. and Badmus, G. 2005. The effects of instructional methods on students achievement in genetics. *Nigerian Journal of Science and Educational Research* 1. 2: 158-164.

Adams, A. and Salome, A.A. 2014. Factors affecting the choice of science subjects among female students in Jigawa metropolis, Nigeria. *Creative Education* 5. 4:1-11.

Adegoke, A.M. 2005. Teaching of safety procedure and devices in chemistry laboratory. *Nigerian Journal of Science Education and Practice* 3. 1: 118-124.

Adejoh, M.J. 2006. Evaluation of the integrated science and introductory technology programmes in secondary schools in Benue state. Ph.D. Thesis. University of Jos, Jos.

Adey, P.S. and Harley, W. 1986. A piagetian analysis of process skill test items. *Journal of Research in Science Teaching* 23. 8: 707-726.

Adigun, A.O. and Zosu, S.J. 2012. Computer-Aided instruction and academic performance in basic technology. *Meeting the challenges of UBE through STM Education. STAN 53rd Annual Conference Proceedings.* 232-238.

Adodo, S.O. and Gbore, L.O. 2012. Prediction of attitude and interest of science students of different ability on their academic performance in basic science. *International Journal of Psychology and Counselling* 4. 6: 68-72.

Ahmad, A. 2010. The effect of using a e-lab on the physics concepts achievement, aspiration of higher-order thinking skills and motivation toward science learning among students of the third preparatory class. *Scientific Journal of Education* 13, 6: 1-46

Aina, J.K. and Adedo, G.A. 2013. Perceived causes of students' low enrolment in science in secondary schools, Nigeria. *International Journal of Secondary Education* 1. 5: 18-22.

Ajala, O.O. 2004. The challenges of integrated science in the present day Nigeria: Implications of practical work. *Nigerian Journal of Science Education and Practice* 2. 1: 39-44.

Ajani, T.O. and Konku, A. A. 2012. Effect of computer-assisted instruction (CAI) on the teaching and learning of mathematics in secondary schools in Ogun state, Nigeria.*COEASU Journal of Multidisciplinary Studies* 3. 1: 68-75.

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

________ 2005b. The challenges of science education in the present day Nigeria, Nigerian *Journal of Science Education and Practice* 3. 1: 1-7.

Ajeyalemi, D. 2011. Practical work in school science: Are the aims and objectives being achieved? Reforms in Science Education. *STAN 52nd Annual Conference Proceedings*. 3-15.

Akanbi, C.O. 2005. Enhancing science education in Nigeria through the use of computer technology. *Nigerian Journal of Science Education and Practice* 3. 1: 56-65.

Akanbi, C.O. and Adagunodo, E.R. 2003. Development of web-based courseware for distance learning in Nigeria. *Proceedings of the Nigeria Computer Society* 14. 1.

Akinbobola, A.O. and Afolabi, F. 2010. Analysis of science process skills inWest African senior secondary school certificate physics practical examinations in Nigeria. *Bulgarian Journal of Science and Education Policy* 4. 1: 32-47.

Akinsanya, P.A. 2012. Using computer graphics, animations and simulations for effective learning and training. *COEASU Journal of Multi disciplinary Studies* 3. 1: 157-169.

Aktamiş, H. and Ergin, Ö. 2008. The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements. *Asia-Pacific Forum on Science Learning and Teaching* 9. 1: 1-21.

Akubuilo, D.U. 2004. The effects of problem-solving instructional strategies on students' achievement and retention in biology with respect to location in Enugu state. *Journal of the Science Teachers Association of Nigeria* 39. 1&2: 94-100.

Alake, M.E. 2007. Utilization of floor puzzle in improving NCE students' achievements in some integrated science concepts. Science, Technology and Mathematics (STM) Education for Sustainable Development. *STAN Proceedings of the 50th Anniversary Conference*. 150-153.

Alao, O.S. 2001. The role of science laboratory in science teaching. *Journal of Pure and Applied Science* 3. 1&2: 138-143.

Alfieri, L.; Brooks, P.J.; Aldrich, N. J. and Tenenbaum, H. R. 2011. Does discovery-based instruction enhance learning? *Journal of Educational Psychology* 103. 1: 1-18.

Al-Shaiey, F. 2006. Status of using computerized science labs at secondary stage and teachers/students' attitudes towards them. *Journal of Educational Sciences and Islamic Studies* 19. 1: 448-460.

Austin, L.M. and Burns, J.R. 1985. *Management Science: An Aid for Managerial Decision Making*. New York: Macmillan Publishing Company Ltd.

Ayogu, Z.U. 2002. Attitude of J.S.S. teachers towards the us of mass media to enhance learning. *World Council for Curriculum and Instruction: Region II Forum* 3. 1: 45-54.

Bae, M. 2015. Interest in science education: a review of the literature and its implication. Retrieved on 5 August, 2015 from http://edt2.educ.msu.edu/DWong/Archive-ProsemRDP/CEP900F04...

Bajah, S.T. 1983. Problems of teaching science in West and East Africa, *A commissioned work for EDUCAFRICA*, UNESCO, Darkar.

___________ 1984. Continuous assessment and practical work in science teaching: A plea for pragmatism. *Journal of the Science Teachers Association of Nigeria* 22. 2: 45-46.

Bajulaiye, A.A. 2005. Preparation of science teachers for the world of work. *Paper presented at a seminar at the department of science and technology education*, University of Lagos, Lagos. 17th June.

Bakare, C.G.M. 1976. *The Academic Need Achievement Scale and Manual*. Department of Guidance and Counselling, University of Ibadan.

Bamidele, L. 2004. Students' poor performance in physics: A bane to our nation's technological development. *Nigerian Journal of Science Education and Practice* 2. 1: 172-179.

Bartholomew, P.N.; Oyedepo, J.A. and Yusuf, J.A. (2011). Expository versus simulated laboratory in teaching professional courses. *JORIND* 9. 2: 52-58.

Başer, M. and Durmuş, S. 2010. The effectiveness of computer supported versus real laboratory inquiry learning environments on the understanding of direct current electricity among pre-service elementary school teachers. *Eurasia Journal of Mathematics, Science and Technology Education* 6. 1: 47-61.

Bates, G.C. 1988. The importance of the laboratory in school science: A research perspective. *The Science Teacher* 49. 2: 22-23.

Bates, A.W. 2005. *Managing Technological Change: Strategies for College and University Leaders*. San Francisco: Jossey-Bass.

Bayrak, B.; Kanli, U. and Ingec, S.K. 2007. To compare the effects of computer based learning and the laboratory based learning on students' achievement regarding electric circuits. *Turkish Online Journal of Educational Technology-TOJET*, 6,1. Retrieved on 6 August, 2015 from http://eric.ed.gov/?id=500072

Benningfield, S. 2013. The effects of gender and implicit theories on science achievement and interest In elementary-aged students. Masters These and Specialists Projects. Paper 1254. Retrieved on 28 April, 2016 from http://digitalcommons.wku.edu/theses/1254

Berge, Z.L. 2006. Effects of group size, gender, and ability grouping on learning science process skills using microcomputers. Journal of Research in Science Teaching, 27,8: 747-759. Retrieved on 8 October, 2015 from http://onlinelibrary.wiley.com/doi/10.1002/tea.3660270805/abstract

Bilesanmi-Awoderu, J.B. and Oludipe, D.I. 2012. Effectiveness of cooperative learning strategies on Nigerian junior secondary students' academic achievement in basic science. British Journal of Education, Society & Behavioural Science 2. 3: 307-325.

Bilgin, I. 2006. The effects of hands-on activities incorporating a cooperative learning approach on eight grade students' science process skills and attitudes toward science. Journal of Baltic Sience Education, 9: 27-37. Retrieved on 8 October, 2015 from http://web.a.ebscohost.com/abstract?direct=true&profile=ehost&sc...

Blair, G.M.; Jones, R.S. and Simpson, R.H. 1968. *Measurement of interest*. New York: Macmillan Publishing Co. Inc.

Blough, G.O. and Schwartz, J. 1974. *Elementary School Science and How to Teach It*. Fifth edition. USA: Holt, Rinehart and Wiston.

Boyd, J. 2001. *Learning Together: An Introductory Guide to Interactive, Cooperative and Collaborative Learning, A Global Learning Communities Manual*. Australia: Global Learning Communities and Julie Boyd.

Bruner, J.S. 1961. The act of discovery. *Havard Educational Review* 31. 1: 21-32.

Bruner, J. 1966. *Towards a Theory of Instruction*. Cambridge, M.A.: Havard University Press.

Bulunuz, M. and Jarrett, O. 2010. Developing an interest in science: background experiences of preservice elementary teachers. *International Journal of Environmental and Science Education* 5. 1: 65-84.

Bybee, R. 2000. Teaching science as inquiry. *In J. Minstrel and E.H. Van Zee (Eds.), Inquiring into inquiry learning and teaching in science*. (pp. 20-46). Washington, D.C.: American Association for the advancement of Science (AAAS).

Campbell, M.D. 2013. Using the learning together strategy to affect student achievement in physical science. Ph.D. Dissertation, Walden University, http://gradworks.umi.com/35/52/3552577.html

Champagne, A.B. and Klopfer, L.E. 1981. Structuring process skills and the solution of verbal problems involving science concepts. *Science Education* 65. 5: 493-511.

Chebii, R.; Wachanga, S. and Kiboss, J. 2012. Effects of science process skills mastery learning approach on students' acquisition of selected chemistry practical skills in school. *Creative Education* 3: 1291-1296.

Coleman, J.S. 1961. *The Adolescent Society*. New York: Free Press of Glencoe.

Cooley, W.W. 1963. *Correlative development of scientists, an overlapping longitudinal study*. Retrieved on 13 October, 2015 from . http://eric.ed.gov/?id=ED002874

Chukwunenye, J.N. 2014. Effects of computer simulated instructional strategy on senior secondary school students' interest and achievement in practical physics. Ph.D. Thesis. Department of Teacher Education, Faculty of Education, Unversity of Ibadan, Ibadan.

Danmaigoro, A. 2005. Language need for teaching science in Nigeria. *Nigeria Journal of Science and Educational Research 1. 2: 36-39.*

Danmole, B.T. 2002. A review of research in primary science education in Nigeria (1977- 2000). *Ibadan Journal of Educational Studies* 2. 1: 503-515.

Dechsri, P.; Jones, L.L. and Heikkinen, H.W. 1998. Effect of a laboratory manual design incorporating visual information-processing aids on student learning and attitudes. *Journal of Research in Science Teaching*, 34,9: 891-904. Retrieved on 6 August, 2015 from http://onlinelibrary.wiley.com/doi/10.1002/(SCI)1098-2736(19971...

Dewey, J. 1913. Interest and Effort in Education. *In J. Dewey (Ed.). The middle works.* Carbondate and Edwardsville: Southern Illinois University Press.

Dillashav, P.G. and Okey, J.R. 1980. A test of the integrated science process skills for secondary science students. *Paper presented at the annual meeting of the national association for research in science teaching, Boston, April 11-13.*

Durowoju, T.S. and Busari, G.A. 2012. Computer assisted instruction, problem solving teaching strategy and gender as determinant of achievement of JSSII students in integrated science. *COEASU Journal of Multidisciplinary Studies* 3. 1: 297-303.

Ekpunobi, A.N. 2005. The challenge of science, technology and mathematics teaching in the implementation of UBE programme. *A paper presented at the Niger state STAN Conference, 29th-30th November.*

Enwereonye, O.N. 2011. Assessing the availability and utilization of learning resources in the teaching of integrated science in junior secondary schools. *Journal of Issues in Special Education* 10. 1: 28-32.

Ertepinar, H. and Geban, O. 2006. Effect of instruction supplied with the investigative-oriented laboratory approach on achievement in a science course. Retrieved on 6 August, 2015 from http://www.tandfonline.com/doi/abs/10.1080/0013188960380306#

Esomonu, N.P.M. and Onunkwo, G.I.N. 2004. Development and validation of an integrated science process skills test (ISPST). *Journal of the Science Teachers Association of Nigeria* 39. 1&2: 75-82.

Eya, N.M. and Elechi, C.N. 2011. Availability and utilization of basic science laboratory facilities in junior secondary schools: A panacea for reform in STEM education. *52nd Annual Conference Proceedings of STAN*. 152-160.

Ezeliora, B. 2004. Motivating secondary school science teachers to face the challenges of the third millennium. *Journal of the Science Teachers Association of Nigeria*, 39. 1&2: 82- 87.

Fagbemi, J.O. 2004. Chemistry education and technological development: problems and prospects. *Nigerian Journal of Science Education and Practice (NJOSEP)* 2. 1: 96-106.

Farenga, S.J. and Joyce, B.A. 1999. Intentions of young students to enroll in science courses in the future: an examination of gender differences. *John Wiley and Sons, Inc.*:57-75.

Farooq, M.S.; Chaundhry, A.H.; Shafiq, M. and Berhanu, G. 2011. Factors affecting students' quality of academic performance: a case of secondary school level. *Journal of Quality and Technology Management* VII. II: 1-14.

Fayemi, N.O. and Fagbemi, J.O. 2005. Problem-based learning in practical chemistry as a foundational strategy for technological breakthrough. *Nigerian Journal of Science Education and Practice* 3. 1: 102-109.

Federal Republic of Nigeria. 2013. *National Policy on Education*. Lagos: NERDC Press.

Feyzioğlu, B. 2009. An investigation of the relationship between science process skills with efficient laboratory use and science achievement in chemistry education. *Journal of Turkish Science Education* 6. 3: 114-132.

Foulds, W. and Rowe, J. 1996. The enhancement of science process skills in primary teacher education students. *Australia Journal of Teacher Education* 21. 1: 16-28.

Freedman, M.P. 1998. Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching*, 34,4: 343-357. Retrieved on 6 August, 2015 from http://onlinelibrary.wiley.com/doi/10.1002(SCI)1098-2736(19970...

Gagné, R.M. 1965. The Psychological Basis of Science – A Process Approach. AAAS Miscellaneous Publication 65-67.

Geban, Ö., Askar, P. and Özkan, İ. 2010. Effects of computer simulations and problem-solving approaches on high school students. *The Journal of Educational Research* 86. 1. online.

Gokkurt, B.; Dundar, S.; Soylu, Y. and Akgun, L. 2012. The effects of learning together technique which is based on cooperative learning on students' achievement in mathematics class. *Social and Behavioral Sciences* 46: 3431-3434

Gonzales, P.; Guzman, J.C.; Partelow, L.; Pahlke, E.; Jocelyne, L.; Kastberg, D.; et.al. 2004. Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003 (NCES 2005-005).

Haastrup, D. 2005. Using organizers to communicate science concepts as an effective way for technological breakthrough. *Nigerian Journal of Science Education and Practice* 3. 1: 88-94.

Hirça, N. 2013. The influence of hands on physics experiments on scientific process skills according to prospective teachers' experiences. *European Journal of Physics Education* 4,1. Retrieved on 5 October, 2015 from http://ejpe.erciyes.edu.tr/index.php/EJPE/article/view/82

Hofstein, A. and Lunetta, V.N. 2004. The laboratory in Science Education: Foundations for the Twenty-First Century. *Wiley Periodicals, Inc*.

Hofstein, A. and Mamlok-Naaman, R. 2007. The laboratory in science education: The state of the art. *Chemistry Education Research and Practice* 8. 2: 105-107.

Hornby, A.S. 2010. *Oxford Advanced Learner's Dictionary of Current English*. New 8th Edition. U.K.: Oxford University Press.

http:/eonreality.wordpress.com/terminology/simulationbasedlearningdefinition.htm

http://en.wikipedia.org/wiki/Adobe After Effect

http://en.wikipedia.org/wiki/Adobe Audition

http://en.wikipedia.org/wiki/Adobe Creative Suite

http://en.wikipedia.org/wiki/Adobe Fireworks

http://en.wikipedia.org/wiki/Adobe Flash Professional http://www.nsta.org/about/positions/computers aspx

https://www2.ed.gov/pubs/OR/ConsumerGuides/cooplearn.html

Huppert, J, Lomask, S.M. and Lazarowitz, R. (2010). Computer simulations in high school: students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education*, 24,8. Retrieved on 5 October, 2015 from http://www.tandfonline.com/doi/abs/10.1080/09500690110049150

Ibe, E. 2011. Level of scientific literacy possessed by upper basic science students: implications for achievement of education reform goals. *Reforms in STEM Education. Science Teachers Association of Nigeria 52nd Annual Conference Proceedings. 161-166.*

Ige, T.A. and Arowolo, J.G. 2003. Effects of hypothetico-deuctive approach on J.S.S. III students' achievement in integrated science. *Journal of the Science Teachers Association of Nigeria* 38. 1&2: 39-45.

Iravani, M.R. and Delfechresh, H. 2011. Effects of CAI on science achievement of higher primary students. *International Journal of Business and Social Science* 2. 19: 170-172.

Isa, H. 2007. Improved practical approaches to biology teaching for sustainable development in Nigeria. *Science, Technology and Mathematics (STM) Education for Sustainable Development STAN Proceedings of the 50th Anniversary Conference*. 102-105.

Jacobson, M. and Ruddy, M. 2004. *Open to Outcome*. Oklahoma City, OK: 'N' Barnes.

Jaakkola, T. and Nurmi, S. 2008. Fostering elementary school students' understanding of simple electricity by combinig simulation and laboratory activities. *Journal of Computer assisted learning* 24.4 online.

Jeenthong, T., Ruenwongsa, P. and Sriwattanarotha, N. 2013. Promoting integrated science process skills through betta-live science laboratory. A Paper Presented at the 5th World Conference on Educational Sciences. Retrieved on 5 October, 2015 from http://www.researchgate.net/publication/273537958_Promoting_Inte...

Johnson, D.W. and Johnson, R.T. 1991. *Learning Together and Alone*. Eaglewood Cliffs, NJ: Pretice-Hall.

Joint Admissions & Matriculations Board. JAMB eBronchure 2015/2016.

Joju, E.A. 2003. Evaluation of the availability of chemistry practical materials in some secondary school laboratories. *Nigerian Journal of Science Education and Practice* 1.1: 27-36.

Kagan, S.K. 2001. *Kagan Structures and Learning Together: What is the Difference?* San Cemente, CA: Kagan Publishing. Kagan Online Magazine. www.KaganOnline.com

Kelly, J.; Bradley, C. and Gratch, J. 2008. Science simulations: do they make a difference in student achievement and attitude in the physics laboratory? Retrieved on 6 August, 2015 from http://eric.ed.gov/?id=ED501653

Kerr, J.F. 1963. *Practical Work in School Science: An Account of Inquiry into the Nature and Purpose of Practical Work in School Science Teaching in England and Wales*. Leicester: Leicester University Press.

Kim, P. 2007. Effects of 3D virtual reality of plate tectonics on fifth grade students' achievement and attitude toward science. *Interactive Learning Environments*, 14.1. Online.

Kirschner, P.A.; Sweller, J. and Clark, R.E. 2006. Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching. *Educational Psychologist* 41. 2: 75-86.

Kolb, D.A. 1984. *Experiential Learning: Experience as the source of Learning and Development.* Eaglewood Cliffs, N.J.: Prentice Hall Inc.

Lazarowitz, R. and Huppert, J. 2014. Science process skills of 10th-grade biology students in a computer-assisted learning setting. *Journal of Research on Computing in Education* 25, 3. Retrieved on 5 October, 2015 from http://www.tandfonline.com/doi/abs/10.1080/08886504.1993.10782057

Leonard, W.H. 2006. A comparison of student performance following instruction by interactive videodisc versus conventional laboratory. *Journal of Research in Science Teaching*, 29: 93-102. Retrieved on 5 October, 2015 from http://onlinelibrary.wiley.com/doi/10.1002/tea.3660290109/abstract

Livermore, A.H. 1964. The process approach of the AAAS commission on science education. *Journal of Research in Science Teaching* 2: 271-282.

Makinde, V. 2005. Blended learning as a way out of poor students' performance. Nigerian *Journal of Science and Educational Research* 1. 2: 148-151.

Mayer, R.E. 2004. Should there be a three-strike rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist* 59. 1: 14-19.

Mbamara, U.S. and Eya, P.E. 2015. Causes of low enrollment of physics as a subject of study by secondary school students in Nigeria: a descriptive survey. *International Journal of Scientific Research in Education* 8. 4: 127-149.

Mbewe, S.; Chabalengula, V.M. and Mumba, F. 2010. Pre-service teachers' familiarity, interest and conceptual understanding of science process skills. *Problems of Education in the 21st Century 22: 76-86.*

McGraw-Hill Encyclopedia of Science and Technology. 9th Edition. 2002. Volume 16. New York: McGraw-Hill Company. Pp. 507.

McLeod, S.A. (2010). Kolb-Learning Styles. Retrieved on 13 October, 2014 from http://www.simplypsychology.org/learning-kolb.html

Millar, R.; Tiberghien, A. and Marechal, J.F. 2002. Varieties of lab work: a way of profiling lab work tasks. *In D. Psillos and H. Niedderer (Eds.), Teaching and Learning in Science Laboratory*. Dordrecht: Kluwer Academic.

Mishra, S.K. and Yadav, B. 2013. Effect of activity based approach on achievement in science of students at elementary stage. *International Journal of Basic and Applied Science*. E- ISSN: 2301-4458; P-ISSN: 2301-8038; Vol. 01, No. 04, April 2013; pp. 716-733.

Moon, J. 2004. *A Handbook of Reflective and Experiential Learning: Theory and Practice*. London: Routledge Falmer. Pp. 126.

Murugan, R. and Jaseena, K.U. (2010). Effect of computer assisted instruction (CAI) on students' achievement in science. *Report of the UGC Minor Research Project as a part of Eleventh Plan*.

National Association of Biology Teachers (NABT). 2005. Role of Laboratory and Field Instruction in Biology Education. Retrieved on 13 October 2014 from http://www.role of laboratory in biology.mht

National Council of Educational Research and Training (NCERT). NCERT Class 9 Science Lab Manual Instruction. Retrieved on 27 August 2014 from www.cbseacademics.in/.../ncert- class-9-sc...

National Research Council. 2000. *Inquiry and the national science education standards*. Washington, D.C.: National Academy Press.

Newton, L. and Rogers, L. 2003. Thinking frameworks for planning ICT in science lessons. *School Science Review* 84. 309: 113-119.

Ndirika, M.C. 2011. Innovative strategies for enhancing science classroom learning environment in Nigeria. *The Educational Psychologist* 5. 1: 68-76.

Nigerian Educational Research and Development Council (NERDC). 2006. *Basic Science for Upper Basic Education, Junior Secondary 1-3.*

______________________________ 2008a. *The 9-year Basic Education Curriculum at A Glance.*

____ 2008b. *Frequently Asked Questions (FAQ). The New 9-year Basic Education Curriculum Structure*.

____ 2012. *Junior Secondary School Curriculum, revised: Basic Science and Technology JSS1-3.*

Njoku, Z.C. 2003. Development and preliminary validation of a scale for the assessment of students' interest in O'level practical chemistry activities. *Journal of the Science Teachers Association of Nigeria* 38. 1&2: 64-70.

________ 2007. Engendering learning equity in science and technology classrooms for sustainable development. *Science, Technology and Mathematics (STM) Education for Sustainable Development STAN Proceedings of the 50th Anniversary Conference*. 24-31.

________ and Okeke, E.A.C. 2003. Recreating science from women's perspective. WOREC *Journal of Gender Studies* 1. 2: 127-134.

Nnadi, F.O. 2002. Facilitating conceptual change, achievement and retention in physics using analogy and PPEEFA instructional packages. *Unpublished M.Sc. Dissertation*, Enugu State University of Science and Technology (ESUT), Enugu.

Nnorom, N.R. 2012. Availability and usability of the basic science laboratory facilities for teaching basic science in upper basic secondary schools. *Meeting the Challenges of UBE Through STM Education. STAN 53rd Annual Conference Proceedings*. 183-189.

Nworgu, L.N. 2005. Effect of gender sensitization package (GSP) on students' achievement in integrated science. *Journal of the Science Teachers Association of Nigeria* 40. 1&2: 74-79.

Obianyo, B.N. 2000. Career choice and gender stereotyping in science. *Paper presented at the national conference on gender equality in Nigeria.* Federal College of Education (T), Umunze, 13-16 June.

Nyamba, S.Y. and Mwajombe, K.K. 2012. Students' preferences of science subjects: does this affect their performance? A case of Udzungwa secondary school, Kilolo, Iringa, Tanzania. *International Journal of Science and Technology* 2. 8: 556-560.

Odetoyinbo, B.B. 2004. Teacher and student factors as correlates of academic achievement in integrated science. *Journal of the Science Teachers Association of Nigeria* 39. 1&2: 17-22.

Odinko, M.N. and Adeyemo, D.A. 1999. Socio-psychological factors as correlates of senior secondary students' attitude towards English language. In Obemeata, J.O.; Ayoade, S.O. and Araromi, M.A. (eds.): *Evaluation in Africa*. In honour of E.A. Yoloye. Stirling-Harden Publishers (Nig) Ltd.

Ogbu, C.C. 2012. Effect of context-based teaching strategy on senior secondary school students' achievement in physical chemistry. *Meeting the Challenges of UBE Through STM Education. STAN 53rd Annual Conference Proceedings*. 265-271.

Ogunbowale, N.B. 2012. Biology laboratory facilities and teachers' job performance in selected secondary schools in Ogun state. *COEASU Journal of Multidisciplinary Studies* 3.1: 471-476.

Ogunkola, J.B. and Bilesanmi-Awoderu, J.B. 2000. Effects of laboratory and lecture methods on students' achievement in biology. *African Journal of Education* 5, 2: 247-260.

Ogunkunle, S.J. 2011. *Nature, Ethics and Methods of Science*. Revised edition. Nigeria: Peerless prints and publishing.

Ogunleye, A.O.; Oke, C.O. and Adeoye, B.F. 2007. The need for a new perspective: Creating e-learning environments in our higher education institutions for the sustainable development of science, technology and mathematics education in Nigeria. *Science, Technology and Mathematics (STM) Education for Sustainable Development STAN Proceedings of the 50th Anniversary Conference*. 58-67.

Ogunwale, Y.E. and Akintoye, K.A. 2005. A comparative analysis of two teaching methods for comparative analysis of two teaching methods for computer science instruction in schools. *Nigerian Journal of Science Education and Practice* 3. 1: 157-166.

Ojeme, B.O. and Umendu, E.C. 2004. *Know Your Computer at a Glance*. Umenze: Annyco Printing Press.

Okafor, N. 2007. Enhancing primary school teachers understanding of science concepts using two modes of distance education. *Science, Technology and Mathematics (STM) Education for Sustainable Development STAN Proceedings of the 50th Anniversary Conference*. 239-243.

Okebukola, P. A. and Ogunniyi, M.B. 2006. Cooperative, competitive, and individualistic science laboratory interaction patterns-effects on students' achievement and acquisition of practical skills. Retrieved on 6 August, 2015 from http://onlinelibrary.wiley.com/doi/10.1002/tea.3660210903/abstrct...

Okeke, E.A.C. 1990. Gender, science and technology in Africa: A challenge for education. *The Rama Mehta Lecture*. Radcliff College, University of Cambridge, U.S.A.

Okeke, D.C. 2012. Impact of material resources in facilitating students interest and academic achievement in agricultural science. *Meeting the Challenges of UBE through STM Education, STAN 53rd Annual Conference Proceedings*, 163-168.

Okeke, S.O.C.; Akusoba, E.U. and Okafor, C.O. 2004. Construction and validation of an instrument for appraising the level of acquisition of science process skills by jss graduates in Anambra state schools. *Journal of the Science Teachers Association of Nigeria* 39. 1&2: 101-108.

Okpala, P.N.; Onocha, C.O. and Oyedeji, O.A. 1987. *Measurement and evaluation in education.* Ibadan: Stirlings-Horden Publishers (Nig.) Ltd. Jattu-Uzairue.

Olatoye, R.A. and Afuwape, M.O. 2004. Students' integrated science achievement as a predictor of later achievement in biology, chemistry and physics. *Journal of the Science Teachers Association of Nigeria* 39. 1&2: 10-15.

Olawepo, A.A. 2001. Science and technology education in the new millennium: A base for sustainable development. *Journal of Science Education* 5. 1&2: 83-90.

Oloyede, E.O. 2005. Science education and technological development in Nigeria. Nigerian *Journal of Science Education and Practice* 3. 1: 19-27.

Oloruntegbe, K.O. and Aganga, A.B. 2001.Course preference pattern and teaching effectiveness: a comparative study of integrated and separate science combinations. *Journal of Science Education* 5. l&2: 151-160.

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

Olutunmbi, T. O. 2004. Information technology: an effective way to deliver nutrition education. *Nigerian Journal of Science Education and Practice (NJOSEP)* 2. 1: 9-15.

Olympiou, G. and Zacharia, Z.C. 2012. Blending physical and virtual manipulatives: an effort to improve students' conceptual understanding though science laboratory experimentation. *Science Education* 96: 21-47.

Omilani, N.A. 2015. Analysis of chemistry students' misconceptions in volumetric and qualitative analysis in senior secondary schools in Ibadan metropolis. Post-field seminar paper presented at the joint staff/higher degree students' seminar series. Department of Teacher Education, University of Ibadan, Ibadan.

Onasoga, O.T. 2012. Information and communication technology: Effective tools for learning business education programmes in tertiary institutions in Ogun state. *COEASU Journal of Multidisciplinary Studies* 3. 1: 202-219.

Onwioduokit, F.A. and Akinbobola, A.O. 2005. Effects of pictorial and written advance organizers on students' achievement in senior secondary school physics. *Journal of the Science Teachers Association of Nigeria* 40. 1&2: 109-116.

Opara, F.M. and Elekalachi, C.I. 2007. Breaking the gender gap in science education through the application of indigenous technology: Implication for sustainable development. *Science, Technology and Mathematics (STM) Education for Sustainable Development. STAN Proceedings of the 50th Anniversary Conference.* 81-85.

Oriade, T.I. 2008. An empirical study on the use of instructional materials in biology curriculum implementation: A case study of selected secondary schools in two L.G.A. of Bauchi state. *49th Annual Conference Proceedings of STAN*. 103-109.

Osborne, J. and Collins, S. 2000. *Pupils' Parents' Views of the School Science Curriculum.* London: King's College.

Osokoya, M.M. 1990. Intelligence and academic performance. *Unpublished M.Ed. Dissertation*, Institute of Education, University of Ibadan, Ibadan.

Osokoya, M.M. 2003. Pattern of career aspiration among senior secondary school chemistry students. *Journal of the Science Teachers Association of Nigeria* 38. 1&2: 16-31.

Oyediran, A.M; Agoro, A.A. and Fabiyi, O.O. 2004. A multi-media approach to the teaching of difficult topics in integrated science. *Journal of the Science Teachers Association of Nigeria* 39. 1&2: 109-112.

Özgelen, S. 2012. Students' science process skills within a cognitive domain framework. *Eurasia Journal of Mathematics, Science and Technology Education* 8. 4: 283-292.

Özsoy, N. and Yildiz, N. 2004. The effect of learning together technique of cooperative learning method on student achievement in mathematics teaching 7th class of primary school. *The Turkish Online Journal of Educational Technology-TOJET* 3. 3: 49-54.

Padilla, M.J. 1990. The science process skills. In *NARST: Publications-Research Matters-to the Science Teacher, March 1, No. 9004*. Retrieved on 8 October, 2015 from https://www.narst.org/publications/research/skill.cfm

Park, H.; Khan, S. and Petrina, S. 2009. ICT in science education: a quasi-experimental study of achievement, attitudes toward science, and career aspirations of Korean middle school students. International Journal of Science Education, 31,8. Retrieved on 13 October, 2015 from http://www.tandfonline.com/doi/abs/10.1080/09500690701787891

Piwuna, C. and Scholar, N. 2010. Teaching and learning of integrated science in universal basic education using information and communication technology (ICT): Challenges and prospects. *International Journal of Forum for African Women Educationalist in Nigeria* 2. 2: 18-19.

Pyatt, K. and Sims, R. 2007. Learner performance and attitudes in traditional versus simulated laboratory experiences. In ICT: Providing choices for learners and learning. Proceedings of ascilite Singapore. Retrieved on 18October2014 from http://www.ascilite.org.au/conferences/singapore07/procs/pyatt.pdf

Raj, R.G. and Devi, S.N. 2014. Science process skills and achievement in science among high school students. *Scholarly Research Journal for Interdisciplinary Studies*. II. XV: 2435-2443.

Saat, R.M. 2004. The acquisition of integrated science process skills in a web-based learning environment. Research in Science & Technological Education, 22,1. Retrieved on 5 October, 2015 from http://www.tandfonline.com/doi/abs/10.1080/0263514042000187520

Saka, F.A. 2005. New technologies for dissemination of nutrition education to learners for technological breakthrough. *Nigerian Journal of Science Education and Practice* 3. 1: 73-78.

Schroeder, C.M.; Scott, T.P.; Tolson, H.; Haung, T. and Lee, Y. 2007. A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching* 44. 10: 1436-1460.

Shaheen, J. and Khattab, K. 2005. *School Lab and its Role in Science Instruction.* Jordan: Usra Publishing.

Shelly, G.B.; Cashman, T.J.; Gunter, G.A. and Gunter, R.E. 2006. *Teachers Discovering Computers: Integrating Technology and Digital Media in the Classroom*. 4th Edition.Australia: Thomson Course Technology.

Slavin, R. 1994. *Using Student Team Learning*. 4th ed. Baltimore: Johns Hopkins.

Slavin, R.E. 1995. Classroom applications of cooperative learning. In Slavin, 1995. *Cooperative Learning: Theory, Research, and Practice*. 2nd edition. Boston: Allyn & Bacon.

Sokolowski, J.A. and Banks, C.M. 2009. *Principles of Modeling and Simulation*. Hoboken N.J.; Wiley. P.6ISBN040289430.

Taiwo, A.E.; Adeniji, A.A. and Muazu, H. 2012. Adequacy of laboratory personnel and material in Nigerian secondary schools: A case study of Abeokuta north, south and Odeda local government areas of Ogun state. *COEASU Journal of Multidisciplinary Studies* 3. 1: 91-96.

Tobin, K.G. 1990. Research in science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics* 90: 403-418.

Trowbridge, L.W. and Bybee, R.W. 1990. *Becoming a Secondary School Science Teacher*. Fifth Edition. Columbus, Ohio: Merrill Publishing Co.

Tuovinen, J.E. and Sweller, J. 1999. A comparison of cognitive load associated with discovery learning and worked examples. *Journal of Educational Psychology* 9. 2: 334-341.

Tüysüz, C. 2010. The effect of virtual laboratory on students' achievement and attitude in Chemistry. *International Online Journal of Educational Science* 2. 1: 37-53.

Wang, J. and Staver, J.R. 2010. Examining relationship between factors of science education and student career aspiration. *The Journal of Educational Research* 94.5.

What is a Career? Retrieved on 13 October, 2015 from http://www.education.vic.gov.au/school/students/beyond/pages/what..

White, E.L. and Harrison, G.H. 2012. U K students' attitudes towards science and potential science-based careers. *Acta Didactica Napocensia* 5. 4: 1-10.

Wyss, V.L.; Heulskamp, D. and Siebert, C.J. 2012. Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental & Science Education* 7. 4: 501-522.

Yang, K. and Heh, J. 2007. The impact of internet virtual physics laboratory instruction on the achievement in physics, science process skills and computer attitudes of 10th-grade students. Journal of Science Education and Technology, 16,5: 451-461. Retrieved on 5 October, 2015 from http://link.springer.com/article/10.1007/s10956-007-9062-6#/page-1

Young, B.C. 1974. Towards a process approach in primary science. *Journal of Science Teachers Association of Nigeria* 12.4: 19-23.

Yusuf, M.O. and Afolabi, A.O. 2010. Effects of computer assisted instruction (CAI) on secondary school students' performance in biology. *The Turkish Online Journal of Educational Technology* 9. 1: 62-69.

Zacharia, Z.C. 2007. Comparing and combining real and virtual experimentation: an effort to enhance students' conceptual understanding of electric circuits. *Journal of Computer Assisted Learning* 23. 2: 120-132.

APPENDIX I

SAMPLE DISTRIBUTION OF PARTICIPANTS BY LOCAL GOVERNMENT EDUCATION AREA AND TREATMENT GROUP

S/N	Name of School	Local Government Education Area	Experimental Group	Number of Students Sampled
1.	Olivet Baptist High School, Owode, Oyo	Oyo-East	I	39
2.	Awe High School, Awe	Afijio	II	30
3.	Oranyan Grammar School, Sabo, Oyo	Oyo-West	III	79
4.	Ibadan Grammar School, Molete, Ibadan	Ibadan South-East	I	71
5.	Oke-Bola Comprehensive High School, Leaf Road, Ibadan	Ibadan South-West	II	30
6.	Abadina College, University of Ibadan, IbadanI	Ibadan-North	III	38
Total				**277**

APPENDIX IIA

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

ACHIEVEMENT TEST IN BASIC SCIENCE (ATBS)

Time: 50minutes

Dear Students,

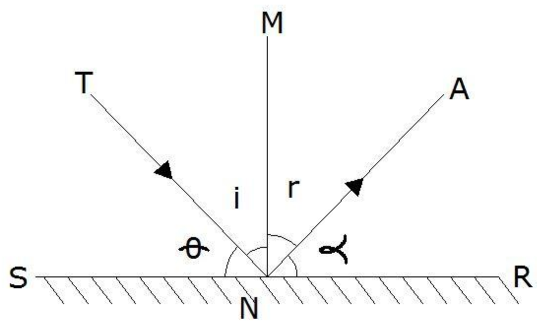
The achievement test in basic science is strictly being used to collect information for a study titled "Effects of Simulated Laboratory and Enriched Laboratory Guide Material Experiments on Students' Learning Outcomes in Basic Science in Oyo State, Nigeria". Thank you.

Instruction: Answer all the questions. Each question is followed by four options lettered **a - d**. Find out the correct option for each question and tick (√), with pencil in the appropriate box on your answer sheet, the answer space which bears the same letter as the option you have chosen. Give only one answer to each question.

1. Which of the following do NOT happen to a ray of light that falls on the surface of an object? It is

   a. absorbed b. transmitted c. obstructed d. reflected

Use the ray diagram below to answer questions 2-11.



2. SR represents

   a. a refracting surface b. a plane surface c. an intersecting surface d. a reflecting surface

3. N is a point of

   a. inflexion b. incidence c. convergence d. intersection

4. MN is known as a

   a. normal b. straight line c. perpendicular line d. ray

5. TN is called

   a. incidence ray b. refracted ray c. reflected ray d. transmitted ray

6. NA represents

a. emergent ray b. reflected ray c. refracted ray d. deflected ray

7. Glancing angle is represented by

a. i b. r c. θ d. α

8. i is known as an angle of

a. reflection b. intersection c. incidence d. refraction

9. r is called an angle of

a. projection b. incidence c. emergence d. reflection

10. Which of the following is correct?

a. θ = i b. i = r c. r = α d. θ = r

11. Which of these is NOT equal to 90^0?

a. θ + i b. r + α c. θ + α d. θ + r

12. Light always travel along a path that is

a. curved b. smooth c. rough d. straight

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

a. inverted b. real c. virtual d. erect

14. The image of a left hand formed by a plane mirror appears to an observer like a right hand. Which of the following terms explains this observation?

a. diffraction b. diffuse reflection c. lateral inversion d. regular reflection

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

a. virtual b. real c. inverted d. erect

16. Which of the following is NOT a characteristic of an image formed by a plane mirror?

a. It is real b. It is virtual c. It is the same size as the object d. It is upright

17. When a ray of light is reflected from a surface, the angle of incidence is always equal to the angle of

a. dip b. refection c. refraction d. declination.

18. The image of an object which is formed by a plane mirror is.

a. farther away into the mirror than the object is in front of it.

b. closer to the mirror than the object

c. the same distance as the object from the mirror

d. formed on the surface of the mirror.

19. Which of the following equipment is used to produce a ray of light in the laboratory? a. torchlight b. solar lamp c. ray box d. lantern

20. A lit electric lamp produces

a. parallel rays b. reflected rays c. convergent rays d. divergent rays

21. Which of the following is the SI unit of electric current?

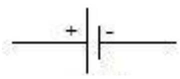
a. Volt b. Ohm c. Ampere d. Joules

22. Which of the following instruments can be used to measure electric potential difference across the ends of a resistor?

a. Ammeter b. Clock c. Thermometer d. Voltmeter

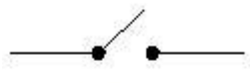
23. The SI unit of electrical energy is

a. Joule b. Newton c. Ampere d. Volt

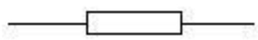
24. 

represents

a. lamp b. resistor c. cell d. key

25.  represents

a. cell b. key c. resistor d. voltmeter

26.  represents

a. resistor b. ammeter c. key d. cell

27. 

represents

a. lamp b. voltmeter c. ammeter d. resistor

28. 

represents

a. voltmeter b. lamp c. cell d. ammeter

29. Two types of electric circuit are

a. series and Binocular b. series and parallel

c. parallel and horizontal d. circular and triangular.

30. The value of potential difference increases as the value of electric current

a. remains the same b. decreases c. increases d. changes

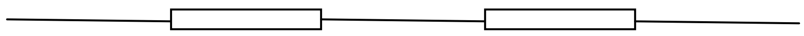
31. When one of the two electric lamps which are connected in series to electricity supply is dead, the second lamp will

a. go bad b. give light c. become hot d. not give light

32. The passage of electric current is maintained in

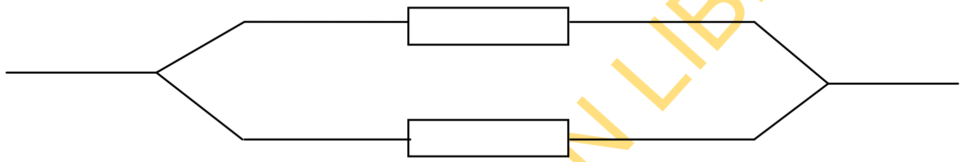
a. an open circuit b. a broken circuit c. a closed circuit d. a direct circuit

33. The resistors in the diagram below are connected



a. in parallel b. improperly c. indirectly d. in series

34. The resistors in the diagram below are connected



a. directly b. in series c. in parallel d. improperly

35. When one of the two electric lamps which are connected in parallel to electricity supply is dead, the second lamp will

a. not give light b. go bad c. give light d. become hot

36. The conventional direction of electric current in an electric circuit is from

a. positive to negative terminals b. negative to positive terminals

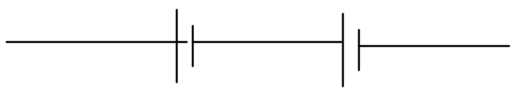
c. left to right d. right to left

37. The direction of flow of electrons within the electric cell is from

a. right to left b. negative to positive electrodes

c. positive to negative electrodes d. left to right

38. The cells in the diagram below are connected



a. vertically b. in series c. horizontally d. in parallel

39. The value of electric current passing through each of the components connected in series is

a. different b. the same c. direct d. alternating

40. The value of electric current passing through each of the components connected in parallel is

a. the same b. direct c. different d. alternating

APPENDIX IIB

ANSWER SHEET

ACHIEVEMENT TEST IN BASIC SCIENCE (ATBS)

Student's Name:

School:

Class:

Gender: Male ( ) Female ( )

Date:

Instruction: Kindly tick (√) the correct option from letters a – d.

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

APPENDIX IIC

MODEL ANSWERS TO ACHIEVEMENT TEST IN BASIC SCIENCE (ATBS)

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

APPENDIX IIIA

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

SCIENCE PROCESS SKILLS TEST IN BASIC SCIENCE (SPSTBS)

Time: 30minutes

Dear Students,

The science process skills test in basic science is strictly being used to collect information for a study titled "Effects of Simulated Laboratory and Enriched Laboratory Guide Material Experiments on Students' Learning Outcomes in Basic Science in Oyo State, Nigeria". Thank you.

Instruction: Answer all the questions. Each question is followed by four options lettered **a - d**. Find out the correct option for each question and tick (√), with pencil in the appropriate box on your answer sheet, the answer space which bears the same letter as the option you have chosen. Give only one answer to each question.

1. Which of the following is NOT used in the conduct of reflection of light experiment?

   a. metre rule b. protractor c. ammeter d. plane mirror

2. The following apparatus are used in the conduct of experiment on the relationship between potential difference and electric current EXCEPT

   a. cell/battery b. optical pin c. plug key d. connecting wires

3. Which of the following pairs are measured during reflection of light experiment?

   a. angle of incidence and electric current
   b. angle of reflection and potential difference
   c. potential difference and electric current
   d. angles of incidence and reflection

Use the following diagrams to answer questions 4 – 11.

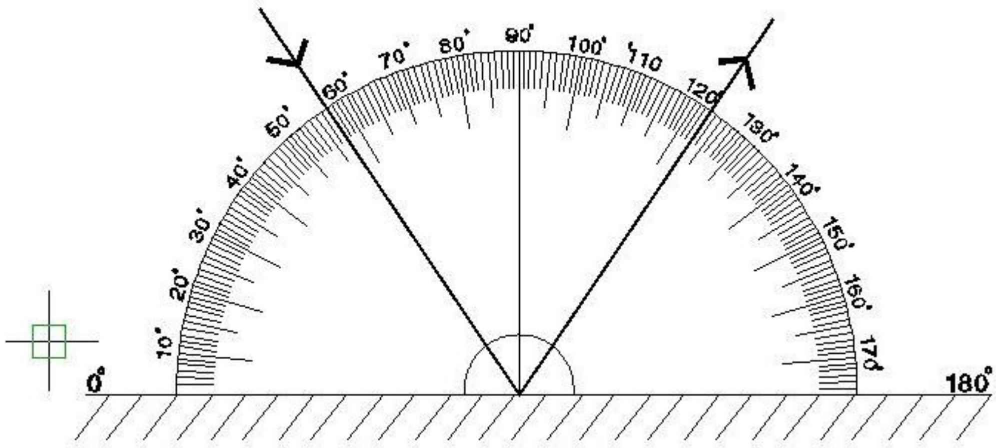


Fig. 1

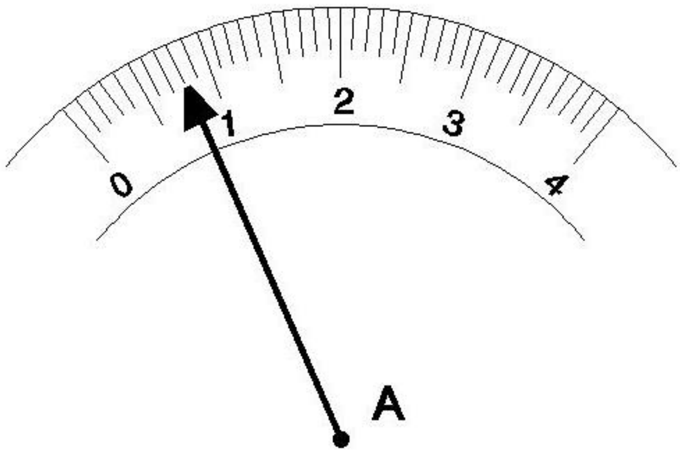


Fig. 2

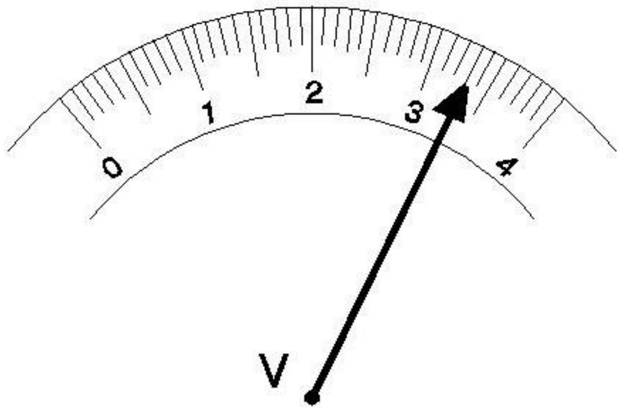


Fig. 3

4. What is the value of the angle of incidence in fig.1?

a. 33^0 b. 57^0 c. 63^0 d. 90^0

5. The value of the angle of reflection shown in fig.1 is

a. 123^0 b. 33^0 c. 137^0 d. 57^0

6. What value of the electric current is indicated in fig.2?

a. 1.2A b. 7.0A c. 0.8A d. 2.8A

7. What is the voltmeter reading in fig.3?

a. 4.7V b. 2.13V c. 2.3V d. 3.3V

8. Using fig.1, describe an incident ray of light. It is a ray of light

a. coming out of the plane mirror

b. moving into the plane mirror

c. which has not strike the plane mirror

d. which moves over the plane mirror

9. In fig.1, a reflected ray could be described as a ray of light which

a. enters the plane mirror b. moves over the plane mirror

c. has not strike the plane mirror d. comes out of the plane mirror

10. Using fig.1, describe an angle of incidence of a ray of light. It is an angle formed between

a. the mirror and the incident ray b. the mirror and the reflected ray

c. the incident ray and the normal d. the reflected ray and the normal

11. In fig.1, an angle of reflection of a ray of light is an angle formed between

a. the reflected ray and the normal b. the reflected ray and the mirror

c. the incident ray and the normal d. the incident ray and the mirror

In the reflection of light experiment, which of the following quantities is

12. a dependent variable?

a. incident ray b. reflected ray c. angle of incidence d. angle of reflection

13. an independent variable?

a. angle of reflection b. angle of incidence c. reflected ray d. incident ray

In the experiment on the relationship between potential difference and electric current, which of the following quantities is

14. a dependent variable?

a. electric resistance b. electric current c. electromotive force of a cell

d. potential difference

15. an independent variable?

a. potential difference b. electric resistance c. electric current d. electric wire

16. The following values of the angles of reflection (r): 25.0^0, 29.5^0, 40.5^0, 55.0^0 and 59.5^0 were measured for these values of angles of incidence (i): 25.5^0, 30.5^0, 40.0^0, 55.0^0 and 60.0^0 respectively. Construct a table of readings to summarize the measurements.

a.

i	25.0^0	29.5^0	40.5^0	55.0^0	59.5^0
r	25.5^0	30.5^0	40.0^0	55.0^0	60.0^0

b.

i	25.5^0	30.5^0	40.0^0	55.0^0	60.0^0
r	29.5^0	40.5^0	25.0^0	59.5^0	55.0^0

c.

i	25.0^0	29.5^0	40.5^0	55.0^0	59.5^0
r	59.5^0	55.0^0	40.5^0	29.5^0	25.0^0

d.

i	25.5^0	30.5^0	40.0^0	55.0^0	60.0^0
r	25.0^0	29.5^0	40.5^0	55.0^0	59.5^0

17. The following measurements were taken for potential difference (V/V): 0.90, 1.70, 2.40, 3.00 and 3.20; and electric current (I/A): 0.32, 0.54, 0.86, 1.10 and 1.40 respectively. Construct a table of readings to summarize the measurements.

a.

I/A	0.90	0.70	2.40	3.00	3.20
V/V	0.32	0.54	0.86	1.10	1.40

b.

I/A	0.32	0.54	0.86	1.10	1.40
V/V	0.90	1.70	2.40	3.00	3.20

c.

I/A	0.90	29.5^0	2.40	3.00	3.20
V/V	1.40	1.10	0.86	0.54	0.32

d.

I/A	1.40	1.10	0.86	0.54	0.32
V/V	0.90	1.70	2.40	3.00	3.20

18. How are the values of electric current related to the values of potential difference in the table of readings given below?

I/A	0.70	1.40	0.80	2.10	2.15
V/V	0.15	0.40	0.50	0.60	0.65

a. The values of electric current increase as the values of potential difference decrease.

b. The values of electric current increase whereas the values of potential difference remain constant.

c. The values of electric current increase as the values of potential difference increase.

d. The values of electric current decrease as the values of potential difference increase.

19. What is the relationship between the angles of incidence and reflection of light in the table of readings given below?

i	20.0^0	30.0^0	40.0^0	50.0^0	60.0^0
r	20.0^0	30.0^0	40.0^0	50.0^0	60.0^0

a. The angles of incidence decrease as the angles of reflection increase.

b. The angles of incidence increase as the angles of reflection decrease.

c. The angles of incidence remain constant as the angles of reflection increase.

d. The angles of incidence and reflection are the same.

20.

i	15.0^0	30.0^0	45.0^0	-	67.0^0
r	15.0^0	30.0^0	-	52.0^0	67.0^0

The missing values of i and r in the table of readings given above are:

a. i = 45.0^0 and r = 52.0^0 b. i = 52.0^0 and r = 45.0^0

c. i = 30.0^0 and r = 67.0^0 d. i = 15.0^0 and 30.0^0

21.

I/A	0.20	0.45	0.70	0.90	1.05
V/V	0.70	1.60	2.45	3.00	3.70

If the value of electric current, I, is increased, what will happen to the value of potential difference, V?

a. It will decrease b. It will remain the same

c. It will increase d. It will become negative

APPENDIX IIIB

ANSWER SHEET

SCIENCE PROCESS SKILLS TEST IN BASIC SCIENCE (SPSTBS)

Student's Name:

School:

Class:

Gender: Male ( ) Female ( )

Date:

Instruction: Kindly tick (√) the correct option from letters a – d.

S/N	a	B	C	d
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				

APPENDIX IIIC

MODEL ANSWERS TO SCIENCE PROCESS SKILLS TEST IN BASIC SCIENCE (SPSTBS)

1.	c	11.	a
2.	b	12.	d
3.	d	13.	b
4.	a	14.	d
5.	b	15.	c
6.	c	16.	d
7.	d	17.	b
8.	b	18.	c
9.	d	19.	d
10.	c	20.	b
		21.	c

APPENDIX IV

INSTRUCTIONAL GUIDE ON SIMULATED LABORATORY (IGSL) EXPERIMENTS

Lesson Note I

Subject: Basic Science

Topic: Reflection of light at a plane surface

Duration: 40minutes

Instructional objectives:

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

i. Define reflection of light.

ii. Define the following terms associated with reflection of light at a plane surface: reflecting surface, incident ray, point of incidence, reflected ray, normal, angle of incidence, angle of reflection, and glancing angle.

iii. Draw a ray diagram showing reflection of light at a plane mirror surface and label its various parts correctly.

Introduction:

The teacher asks the students the following questions on the previous knowledge:

Question: What is light?

Answer: Light is a form of energy which enables us to see things in our environment as it falls on them. It can be changed to another form of energy.

Question: Does light travel along straight or curved paths?

Answer: Light travels along straight paths.

Question: What is a ray of light?

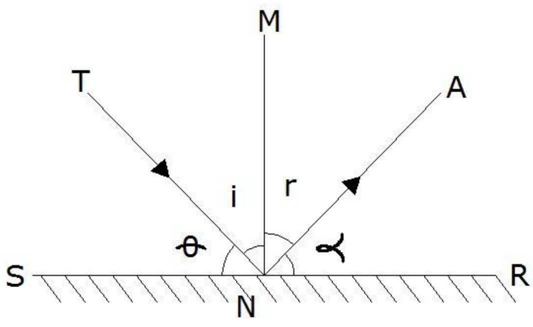
Answer: A ray of light is the path taken by light energy. It is usually represented by a directed line segment.

Question: What happen to light energy when it falls on an object?

Answer: Light energy is either absorbed or sent back by the object on which it falls.

Contents:

1. Definition of reflection of light.
2. Definition of terms associated with reflection of light.
3. A well labelled ray diagram showing reflection of light.



SR – Plane reflecting surface e.g. plane mirror.

TN – Incident ray.

N - Point of incidence.

NA - Reflected ray.

NM – Normal.

i - Angle of incidence.

r - Angle of reflection.

θ, α - Glancing angles.

Reflection of Light at a Plane Surface.

Presentation of the contents by the teacher:

STEP I – Introduction.

STEP II – Defines reflection of light.

STEP III – Lists and explains the terms associated with reflection of light at a plane surface.

STEP IV – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Define reflection of light.
2. Draw a well labelled diagram to show how light energy could be reflected at a plane surface.

Teacher's activities:

1. Introduces the lesson.
2. Defines reflection of light.
3. Lists and uses appropriate chart to explain the terms associated with reflection of light at a plane surface.

4. Provides answers to students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note II

Subject: Basic Science

Topic: Reflection of light at plane surface

Duration: 40minutes

Instructional objectives:

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

i. State the relationship between angles of incidence and reflection of light.
ii. List five characteristics of the image of an object formed in a plane mirror.

Introduction:

The teacher asks the students to draw a well labelled diagram to show how light energy could be reflected at the surface of a plane mirror.

Contents:

1. Relationship between angles of incidence and reflection of light.
2. Characteristics of the image of an object formed in a plane mirror.

Presentation of the contents by the teacher:

STEP I - Introduction.

STEP II - States the relationship between angles of incidence and reflection of light.

STEP III - Lists and explains five characteristics of the image of an object formed in a plane mirror.

STEP V: Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. State the relationship between the angles of incidence and reflection of light.
2. List five characteristics of the image of an object formed in a plane mirror.

Teacher's activities:

1. Introduces the lesson.
2. States the relationship between angles of incidence and reflection of light.
3. Lists and explains five characteristics of the image of an object formed in a plane mirror.
4. Provides answers to students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer evaluation questions.

Lesson Note III

Subject: Basic Science

Topic: Experiment on reflection of light at plane surface

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on reflection of light at a plane mirror surface.
ii. Locate images of objects in a plane mirror by no parallax method.
iii. Measure the angles of incidence and reflection correctly for the glancing angles: 70^0, 60^0, 50^0, 40^0 and 30^0.
iv. Record their observations using the given format.
v. Measure and record the angles of incidence and reflection correctly for glancing angle of 90^0.
vi. State the relationship between the angles of incidence and reflection of light.

Introduction:

The teacher asks the students to state the relationship between the angles of incidence and reflection of light.

Contents:

1. Setting up the experiment on reflection of light at a plane mirror surface.
2. Locating images of objects in a plane mirror by no parallax method.
3. Measuring angles of incidence and reflection.
4. Constructing a table of readings.

Presentation of the contents by the teachers:

STEP I – Introduction (States the aim of the experiment).

STEP II - Selects the simulated laboratory experiment on reflection of light from the stand-alone software installed on the computer.

STEP III - Demonstrates how to conduct the simulated laboratory experiment on reflection of light and generate model readings.

STEP IV - Answers students' questions.

STEP V - Puts students in groups of three, let them set up and perform the simulated laboratory experiment to generate individual readings for glancing angles $\theta = 70^0$, 60^0, 50^0, 40^0 and 30^0.

STEP VI - Supervises students during the conduct of the experiment and attends to their challenges.

STEP VII - Asks each student to measure and record the values of i and r on his /her table of readings using the given format.

STEP VIII – Asks students to guess the relationship between angles of incidence and reflection for glancing angle 90^0.

STEP IX – Instructs the students to set up and perform the simulated laboratory experiment for glancing angle $\theta = 90^0$ (Activity I).

STEP IX – Supervises students work and attend to their individual challenges.

STEP XI – Asks each student to measure and record the values of i and r for $\theta = 90^0$.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. What is the relationship between the angles of incidence and reflection?
2. What will be the direction of the new reflected ray if the new incident ray replaces the old reflected ray?

Teacher's activities:

1. Sets up simulated laboratory experiment on reflection of light and demonstrates how to perform it.
3. Answers students' questions on the demonstrated experiment.
4. Supervises students as they perform the simulated laboratory experiment on reflection of light.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Set up the simulated laboratory experiment.
3. Conduct the simulated laboratory experiment for glancing angles $\theta = 70^0$, 60^0, 50^0, 40^0 and 30^0.
4. Measure the corresponding angles of incidence and reflection.
5. Construct individual table of readings.
6. Record measured values on the table.
7. Deduce relationship between angles of incidence and reflection from their measured values.
8. Guess the relationship between angles of incidence and reflection for glancing angle 90^0.
9. Conduct the simulated experiment for glancing angle $\theta = 90^0$ (Activity I).
10. Measure and record the angles of incidence and reflection for glancing angle $\theta = 90^0$.
11. Deduce relationship between angles of incidence and reflection for glancing angle 90^0.
12. Compare hypothesized relationship between angles of incidence and reflection with deduced relationship.
13. Ask questions when necessary.
14. Answer evaluation questions.

Lesson Note IV

Subject: Basic Science

Topic: Electric cell

Duration: 40minutes

Instructional objectives:

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

i. Define an electric cell.

ii. Describe an electric cell in its basic form.

iii. List and explain basic components of an electric cell.

Introduction:

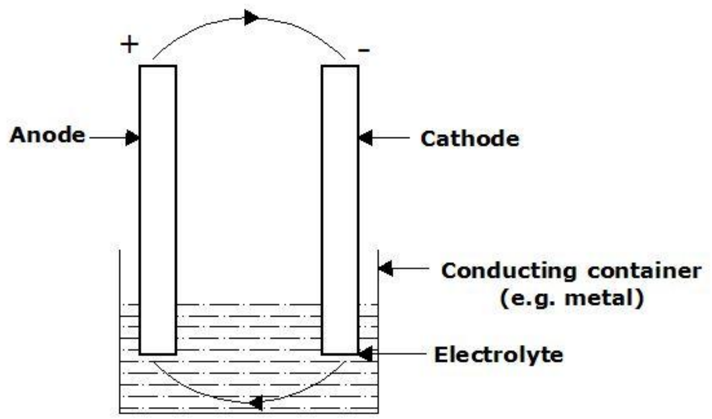
The teacher asks the students this question:

Question: Mention all sources of electricity that you know.

Answer: Ibadan Electricity Distribution Company (IBEDC) Plc, Battery, Electric Generator (or Dynamo), Solar inverter (e.g. Solar Lamp), etc.

Contents:

1. Definition of an electric cell.
2. Description of an electric cell.
3. A well labelled diagram of a simple cell.
4. List and explain basic components of an electric cell.



A Simple Cell

NB: Current of negative charges is shown with arrows.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Defines an electric cell.

STEP III – Uses a well labelled diagram to describe an electric cell.

STEP IV – Explains the following components of an electric cell: conducting container, electrodes (cathode and anode) and electrolyte.

STEP V – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Define an electric cell.
2. Draw a well labelled diagram of a simple cell.
3. List and explain three basic components of an electric cell.

Teacher's activities:

1. Introduces the lesson.
2. Defines an electric cell.
3. Uses a well labelled diagram to describe an electric cell.
4. Lists and explains basic components of an electric cell.
5. Provides answers to students' questions.
6. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note V

Subject: Basic Science

Topic: Introduction to electric circuit

Duration: 40minutes

Instructional objectives:

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

i. Define electric current, potential difference, resistance and electromotive force of a cell.

ii. Identify instruments for measuring electric current and potential difference.

iii. Distinguish between original and conventional directions of an electric current.

iv. Draw and label common electrical symbols.

v. Define an electric circuit.

vi. Distinguish between open and closed electric circuits.

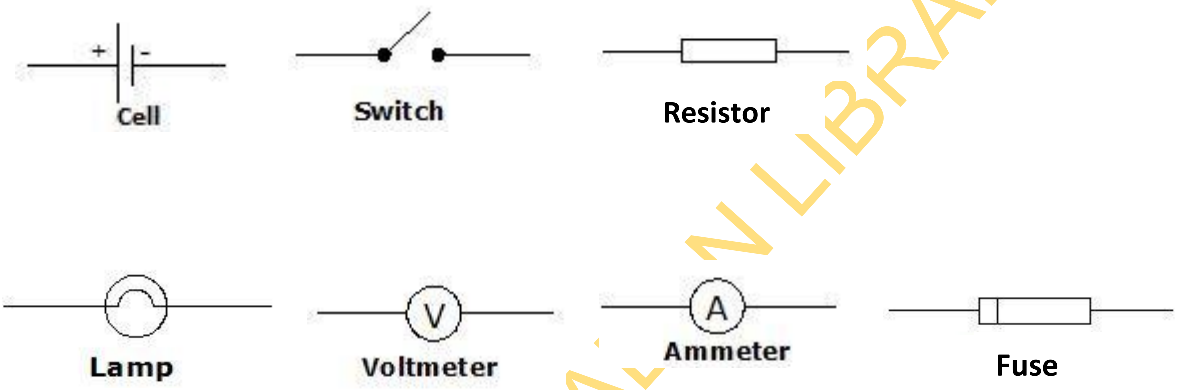
Introduction:

The teacher asks the students these questions:

1. Define an electric cell.
2. Draw a well labeled diagram of a simple cell.
3. Briefly explain the functions of an electrolyte and the two electrodes in an electric cell.

Contents:

1. Definition of electric current, potential difference, resistance and electromotive force (emf.) of a cell.
2. Ammeter as current-measuring instrument and voltmeter as potential difference –measuring instrument.
3. Distinction between original and conventional directions of an electric current.
4. A well labelled diagram of common electrical symbols.



Some Common Electrical Symbols.

5. Definition of an electric circuit.
6. Distinction between open and closed electric circuits.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Defines electric current, potential difference, resistance and electromotive force (e.m.f) of a cell.

STEP III – Shows an ammeter as a current-measuring instrument and a voltmeter as a potential difference – measuring instrument.

STEP IV – Distinguishes between original and conventional directions of an electric current.

STEP V – Lists common electrical components and draw their symbols.

STEP VI – Defines an electric circuit.

STEP VII – Distinguishes between open and closed electric circuits.

STEP VIII – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students to answer the following questions:

1. Define electric current, potential difference, resistance and electromotive force of a cell.
2. Which instrument measures: i. electric current and ii. potential difference.
3. Distinguish between original and conventional directions of an electric current.
4. Draw the symbols of a cell, plug key, resistance box, resistor, ammeter, voltmeter, wires joined and wires crossed.
5. Define an electric circuit.
6. Distinguish between open and closed circuits.

Teacher's activities:

1. Introduces the lesson.
2. Shows instruments for measuring electric current and potential difference to the students.
3. Explains the difference between original and conventional directions of an electric current.
4. Shows common electrical symbols on an appropriate chart to the students.
5. Defines an electric circuit.
6. Explains the difference between open and closed electric circuits.
7. Answers students' questions.
8. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note VI

Subject: Basic Science

Topic: Networking in electric circuits

Duration: 40minutes

Instructional objectives:

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

i. Draw, correctly, labelled diagrams showing series network of electric cells and series arrangement of electrical resistors.

ii. Draw, correctly, labelled diagrams showing parallel network of electric cells and parallel arrangement of electrical resistors.

ii. Determine the positions of an ammeter in an electric circuit involving series and parallel network of resistors.

iii. Determine the positions of a voltmeter in an electric circuit involving series and parallel network of resistors.

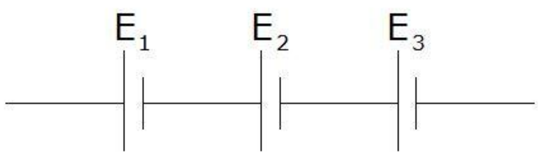
Introduction: The teacher asks the students the following questions on the previous knowledge:

1. Define the e.m.f. of a cell and electrical resistance.
2. Draw the electrical symbols of a cell and resistors.

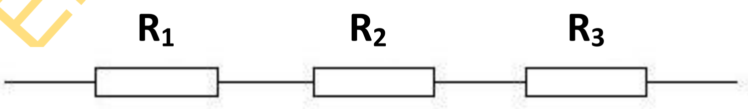
Contents:

1. Well labeled diagram of:

   i. Cells connected in series

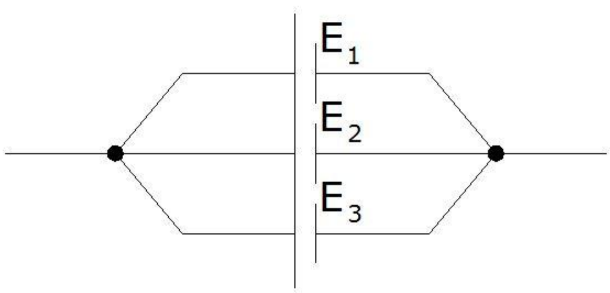


   ii. Resistors connected in series

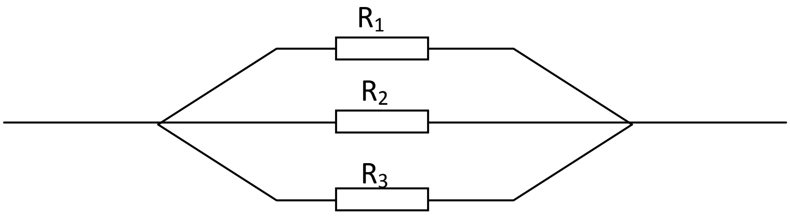


4. Well labelled diagram of:

   i. Cells connected in parallel



ii. Resistors connected in parallel



7. Position of an ammeter in an electric circuit – Always connect ammeter in series with the component which electric current is to be measured.

8. Position of a voltmeter in an electric circuit – Always connect voltmeter in parallel with the component which potential difference is to be measured.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Leads the students to draw series arrangement of:
i. three electric cells and ii. three electrical resistors.

STEP III – Explains the position of an ammeter in an electric circuit.

STEP IV – Explains the position of a voltmeter in an electric circuit.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Draw circuit diagrams for two resistors connected in: i. series ii. parallel.
2. How should: i. an ammeter and ii. a voltmeter be positioned in an electric circuit?

Teacher's activities:

1. Introduces the lesson.
2. Leads the students to draw: i. series and ii. parallel arrangement of – i. three electric cells and ii. three resistors in an electric circuit.
3. Explains the position of: i. an ammeter and ii. a voltmeter in an electric circuit.
4. Answers students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note VII

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using one resistor)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using one resistor only.

ii. Use an ammeter to measure the electric current, I, passing through a resistor for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of a resistor for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between potential difference and electric current.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for one resistor (i.e. Main Experiment).
2. Measurement of electric current passing through a resistor.
3. Measurement of potential difference across the ends of a resistor.
4. Construction of a table of values.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Selects the simulated laboratory experiment on relationship between potential difference and electric current for one resistor (Main Experiment) from the stand-alone software installed on the computer.

STEP III – Demonstrates how to conduct the simulated laboratory experiment on relationship between potential difference and electric current for one resistor (Main Experiment) and generate model readings.

STEP IV – Answers students' questions.

STEP V – Puts students in groups of five, let them set up and perform the simulated laboratory experiment to generate individual readings for e.m.f.s, E = 1.5V, 3.0V, 4.5V, 6.0V and 7.5V.

STEP VI – Supervises students' work and attend to individual challenges.

STEP VII – Asks the students to measure and record the values of V and I on their tables of readings using the given format.

Evaluation of the lesson by the teacher:

Asks the students to state how potential difference is related to electric current for a given value of the resistor?

Teacher's activities:

1. Sets up simulated laboratory experiment on relationship between potential difference and electric current for one resistor (Main Experiment) and demonstrates how to perform it.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands.
4. Supervises students as they perform the simulated laboratory experiment on relationship between potential difference and electric current for one resistor.
5. Attends to individual student's challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Set up the simulated laboratory experiment.
3. Conduct the simulated laboratory experiment for e.m.f.s, E = 1.5V, 3.0V, 4.5, 6.0V and 7.5V.
4. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the resistor.
5. Construct individual table of readings.
6. Record measured values on the tables.
7. Deduce the relationship between potential difference and electric current for one resistor.
8. Ask questions when necessary.
9. Answer evaluation questions.

Lesson Note VIII

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using two resistors connected in series)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using two resistors connected in series.

ii. Use an ammeter to measure the electric current, I, passing through the resistors for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of the series combination of two resistors for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for two resistors connected in series (Activity I).
2. Measurement of electric current passing through the series combination of two resistors.
3. Measurement of potential difference across the ends of the series combination of two resistors.
4. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Selects the simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in series (Activity I) from the stand-alone software installed on the computer.

STEP III – Demonstrates how to conduct the simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in series (Activity I) and generate model readings.

STEP IV – Answers students' questions.

STEP V – Puts students in groups of five, let them set up and perform the simulated laboratory experiment to generate individual readings for e.m.f.s, E = 1.5V, 3.0V, 4.5V, 6.0V and 7.5V.

STEP VI – Supervises students' work and attend to individual challenges.

STEP VII – Asks the students to measure and record the values of V and I on their tables of readings using the given format.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given effective value of the series combination of resistors?

Teacher's activities:

1. Sets up simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in series (Activity I) and demonstrates how to perform it.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands.
4. Supervises students as they perform the simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in series.
5. Attends to individual student's challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Guess the relationship between potential difference and electric current for two resistors connected in series.
2. Observe the demonstrational experiment.
3. Set up the simulated laboratory experiment.
4. Conduct the simulated laboratory experiment for e.m.f.s, E = 1.5V, 3.0V, 4.5, 6.0V and 7.5V.
5. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of series combination of the resistors.
6. Construct individual table of readings.
7. Record measured values on the table.
8. Deduce relationship between potential difference and electric current for two resistors connected in series.

9. Compare hypothesized relationship between potential difference and electric current with the deduced relationship.
10. Ask questions when necessary.
11. Answer evaluation questions.

Lesson Note IX

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using two resistors connected in parallel)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current for two resistors connected in parallel.

ii. Use an ammeter to measure the electric current passing through the resistors for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference across the ends of the parallel combination two resistors for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for two resistors connected in parallel (Activity II).
2. Measurement of electric current passing through the parallel combination of two resistors.
3. Measurement of potential difference across the ends of the parallel combination of two resistors.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Selects the simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in parallel (Activity II) from the stand-alone software installed on the computer.

STEP III – Demonstrates how to conduct the simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in parallel (Activity II) and generate model readings.

STEP IV – Answers students' questions.

STEP V - Puts students in groups of five, let them set up and perform the simulated laboratory experiment to generate individual readings for e.m.f.s, E = 1.5V, 3.0V, 4.5V, 6.0V and 7.5V.

STEP VI – Supervises students' work and attend to individual challenges.

STEP VII – Asks the students to measure and record the values of V and I on their tables of readings using the given format.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given effective value of the parallel combination of resistors?

Teacher's activities:

1. Sets up simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in parallel (Activity II) and demonstrates how to perform it.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in group of five, to experimental stands.
4. Supervises students as they perform the simulated laboratory experiment on relationship between potential difference and electric current for two resistors connected in parallel.
5. Attends to individual student's challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Guess the relationship between potential difference and electric current for two resistors connected in parallel.

2. Observe the demonstrational experiment.
3. Set up the simulated laboratory experiment.
4. Conduct the simulated laboratory experiment for e.m.f.s, E = 1.5V, 3.0V, 4.5, 6.0V and 7.5V.
5. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of parallel combination of the resistors.
6. Construct individual table of readings.
7. Record measured values on the tables.
8. Deduce relationship between potential difference and electric current for two resistors connected in parallel.
9. Compare hypothesized relationship between potential difference and electric current with the deduced relationship.
10. Ask questions when necessary.
11. Answer evaluation questions.

APPENDIX V

INSTRUCTIONAL GUIDE ON ENRICHED LABORATORY GUIDE MATERIAL (IGELGM) EXPERIMENTS

Lesson Note I

Subject: Basic Science

Topic: Reflection of light at a plane surface

Duration: 40minutes

Instructional objectives:

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

i. Define reflection of light.

ii. Define the following terms associated with reflection of light at a plane surface: reflecting surface, incident ray, point of incidence, reflected ray, normal, angle of incidence, angle of reflection, and glancing angle.

iii. Draw a ray diagram showing reflection of light at a plane mirror surface and label its various parts correctly.

Introduction:

The teacher asks the students the following questions on the previous knowledge:

Question: What is light?

Answer: Light is a form of energy which enables us to see things in our environment as it falls on them. It can be changed to another form of energy.

Question: Does light travel along straight or curved paths?

Answer: Light travels along straight paths.

Question: What is a ray of light?

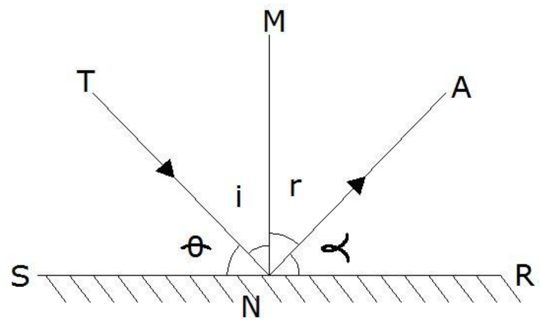
Answer: A ray of light is the path taken by light energy. It is usually represented by a directed line segment.

Question: What happen to light energy when it falls on an object?

Answer: Light energy is either absorbed or sent back by the object on which it falls.

Contents:

1. Definition of reflection of light.
2. Definition of terms associated with reflection of light.
3. A well labelled ray diagram showing reflection of light.



SR – Plane reflecting surface e.g. plane mirror.

TN – Incident ray.

N - Point of incidence.

NA - Reflected ray.

NM – Normal.

i - Angle of incidence.

r - Angle of reflection.

θ, α - Glancing angles.

Reflection of Light at a Plane Surface

Presentation of the contents by the teacher:

STEP I – Introduction.

STEP II – Defines reflection of light.

STEP III – Lists and explains the terms associated with reflection of light at a plane surface.

STEP IV – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Define reflection of light.
2. Draw a well labelled diagram to show how light energy could be reflected at a plane surface.

Teacher's activities:

1. Introduces the lesson.
2. Defines reflection of light.
3. Lists and uses appropriate chart to explain the terms associated with reflection of light at a plane surface.
4. Provides answers to students' questions.

5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note II

Subject: Basic Science

Topic: Reflection of light at plane surface

Duration: 40minutes

Instructional objectives:

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

i. State the relationship between angles of incidence and reflection of light.

ii. List five characteristics of the image of an object formed in a plane mirror.

Introduction:

The teacher asks the students to draw a well labelled diagram to show how light energy could be reflected at the surface of a plane mirror.

Contents:

1. Relationship between angles of incidence and reflection of light.
2. Characteristics of the image of an object formed in a plane mirror.

Presentation of the contents by the teacher:

STEP I - Introduction.

STEP II - States the relationship between angles of incidence and reflection of light.

STEP III - Lists and explains five characteristics of the image of an object formed in a plane mirror.

STEP V - Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. State the relationship between the angles of incidence and reflection of light.
2. List five characteristics of the image of an object formed in a plane mirror.

Teacher's activities:

1. Introduces the lesson.
2. States the relationship between angles of incidence and reflection of light.
3. Lists and explains five characteristics of the image of an object formed in a plane mirror.
4. Provides answers to students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer evaluation questions.

Lesson Note III

Subject: Basic Science

Topic: Experiment on reflection of light at plane surface

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on reflection of light at a plane mirror surface.

ii. Locate images of objects in a plane mirror by no parallax method.

iii. Measure the angles of incidence and reflection correctly for the glancing angles: 70^0, 60^0, 50^0, 40^0 and 30^0.

iv. Record their observations using the given format.

viii. Measure and record the angles of incidence and reflection correctly for glancing angle of 90^0.

Introduction:

The teacher asks the students to state the relationship between angles of incidence and reflection of light.

Contents:

1. Setting up the experiment on reflection of light at a plane mirror surface.
2. Locating images of objects in a plane mirror by no parallax method.
3. Drawing ray diagrams on the drawing sheet/tracing paper.
4. Constructing normal at the point of incidence.

5. Measuring angles of incidence and reflection.
6. Constructing a table of readings.

Presentation of the contents by the teachers:

STEP I - Introduction (States the aim of the experiment).

STEP II – Demonstrates how to conduct the experiment on reflection of light using real apparatus and following the procedure of experiment one in the Enriched Laboratory Guide Material (ELGM) on Basic Science.

STEP III - Answers students' questions.

STEP IV - Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP V – Asks students to follow the procedure of experiment one in the ELGM to generate group readings for glancing angles $\theta = 70^0$, 60^0, 50^0,40^0 and 30^0.

STEP VI - Asks students to guess the relationship between angles of incidence and reflection for glancing angle 90^0.

STEP VII – Asks students to repeat the procedure for angle $\theta = 90^0$ (Activity I in the ELGM), measure and record the corresponding values of i and r.

STEP VIII - Supervises students during the conduct of the experiment and attend to their challenges.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. What is the relationship between the angles of incidence and reflection?
2. What will be the direction of the new reflected ray if the new incident ray replaces the old reflected ray?

Teacher's activities:

1. States the aim of the experiment.
2. Sets up experiment on reflection of light using real apparatus and demonstrates how to carry out the procedure in experiment one of the ELGM.
3. Answers students' questions on the demonstrated experiment.
4. Assigns students in groups of five to experimental stands in the physical laboratory.

5. Supervises students as they perform experiment one in the ELGM using real apparatus.
6. Attends to group challenges.
7. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Follow the procedure in the ELGM to conduct experiment one for glancing angles $\theta = 70^0, 60^0, 50^0, 40^0$ and 30^0 using real apparatus.
3. Measure the corresponding angles of incidence and reflection.
4. Construct individual table of readings.
5. Record measured values on the table.
6. Deduce the relationship between angles of incidence and reflection from measured values.
7. Guess the relationship between angles of incidence and reflection for glancing angle 90^0.
8. Conduct the experiment in Activity One of experiment one of the ELGM.
9. Measure and record the angles of incidence and reflection for glancing angle $\theta = 90^0$.
10. Deduce the relationship between angles of incidence and reflection for glancing angle $\theta = 90^0$.
11. Compare hypothesized relationship between angles of incidence and reflection with deduced relationship.
12. Ask questions when necessary.
13. Answer evaluation questions.

Lesson Note IV

Subject: Basic Science

Topic: Electric cell

Duration: 40minutes

Instructional objectives:

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

i. Define an electric cell.

ii. Describe an electric cell in its basic form.

iii. List and explain basic components of an electric cell.

Introduction:

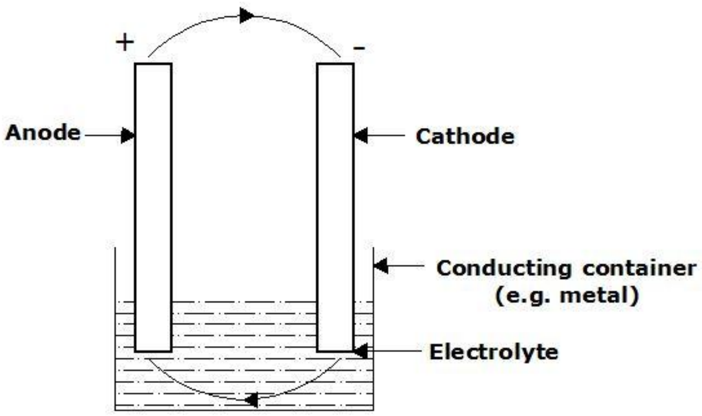
The teacher asks the students this question:

Question: Mention all sources of electricity that you know.

Answer: Ibadan Electricity Distribution Company (IBEDC) Plc, Battery, Electric Generator (or Dynamo), Solar inverter (e.g. Solar Lamp), etc.

Contents:

1. Definition of an electric cell.
2. Description of an electric cell.
3. A well labelled diagram of a simple cell.
4. List and explain basic components of an electric cell.



A Simple Cell

NB: Current of negative charges is shown with arrows.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Defines an electric cell.

STEP III – Uses a well labelled diagram to describe an electric cell.

STEP IV – Explains the following components of an electric cell: conducting container, electrodes (cathode and anode) and electrolyte.

STEP V – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Define an electric cell.

2. Draw a well labelled diagram of a simple cell.
3. List and explain three basic components of an electric cell.

Teacher's activities:

1. Introduces the lesson.
2. Defines an electric cell.
3. Uses a well labeled diagram to describe an electric cell.
4. Lists and explains basic components of an electric cell.
5. Provides answers to students' questions.
6. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note V

Subject: Basic Science

Topic: Introduction to electric circuit

Duration: 40minutes

Instructional objectives:

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

i. Define electric current, potential difference, resistance and electromotive force of a cell.
ii. Identify instruments for measuring electric current and potential difference.
iii. Distinguish between original and conventional directions of an electric current.
iv. Draw and label common electrical symbols.
v. Define an electric circuit.
vi. Distinguish between open and closed electric circuits.

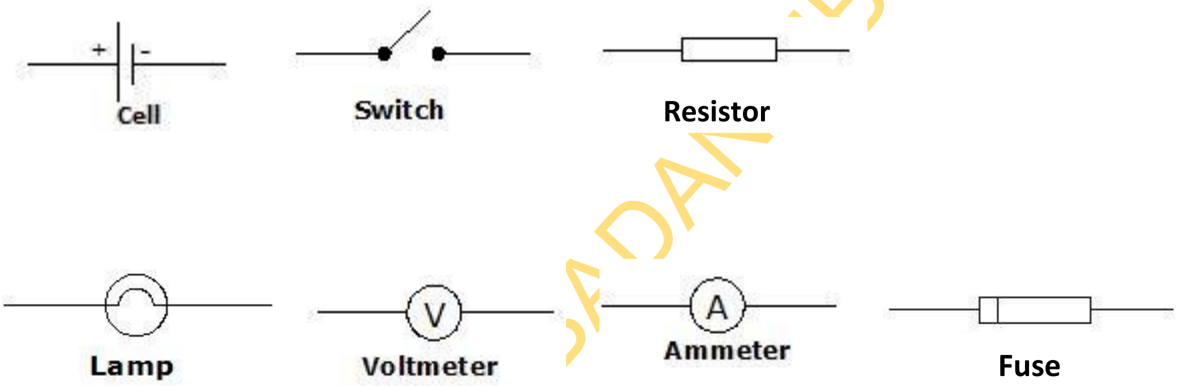
Introduction:

The teacher asks the students these questions:

1. Define an electric cell.
2. Draw a well labelled diagram of a simple cell.
3. Briefly explain the functions of an electrolyte and the two electrodes in an electric cell.

Contents:

1. Definition of electric current, potential difference, resistance and electromotive force (emf.) of a cell.
2. Ammeter as current-measuring instrument and voltmeter as potential difference –measuring instrument.
3. Distinction between original and conventional directions of an electric current.
4. A well labelled diagram of common electrical symbols.
5. Definition of an electric circuit.
6. Distinction between open and closed electric circuits.



Some Common Electrical Symbols.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Defines electric current, potential difference, resistance and electromotive force (e.m.f) of a cell.

STEP III – Shows an ammeter as a current-measuring instrument and a voltmeter as a potential difference – measuring instrument.

STEP IV – Distinguishes between original and conventional directions of an electric current.

STEP V – Lists common electrical components and draw their symbols.

STEP VI – Defines an electric circuit.

STEP VII – Distinguishes between open and closed electric circuits.

STEP VIII – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students to answer the following questions:

1. Define electric current, potential difference, resistance and electromotive force of a cell.
2. Which instrument measures: i. electric current and ii. potential difference.
3. Distinguish between original and conventional directions of an electric current.
4. Draw the symbols of a cell, plug key, resistance box, resistor, ammeter, voltmeter, wires joined and wires crossed.
5. Define an electric circuit.
6. Distinguish between open and closed circuits.

Teacher's activities:

1. Introduces the lesson.
2. Shows instruments for measuring electric current and potential difference to the students.
3. Explains the difference between original and conventional directions of an electric current.
4. Shows common electrical symbols on an appropriate chart to the students.
5. Defines an electric circuit.
6. Explains the difference between open and closed electric circuits.
7. Answers students' questions.
8. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note VI

Subject: Basic Science

Topic: Networking in electric circuits

Duration: 40minutes

Instructional objectives:

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

i. Draw, correctly, labelled diagrams showing series network of electric cells and series arrangement of electrical resistors.

ii. Draw, correctly, labelled diagrams showing parallel network of electric cells and parallel arrangement of electrical resistors.

iii. Determine the positions of an ammeter in an electric circuit involving series and parallel network of resistors.

iv. Determine the positions of a voltmeter in an electric circuit involving series and parallel network of resistors.

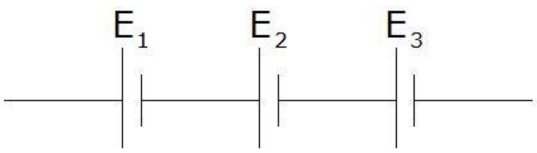
Introduction: The teacher asks the students the following questions on the previous knowledge:

1. Define the e.m.f. of a cell and electrical resistance.
2. Draw the electrical symbols of a cell and resistors.

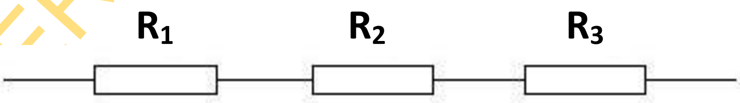
Contents:

1. Well labeled diagram of:

i. Cells connected in series

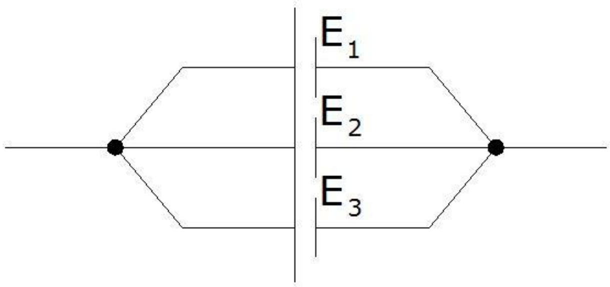


ii. Resistors connected in series

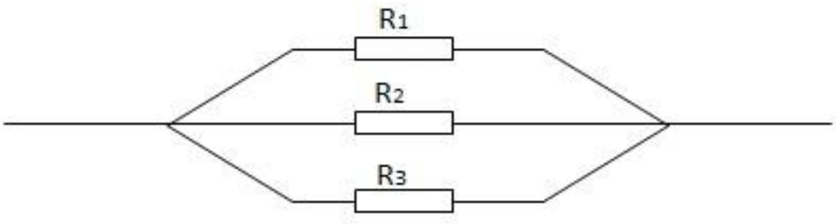


4. Well labelled diagram of:

i. Cells connected in parallel



ii. Resistors connected in parallel



7. Position of an ammeter in an electric circuit – Always connect ammeter in series with the component which electric current is to be measured.
8. Position of a voltmeter in an electric circuit – Always connect voltmeter in parallel with the component which potential difference is to be measured.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Leads the students to draw series arrangement of:
i. three electric cells and ii. three electrical resistors.

STEP III – Explains the position of an ammeter in an electric circuit.

STEP IV – Explains the position of a voltmeter in an electric circuit.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Draw circuit diagrams for two resistors connected in: i. series ii. parallel.
2. How should: i. an ammeter and ii. a voltmeter be positioned in an electric circuit?

Teacher's activities:

1. Introduces the lesson.
2. Leads the students to draw: i. series and ii. parallel arrangement of – i. three electric cells and ii. three resistors in an electric circuit.
3. Explains the position of: i. an ammeter and ii. a voltmeter in an electric circuit.
4. Answers students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note VII

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using one resistor)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using one resistor only.

ii. Use ammeter to measure the electric current, I, passing through a resistor for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of the resistor for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for one resistor.
2. Measurement of electric current passing through a resistor.
3. Measurement of potential difference across the ends of a resistor.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates how to conduct the experiment on relationship between potential difference and electric current for one resistor using real apparatus and following the procedure for experiment two in the ELGM.

STEP III – Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP IV – Asks students to perform experiment two in the ELGM using real apparatus.

STEP V – Supervises students' work and attend to group challenges.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given value of the resistor?

Teacher's activities:

1. Sets up experiment on relationship between potential difference and electric current for one resistor using real apparatus and demonstrates how to carry out the procedure for experiment two in the ELGM.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform experiment two in the ELGM using real apparatus.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Follow the procedure in ELGM to conduct experiment two using real apparatus for e.m.f.s, E = 1.5V, 3.0V, 4.5, 6.0V and 7.5V.
3. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the resistor.
4. Construct individual table of readings.
5. Record measured values on the table.
6. Deduce the relationship between potential difference and electric current for one resistor.
7. Ask questions when necessary.
8. Answer evaluation questions.

Lesson Note VIII

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using two resistors connected in series)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using two resistors connected in series.

ii. Use ammeter to measure the electric current, I, passing through the resistors for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of the series combination of two resistors for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for two resistors connected in series (Activity I).
2. Measurement of electric current through the series combination of two resistors.
3. Measurement of potential difference across the ends of the series combination of two resistors.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates experiment on relationship between potential difference and electric current for two resistors connected in series using real apparatus and following the procedure for Activity one of experiment two in the enriched laboratory guide material (ELGM) on Basic Science.

STEP III – Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP IV – Asks students to perform experiment two (Activity One) in the ELGM using real apparatus.

STEP V – Supervises students' work and attend to group challenges.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given effective value of the series combination of resistors?

Teacher's activities:

1. Sets up experiment on relationship between potential difference and electric current for two resistors connected in series using real apparatus and demonstrates how to carry out the procedure for experiment two (Activity One) in the ELGM.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform experiment two in the ELGM using real apparatus.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Guess the relationship between potential difference and electric current for two resistors connected in series.
2. Observe the demonstrational experiment.
3. Follow the procedure in ELGM to conduct experiment two using real apparatus E, = 1.5V.
4. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the series combination of the resistors.
5. Construct table of readings.
6. Record measured values on the table of readings.
7. Deduce the relationship between potential difference and electric current for two resistors connected in series.
8. Compare the hypothesized relationship between potential difference and electric current with the deduced relationship.
9. Ask questions when necessary.
10. Answer evaluation questions.

Lesson Note IX

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using two resistors connected in parallel)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using two resistors connected in parallel.

ii. Use ammeter to measure the electric current passing through the resistors for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference across the ends of the parallel combination of two resistors for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current relationship between potential difference and electric current for two resistors connected in parallel (Activity II).
2. Measurement of electric current through the parallel combination of two resistors.
3. Measurement of potential difference across the ends of the parallel combination of two resistors.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates experiment on relationship between potential difference and electric current for two resistors connected in parallel using real apparatus and following the procedure for Activity Two of experiment two in the enriched laboratory guide material (ELGM) on Basic Science.

STEP III – Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP IV – Asks students to perform experiment two (Activity Two) in the ELGM using real apparatus.

STEP V – Supervises students' work and attend to group challenges.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given effective value of the series combination of resistors.

Teacher's activities:

1. Sets up experiment on relationship between potential difference and electric current for two resistors connected in parallel using real apparatus and demonstrates how to carry out the procedure for experiment two (Activity Two) in the ELGM.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform experiment two (Activity Two) in the ELGM using real apparatus.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Guess the relationship between potential difference and electric current for two resistors connected in parallel.
2. Observe the demonstrational experiment.
3. Follow the procedure in ELGM to conduct experiment two (Activity Two) using real apparatus.
4. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the parallel combination of the resistors.
5. Construct table of readings.
6. Record measured values on the table of readings.
7. Deduce relationship between potential difference and electric current for two resistors connected in parallel.

8. Compare the hypothesized relationship between potential difference and electric current with the deduced relationship.
9. Ask questions when necessary.
10. Answer evaluation questions.

APPENDIX VI

INSTRUCTIONAL GUIDE ON CONVENTIONAL (EXPOSITORY) LABORATORY (IGCEL) EXPERIMENTS

Lesson Note I

Subject: Basic Science

Topic: Reflection of light at a plane surface

Duration: 40minutes

Instructional objectives:

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

i. Define reflection of light.

ii. Define the following terms associated with reflection of light at a plane surface: reflecting surface, incident ray, point of incidence, reflected ray, normal, angle of incidence, angle of reflection, and glancing angle.

iii. Draw a ray diagram showing reflection of light at a plane mirror surface and label its various parts correctly.

Introduction:

The teacher asks the students the following questions on the previous knowledge:

Question: What is light?

Answer: Light is a form of energy which enables us to see things in our environment as it falls on them. It can be changed to another form of energy.

Question: Does light travel along straight or curved paths?

Answer: Light travels along straight paths.

Question: What is a ray of light?

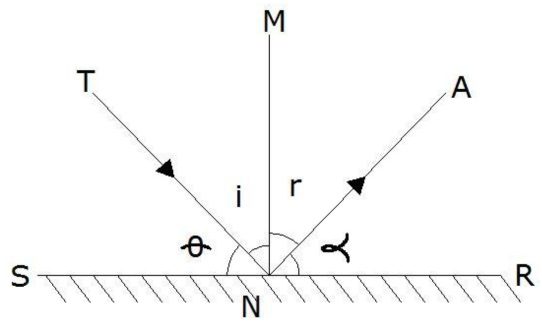
Answer: A ray of light is the path taken by light energy. It is usually represented by a directed line segment.

Question: What happen to light energy when it falls on an object?

Answer: Light energy is either absorbed or sent back by the object on which it falls.

Contents:

1. Definition of reflection of light.
2. Definition of terms associated with reflection of light.
3. A well labelled ray diagram showing reflection of light.



SR – Plane reflecting surface e.g. plane mirror.

TN – Incident ray.

N - Point of incidence.

NA - Reflected ray.

NM – Normal.

i - Angle of incidence.

r - Angle of reflection.

θ, α - Glancing angles.

Reflection of Light at a Plane Surface.

Presentation of the contents by the teacher:

STEP I – Introduction.

STEP II – Defines reflection of light.

STEP III – Lists and explains the terms associated with reflection of light at a plane surface.

STEP IV – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Define reflection of light.
2. Draw a well labelled diagram to show how light energy could be reflected at a plane surface.

Teacher's activities:

1. Introduces the lesson.
2. Defines reflection of light.
3. Lists and uses appropriate chart to explain the terms associated with reflection of light at a plane surface.

4. Provides answers to students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note II

Subject: Basic Science

Topic: Reflection of light at plane surface

Duration: 40minutes

Instructional objectives:

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

i. State the relationship between angles of incidence and reflection of light.
ii. List five characteristics of the image of an object formed in a plane mirror.

Introduction:

The teacher asks the students to draw a well labelled diagram to show how light energy could be reflected at the surface of a plane mirror.

Contents:

1. Relationship between angles of incidence and reflection of light.
2. Characteristics of the image of an object formed in a plane mirror.

Presentation of the contents by the teacher:

STEP I - Introduction.

STEP II - States the relationship between angles of incidence and reflection of light.

STEP III - Lists and explains five characteristics of the image of an object formed in a plane mirror.

STEP V: Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. State the relationship between the angles of incidence and reflection of light.
2. List five characteristics of the image of an object formed in a plane mirror.

Teacher's activities:

1. Introduces the lesson.
2. States the relationship between angles of incidence and reflection of light.
3. Lists and explains five characteristics of the image of an object formed in a plane mirror.
4. Provides answers to students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer evaluation questions.

Lesson Note III

Subject: Basic Science

Topic: Experiment on reflection of light at plane surface

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on reflection of light at a plane mirror surface.

ii. Locate images of objects in a plane mirror by no parallax method.

iii. Measure the angles of reflection correctly for given angles of incidence: 20^0, 30^0, 40^0, 50^0 and 60^0.

iv. Record their observations using the given format.

Introduction:

The teacher asks the students to state the relationship between angles of incidence and reflection of light.

Contents:

1. Setting up the experiment on reflection of light at a plane mirror surface.
2. Locating images of objects in a plane mirror by no parallax method.
3. Drawing ray diagrams on the drawing sheet/tracing paper.
4. Constructing normal at the point of incidence.
5. Measuring angles of reflection for given angles of incidence.
6. Constructing a table of readings.

Presentation of the contents by the teachers:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates how to conduct the experiment on reflection of light using real apparatus.

STEP III - Answers students' questions.

STEP IV - Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP V – Asks students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings for angles of incidence i = 20^0, 30^0, 40^0,50^0 and 60^0.

STEP VI - Supervises students' during the conduct of the experiment and attend to their challenges.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. What is the relationship between the angles of incidence and reflection?
2. What will be the direction of the new reflected ray if the new incident ray replaces the old reflected ray?

Teacher's activities:

1. Sets up experiment on reflection of light using real apparatus and demonstrates how to carry it out.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform experiment on reflection of light using real apparatus.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Follow the procedure as demonstrated by the teacher to perform experiment on reflection of light for angles of incidence i = 20^0, 30^0, 40^0, 50^0 and 60^0 using real apparatus.

3. Measure the corresponding angles of reflection.
4. Construct table of readings.
5. Record measured values on the table of readings.
6. Confirm the relationship between angles of incidence and reflection.
7. Ask questions when necessary.
8. Answer evaluation questions.

Lesson Note IV

Subject: Basic Science

Topic: Electric cell

Duration: 40minutes

Instructional objectives:

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

i. Define an electric cell.

ii. Describe an electric cell in its basic form.

iii. List and explain basic components of an electric cell.

Introduction:

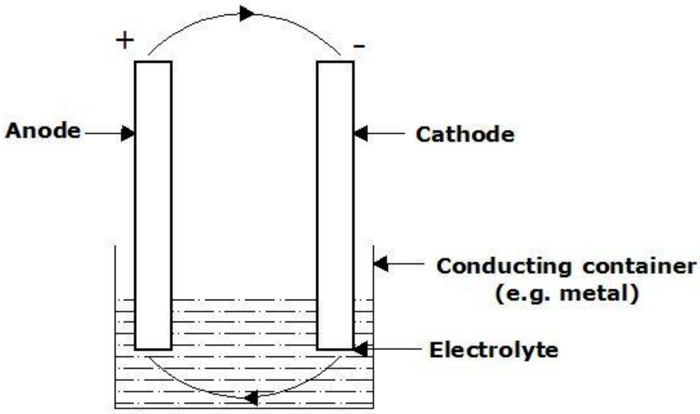
The teacher asks the students this question:

Question: Mention all sources of electricity that you know.

Answer: Ibadan Electricity Distribution Company (IBEDC) Plc, Battery, Electric Generator (or Dynamo), Solar inverter (e.g. Solar Lamp), etc.

Contents:

1. Definition of an electric cell.
2. Description of an electric cell.
3. A well labelled diagram of a simple cell.
4. Lists and explains basic components of an electric cell.



A Simple Cell

NB: Current of negative charges is shown with arrows.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Defines an electric cell.

STEP III – Uses a well labeled diagram to describe an electric cell.

STEP IV – Explains the following components of an electric cell: conducting container, electrodes (cathode and anode) and electrolyte.

STEP V – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Define an electric cell.
2. Draw a well labelled diagram of a simple cell.
3. List and explain three basic components of an electric cell.

Teacher's activities:

1. Introduces the lesson.
2. Defines an electric cell.
3. Uses a well labeled diagram to describe an electric cell.
4. Lists and explains basic components of an electric cell.
5. Provides answers to students' questions.
6. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note V

Subject: Basic Science

Topic: Introduction to electric circuit

Duration: 40minutes

Instructional objectives:

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

i. Define electric current, potential difference, resistance and electromotive force of a cell.

ii. Identify instruments for measuring electric current and potential difference.

iii. Distinguish between original and conventional directions of an electric current.

iv. Draw and label common electrical symbols.

v. Defines an electric circuit.

vi. Distinguish between open and closed electric circuits.

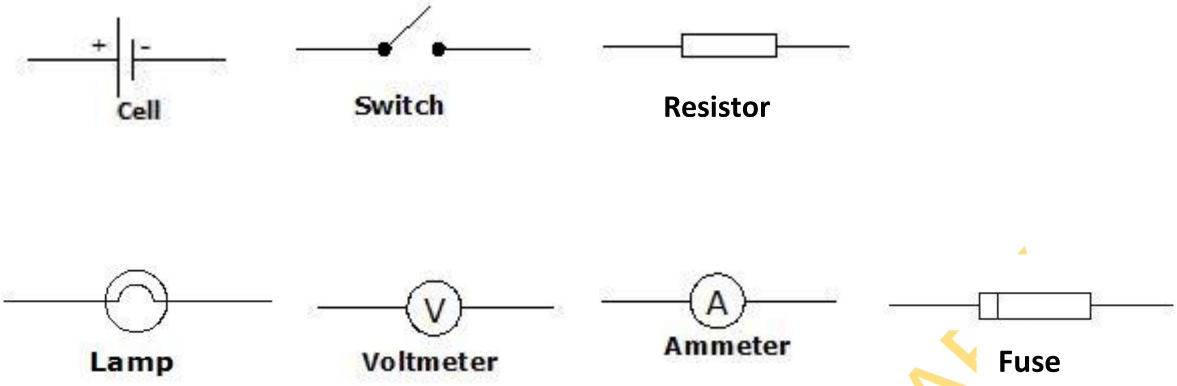
Introduction:

The teacher asks the students these questions:

1. Define an electric cell.
2. Draw a well labeled diagram of a simple cell.
3. Briefly explain the functions of an electrolyte and the two electrodes in an electric cell.

Contents:

1. Definition of electric current, potential difference, resistance and electromotive force (emf.) of a cell.
2. Ammeter as current-measuring instrument and voltmeter as potential difference –measuring instrument.
3. Distinction between original and conventional directions of an electric current.
4. A well labelled diagram of common electrical symbols.



Some Common Electrical Symbols.

5. Definition of an electric circuit.
6. Distinction between open and closed electric circuits.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Defines electric current, potential difference, resistance and electromotive force (e.m.f) of a cell.

STEP III – Shows an ammeter as a current-measuring instrument and a voltmeter as a potential difference – measuring instrument.

STEP IV – Distinguishes between original and conventional directions of an electric current.

STEP V – Lists common electrical components and draw their symbols.

STEP VI – Defines an electric circuit.

STEP VII – Distinguishes between open and closed electric circuits.

STEP VIII – Entertains questions from the students.

Evaluation of the lesson by the teacher:

Asks the students to answer the following questions:

1. Define electric current, potential difference, resistance and electromotive force of a cell.
2. Which instrument measures: i. electric current and ii. potential difference.
3. Distinguish between original and conventional directions of an electric current.

4. Draw the symbols of a cell, plug key, resistance box, resistor, ammeter, voltmeter, wires joined and wires crossed.
5. Define an electric circuit.
6. Distinguish between open and closed circuits.

Teacher's activities:

1. Introduces the lesson.
2. Shows instruments for measuring electric current and potential difference to the students.
3. Explains the difference between original and conventional directions of an electric current.
4. Shows common electrical symbols on an appropriate chart to the students.
5. Defines an electric circuit.
6. Explains the difference between open and closed electric circuits.
7. Answers students' questions.
8. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note VI

Subject: Basic Science

Topic: Networking in electric circuits

Duration: 40minutes

Instructional objectives:

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

i. Draw, correctly, labelled diagrams showing series network of electric cells and series arrangement of electrical resistors.

ii. Draw, correctly, labelled diagrams showing parallel network of electric cells and paralel arrangement of electrical resistors.

iii. Determine the positions of an ammeter in an electric circuit involving series and parallel network of resistors.

iv. Determine the positions of a voltmeter in an electric circuit involving series and parallel network of resistors.

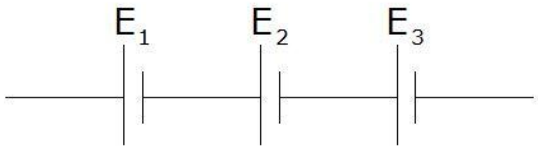
Introduction: The teacher asks the students the following questions on the previous knowledge:

1. Define the e.m.f. of a cell and electrical resistance.
2. Draw the electrical symbols of a cell and resistors.

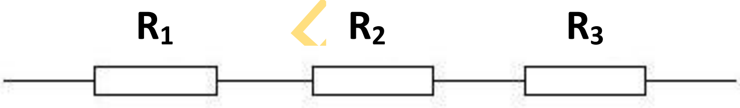
Contents:

1. Well labeled diagram of:

   i. Cells connected in series

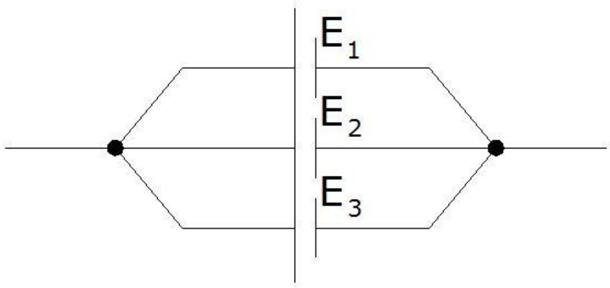


   ii. Resistors connected in series

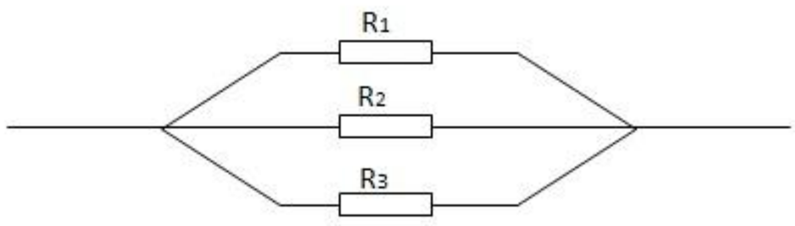


4. Well labelled diagram of:

   i. Cells connected in parallel



ii. Resistors connected in parallel



7. Position of an ammeter in an electric circuit – Always connect ammeter in series with the component which electric current is to be measured.
8. Position of a voltmeter in an electric circuit – Always connect voltmeter in parallel with the component which potential difference is to be measured.

Presentation of contents by the teacher:

STEP I – Introduction.

STEP II – Leads the students to draw series arrangement of:
i. three electric cells and ii. three electrical resistors.

STEP III – Explains the position of an ammeter in an electric circuit.

STEP IV – Explains the position of a voltmeter in an electric circuit.

Evaluation of the lesson by the teacher:

Asks the students the following questions:

1. Draw circuit diagrams for two resistors connected in: i. series ii. parallel.
2. How should: i. an ammeter and ii. a voltmeter be positioned in an electric circuit?

Teacher's activities:

1. Introduces the lesson.
2. Leads the students to draw: i. series and ii. parallel arrangement of – i. three electric cells and ii. three resistors in an electric circuit.
3. Explains the position of: i. an ammeter and ii. a voltmeter in an electric circuit.
4. Answers students' questions.
5. Administers the evaluation questions to the students orally.

Students' activities:

1. Ask questions based on the lesson taught.
2. Answer the evaluation questions.

Lesson Note VII

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using one resistor)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using one resistor only.

ii. Use ammeter to measure the electric current, I, passing through a resistor for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of the resistor for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on the relationship between potential difference and electric current for one resistor.
2. Measurement of electric current passing through a resistor.
3. Measurement of potential difference across the ends of a resistor.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates how to conduct the experiment on relationship between potential difference and electric current for one resistor using real apparatus.

STEP III – Answers students' questions.

STEP IV – Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP V – Asks students to repeat the procedure as demonstrated by the teacher and generate individual readings for e.m.f.s E =1.5V, 3.0V, 4.5V, 6.0V and 7.5V.

STEP VI – Supervises students' work and attend to group challenges.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given value of the resistor?

Teacher's activities:

1. Sets up experiment on relationship between potential difference and electric current for one resistor using real apparatus and demonstrates how to carry it out.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform the experiment.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Follow the procedure as demonstrated by the teacher to perform experiment on relationship between potential difference and electric current for one resistor using e.m.f.s, E =1.5V, 3.0V, 4.5V, 6.0V and 7.5V.
3. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the resistor.
4. Construct table of readings.
5. Record measured values on the table of readings.
6. Deduce relationship between V and I.
7. Ask questions when necessary.
8. Answer evaluation questions.

Lesson Note VIII

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using two resistors connected in series)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using two resistors connected in series.

ii. Use ammeter to measure the electric current, I, passing through the resistors for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of the series combination of two resistors for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for two resistors connected in series.
2. Measurement of electric current through the series combination of two resistors.
3. Measurement of potential difference across the ends of the series combination of two resistors.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates how to conduct the experiment on relationship between potential difference and electric current for two resistors connected in series using real apparatus.

STEP III – Answers students' questions.

STEP IV – Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP V – Asks students to repeat the procedure as demonstrated by the teacher and generate individual readings for e.m.f.s E =1.5V, 3.0V, 4.5V, 6.0V and 7.5V.

STEP VI – Supervises students' work and attend to group challenges.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given value of the resistor?

Teacher's activities:

1. Sets up experiment on relationship between potential difference and electric current for two resistors connected in series using real apparatus and demonstrates how to carry it out.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform the experiment.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Follow the procedure as demonstrated by the teacher to perform experiment on relationship between potential difference and electric current for two resistors connected in series using e.m.f.s, E =1.5V, 3.0V, 4.5V, 6.0V and 7.5V.
3. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the resistor.
4. Construct table of readings.
5. Record measured values on the table of readings.
6. Deduce relationship between V and I.
7. Ask questions when necessary.
8. Answer evaluation questions.

Lesson Note IX

Subject: Basic Science

Topic: Experiment on relationship between potential difference and electric current (using two resistors connected in parallel)

Duration: 1hour 20minutes

Instructional objectives:

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

i. Set up an experiment on relationship between potential difference and electric current using two resistors connected in parallel.

ii. Use ammeter to measure the electric current, I, passing through the resistors for given values of e.m.f., E, of the battery.

iii. Use a voltmeter to measure the potential difference, V, across the ends of the parallel combination of two resistors for given values of e.m.f., E, of the battery.

iv. Record their observations using the given format.

v. Deduce the relationship between V and I.

Contents:

1. Setting up the experiment on relationship between potential difference and electric current for two resistors connected in parallel.
2. Measurement of electric current through the parallel combination of two resistors.
3. Measurement of potential difference across the ends of the parallel combination of two resistors.
4. Construction of a table of readings.
5. Deduction of relationship between V and I.

Presentation of contents by the teacher:

STEP I – Introduction (States the aim of the experiment).

STEP II – Demonstrates how to conduct the experiment on relationship between potential difference and electric current for two resistors connected in parallel using real apparatus.

STEP III – Answers students' questions.

STEP IV – Assigns students, in groups of five, to experimental stands in the physical laboratory.

STEP V – Asks students to repeat the procedure as demonstrated by the teacher and generate group readings for e.m.f.s E =1.5V, 3.0V, 4.5V, 6.0V and 7.5V.

STEP VI – Supervises students' work and attend to individual challenges.

Evaluation of the lesson by the teacher:

Asks the students to state how the potential difference is related to the electric current for a given value of the resistor?

Teacher's activities:

1. Sets up experiment on relationship between potential difference and electric current for two resistors connected in parallel using real apparatus and demonstrates how to carry it out.
2. Answers students' questions on the demonstrated experiment.
3. Assigns students, in groups of five, to experimental stands in the physical laboratory.
4. Supervises students as they perform the experiment.
5. Attends to group challenges.
6. Administers the evaluation questions to the students.

Students' activities:

1. Observe the demonstrational experiment.
2. Follow the procedure as demonstrated by the teacher to perform experiment on relationship between potential difference and electric current for two resistors connected in parallel using e.m.f.s, E =1.5V, 3.0V, 4.5V, 6.0V and 7.5V.
3. Measure the corresponding values of electric current, I, and potential difference, V, across the ends of the resistor.
4. Construct table of readings.
5. Record measured values on the table of readings.
6. Deduce relationship between V and I.
7. Ask questions when necessary.
8. Answer evaluation questions.

APPENDIX VII

BASIC CONCEPTS IN LIGHT AND ELECTRICAL ENERGY

LESSON 1

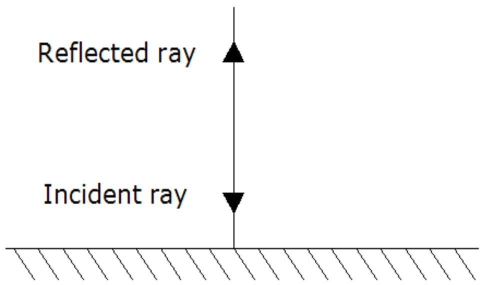
LIGHT ENERGY

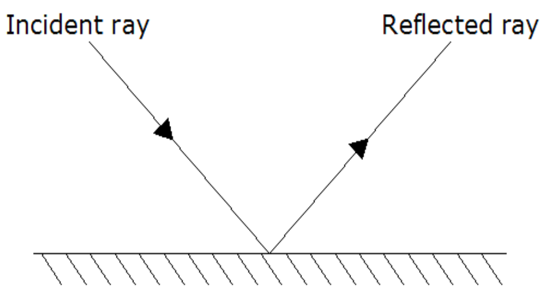
- Light is a form of energy which enables us to see things in our environment as it falls on them.
- It can be changed into another form of energy. For example, a photoelectric cell can be used to change light energy into electrical energy.
- The chief/major source of light energy is the sun. The moon and stars are also natural sources of light energy.
- Light energy from the natural sources travel through space to the surface of the earth.
- Light energy is one of the various kinds of energy contained in the radiant energy. Heat is also present in the radiant energy.
- Light travels in straight lines. However, it could be made to travel in curved path by using special instruments.
- A *ray* of light is a straight line along which light energy travels. It is difficult to obtain a ray of light in practice.
- A *ray box* is used to produce rays of light in the laboratory.
- A *beam* of light is a collection of rays of light.
- A beam of light which contains parallel rays of light is called a *parallel beam* of light.
- A beam of light which consists of light rays from different directions (usually two or more sources of light) and moving towards each other (a common point) is called a *convergent beam* of light.
- A beam of light which is a collection of light rays (either from the same light source or different sources of light) which move away from each other (travelling in various directions) is known as a *divergent beam* of light.
- The image produced in a pin-hole camera is made possible because light travels in straight lines.
- When light falls on an object, part of it may
  - (a) be sent back from the surface of the object;
  - (b) be absorbed into the object; and
  - (c) pass through the object to the other side of the object.

- Materials which allow light to pass through them are *Transparent materials.*
- Materials which do not allow light to pass through them are *Opaque*.

Refection of light

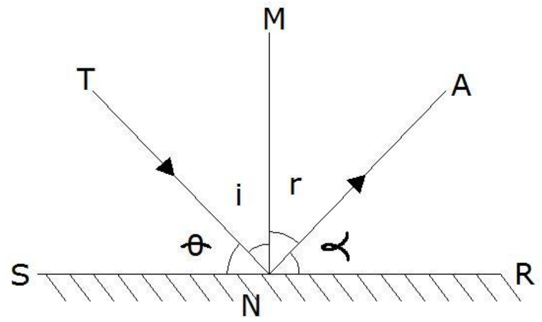
- Reflection of light is the sending back of light rays from the surface on which they fall.
- Light could be reflected along its original path or along a new path.





- Light which falls normally (making angle 90^0 with the surface) on an object is reflected back along its original path.
- Light which falls, at an angle less than 90^0 to the surface, on an object is reflected along a new direction at an angle less than 90^0 to the surface.
- A plane mirror is used to produce reflection of light in the laboratory.
- The surface of an object which reflects light rays is called the *Reflecting surface* e.g. plane mirror.
- Light ray which falls on the reflecting surface is known as *Incident ray.*
- Light ray which is reflected from the reflecting surface is known as *Reflected ray*.
- The angle which either the incident ray or reflected ray makes with the reflecting surface is called *Glancing angle*.
- A point on the reflecting surface where the incident ray hits it and from which the reflected ray is reflected is called a *Point of Incidence* (a point on the reflecting surface where incidence and reflection of light takes place simultaneously).
- *Normal* is a line drawn perpendicular to the reflecting surface at the point of incidence.

- *Angle of incidence* is the angle formed between the incident ray and the normal.
- *Angle of reflection* is the angle formed between the reflected ray and the normal.



LESSON II

- An object placed in front of a plane mirror incident many rays of light onto the mirror. Each of these rays is reflected by the mirror.

  A point where at least two reflected rays representing the reflections of two incident rays from the same point on an object appears to meet gives its image behind the mirror.

- The image of an object produced in a plane mirror has the following properties:

  (a) It is erect or upright.

  (b) It is virtual (imaginary).

  (c) It is the same size as the object.

  (d) Its distance behind the mirror is the same as the distance of the object in front of the mirror.

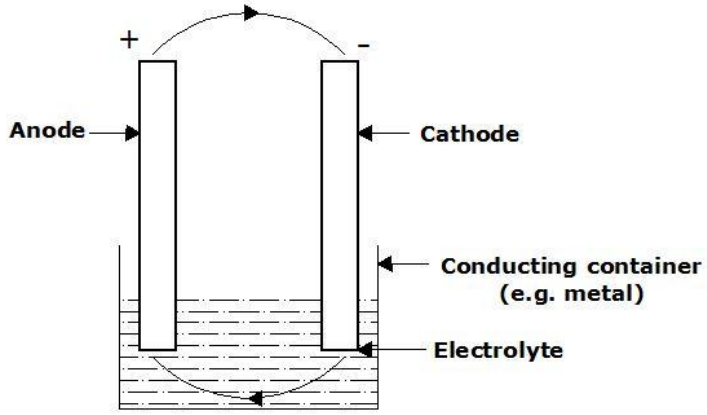
  (e) It is laterally inverted.

LESSON IV

ELECTRICAL ENERGY

Electric cell

- An electric cell is a source of electrical energy. It is a device for producing electricity (electric current) by chemical action. It is the basic unit of a battery. Thus, a battery consists of many electric cells. It is also known as an Accumulator. Examples of an electric cell include: Voltaic Cell, Galvanic cell, Daniel cell, Leclanche cell, Weston cell, Mercury cell, etc. Examples of battery include: torch light/ radio battery, car battery and so on.
- In its simplest form, an electric cell consists of a metal container of two other different metals (e.g. copper and zinc as found in Daniel cell; carbon and zinc as observed in Leclanché cell and so on), each having one of its ends dipped into either a dilute acid (e.g. dilute sulphuric acid) or a salt solution (e.g. zinc sulphate solution). One of the two metal rods serve as an inlet (called the cathode) and the other, an outlet (known as the anode) for the electricity (electric current) generated / produced by the cell. Thus, the two metals in an electric cell are referred to as *Electrodes*. An electrode is a conductor by which electric current enters or leaves an *Electrolyte*. The *anode* is the positive electrode and the *cathode* is the negative electrode. The electrolyte is a compound (e.g. dilute sulphuric acid or zinc sulphate solution) which, in solution or in molten state, conducts an electric current and is simultaneously decomposed by it. The ions of an electrolyte carry the electric current unlike in metals where electric current is carried by electrons. In an electric cell, the electrolyte dissociates into its ions. The negative ions (*anions*) are attracted to the positive electrodes thereby creating a current (movement/drift) of negative charges within the cell. The direction of this current is from the positive electrodes to the negative electrode outside the cell. Thus, there is a complete cycle of the current of the negative charges within and outside the electric cell.



A Simple Cell

NB: Current of negative charges is shown with arrows.

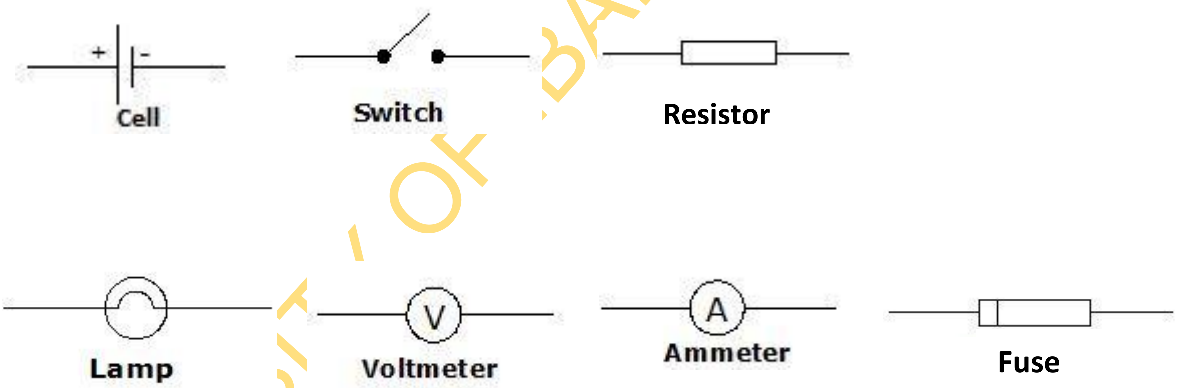
Lesson V

Introduction to electric circuit

- *Electric current* is a steady flow of electrical charges such that equal amount move/pass through a cross section of substance in equal time interval. It is usually represented by I in electric circuit equations and measured in *Ampere*, A, using an *Ammeter*.
- The passage of electric current within an electric cell is from the negative electrode (terminal /pole) to the positive electrode. This is the *original direction* of electric current (the direction of movement of electrons or negative charges)
- However, scientists agreed that the direction of electric current in an electric circuit must be taken as from the positive to the negative electrode (or terminal/pole) of a cell. This is the *conventional direction* of electric current.
- *Potential difference*: The positive and negative electrodes /poles /terminals of an electric cell have different electric potentials (abilities). Conventionally, the positive terminal has higher electric potential (deficient in negative electric charges) than the negative terminal (having surplus of negative electric charges) when they are joined by an electric conductor such as wire. Thus, electric current will pass between them through the wire and if the wire is connected to an electric bulb, it is lit up by the electric current. The electric bulb then converts electrical energy into heat and light energies. Therefore,

potential difference between two points in an electric circuit is the amount of electrical energy which is changed/ converted to other forms of energy when one Coulomb of electric charge passes between the points. It is measured in *Volts*, V, using a *Voltmeter*.

- *Resistance* is the amount of opposition which an electrical conductor offers to the passage of electric current. It depends on the thickness (cross-section) and length of electrical conductor. It is measured in *Ohms* using *Ohm-meter*.
- Electromotive force of a cell is the total amount of electrical energy available in the cell which could be changed or converted to other forms of energy in an electric circuit. It is the sum of the potential difference between the cell terminals due to the movement of electrical charges through the electrolyte of the cell and electric circuit components. It is represented by E and measured in *Volts*, V, using a *Voltmeter*.
- Some common electrical symbols



Some Common Electrical Symbols.

- An *electric circuit* is the complete path through which electric current passes. In its simplest form, an electric current comprises of a source of electricity (e.g. electric cell or battery), an electrical conductor (the electric wire and other resistor(s)) and a switch (e.g. tapping /plug key).
- There are two types of electric circuit, namely: open and closed circuit.
- A *closed* electric circuit is one in which the movement of electrical charges through all components of the circuit is complete such that the supply of electric current is maintained.

- An *open* electric circuit is one in which the movement electric charges through all components of the circuit is not complete such that there is no supply of electric current from the cell/battery/ source.
- A *switch* is used to make or break a circuit (produce a closed or open electric circuit).

Lesson VI

Networking in electric circuits

- Electrical components could be arranged or connected in two ways, namely: series and parallel.
- In *series* arrangement /combination/ connection, positive terminal of a component (e.g. cell) is connected to the negative terminal of another component.
- In *parallel* arrangement, positive terminals of all components are connected and their negative terminals are joined together.
- An ammeter is usually connected in series in an electric circuit.
- A voltmeter is usually connected in parallel across the terminals of the electric circuit component(s) which potential difference it wants to measure.

APPENDIX VIII

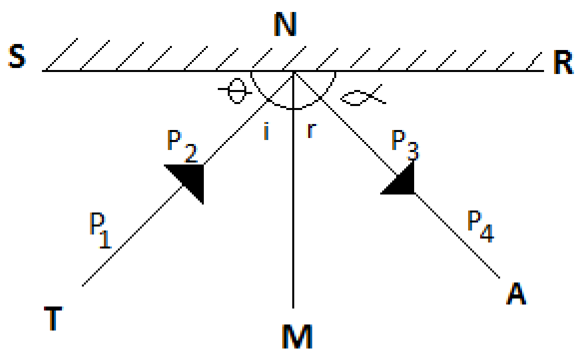
ENRICHED LABORATORY GUIDE MATERIAL ON BASIC SCIENCE

EXPERIMENT ONE: Reflection of light

Aim: To investigate the relationship between angles of incidence and reflection of light at a plane mirror surface.

Apparatus: Plane mirror with stand (1), optical pins (4), drawing board (1), white paper / cardboard (3), and drawing pins (4).

Diagram:



Procedure:

Step 1: Place a drawing board on the laboratory table.

Step 2: Spread a sheet of white paper on the drawing board.

Step 3: Use four drawing pins, one at each corner of the paper, to fasten the paper to the drawing board.

Step 4: Place a plane mirror with holder on the paper.

Step 5: Use a sharp pencil to trace the position of the mirror on the paper. This is a straight line.

Step 6: Indicate the reflecting surface, SR, by shading the other side of the straight line to represent the back of the mirror.

Step 7: Remove the mirror from the paper.

Step 8: Use a protractor to measure angle $\theta^0 = 70^0$ with respect to the plane mirror.

Step 9: Use a pencil to draw a straight line TN which makes angle $\theta^0 = 70^0$ with the reflecting surface, SR, to meet it at point N.

Step10: Along TN, measure and indicate point P_1 and P_2 such that P_1 N = 6cm and P_2N = 3cm respectively.

Step11: Replace the mirror onto the reflecting surface SR.

Step12: Place one optical pin at point P_1.

Step13: Place another optical pin at point P_2.

Step14: Looking at the images of pins P_1 and P_2 in the mirror, adjust the position of your eyes until the two images coincide (appear as one image) inside the mirror.

Step15: While maintaining this position of your eyes, use another optical pin P_3 to block/cover the combined image of pins P_1 and P_2 (P_3,P_2 and P_1 appear as one – pin P_3).

Step16: Use another optical pin P_4 to block/cover the combined image of pins P_1 and P_2 as well as the optical pin P_3 (P_4, P_3, P_2 and P_1 appear as one pin P_4).

Step17: Remove the pins P_1, P_2, P_3 and P_4; circle the pin-holes and label them accordingly.

Step18: Remove the plane mirror.

Step19: Draw a straight line through the pin-holes P_3 and P_4 to meet the reflecting surface SR at N.

Step20: Use a protractor to draw a line MN perpendicular to SR at N.

Step21: Use a protractor to measure angles i and r.

Step21: Repeat the procedure for values of $\theta^0 = 60^0$, 50^0, 40^0 and 30^0.

Results: Tabulate your readings as shown in the table below.

θ^0	i^0	r^0

Conclusion: What is the relationship between values of i^0 and r^0 in the table above?

Extrapolation/Further experiment:

ActivityI:

1. Repeat the procedure for $\theta^0 = 90^0$.

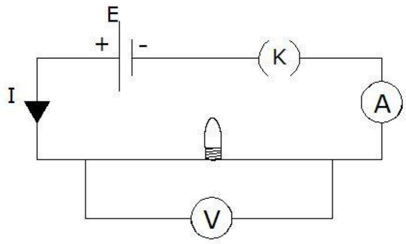
2. Measure and record angles i and r.

EXPERIMENT TWO: Relationship between potential difference and Electric current

Aim: To investigate the relationship between potential difference and electric current.

Apparatus: Electric cells (5 x 1.5V torchlight batteries), connecting wires (6), electric bulb (1), plug key (1), ammeter (1) and voltmeter (1).

Diagram:



Procedure:

Step 1: Remove the plug of the key, K.

Step 2: Join a wire to one terminal of the key.

Step 3: Join the free end of the wire to the negative terminal of one torchlight battery of emf, E=1.5V.

Step 4: Join another wire to the positive terminal of the battery.

Step 5: Join the free end of the wire to one terminal of a lamp holder.

Step 6: Join a wire to the free terminal of the lamp holder.

Step7: Join the free end of the wire to the negative terminal of an ammeter, A.

Step8: Join a wire to the positive terminal of the ammeter.

Step9: Join the free end of the wire to the negative terminal of the key.

Step10: Join a wire to the negative terminal of a voltmeter.

Step11: Join the free end of the wire to the negative end of the lamp holder.

Step 12: Join another wire to the positive terminal of the voltmeter.

Step 13: Join the free end of the wire to the positive terminal of the lamp holder.

Step14: Insert an electric bulb in the lamp holder.

Step15: Replace the plug of the key, K.

Step16: What happen to the electric bulb?

Step17: Measure and record the ammeter and voltmeter readings I and V, respectively.

Step18: Repeat the procedure for values of E=3.0V (2batteries), 4.5V (3batteries), 6.0V (4batteries) and 7.5V (5batteries).

Step19: In each case, observe and record the ammeter and voltmeter readings I and V, respectively.

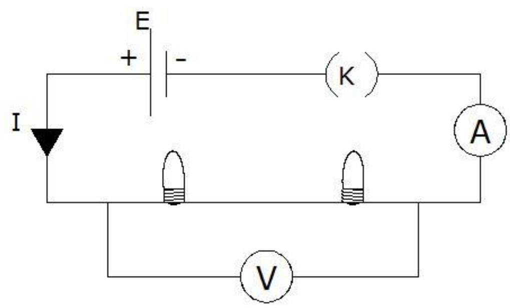
Results: Tabulate your readings as shown below.

Emf, E (V)	V (V)	I (A)
1.5		
3.0		
4.5		
6.0		
7.5		

Conclusion: What is the relationship between the values of V and I in the table above?

Extrapolations/Further experiments

Activity I:



Procedure:

Step 1: Remove the plug of the key, K.

Step 2: Join a wire to one terminal of the key.

Step 3: Join the free end of the wire to the negative terminal of one torchlight battery of emf, E=1.5V.

Step 4: Join another wire to the positive terminal of the battery.

Step 5: Join the free end of the wire to one terminal of a lamp holder.

Step 6: Join a wire to the free terminal of the lamp holder.

Step 7: Join the free end of the wire to one terminal of another lamp holder.

Step 8: Join a wire to the free terminal of the second lamp holder.

Step9: Join the free end of the wire to the negative terminal of an ammeter, A.

Step10: Join a wire to the positive terminal of the ammeter.

Step11: Join the free end of the wire to the negative terminal of the key.

Step12: Join a wire to the negative terminal of a voltmeter.

Step13: Join the free end of the wire to the negative end of the first lamp holder.

Step 14: Join another wire to the positive terminal of the voltmeter.

Step 15: Join the free end of the wire to the positive terminal of the second lamp holder.

Step16: Insert an electric bulb in the first lamp holder.

Step17: Insert another electric bulb in the second lamp holder.

Step18: Replace the plug of the key, K.

Step19: What happen to the electric bulbs?

Step20: Measure and record the ammeter and voltmeter readings I and V respectively.

Step21: Repeat the procedure for values of E=3.0V (2batteries), 4.5V (3batteries), 6.0V (4batteries) and 7.5V (5batteries).

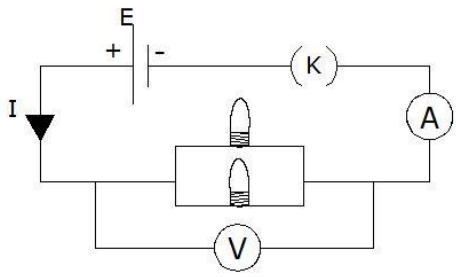
Step21: In each case, observe and record the ammeter and voltmeter readings I and V respectively.

Results: Tabulate your readings as shown below.

Emf, E (V)	V (V)	I (A)
1.5		
3.0		
4.5		
6.0		
7.5		

Conclusion: What is the relationship between the values of V and I in the table above?

Activity II:



Procedure:

Step 1:	Remove the plug of the key, K.
Step 2:	Join a wire to one terminal of the key.
Step 3:	Join the free end of the wire to the negative terminal of one torchlight battery of emf, E=1.5V.
Step 4:	Join another wire to the positive terminal of the battery.
Step 5:	Join the free end of the wire to one terminal of a lamp holder.
Step 6:	Join a wire to the free terminal of the lamp holder.
Step7:	Join the free end of the wire to the negative terminal of an ammeter, A.
Step8:	Join a wire to the positive terminal of the ammeter.
Step9:	Join the free end of the wire to the negative terminal of the key.
Step10:	Join a wire to one terminal of another lamp holder.
Step11:	Join the free end of the wire to the negative terminal of the first lamp holder.
Step12:	Join another wire to the free terminal of the second lamp holder.
Step13:	Join the free end of the wire to the positive terminal of the first lamp.
Step14:	Join a wire to the negative terminal of a voltmeter.
Step15:	Join the free end of the wire to the negative terminal of the first lamp holder.
Step 16:	Join another wire to the positive terminal of the voltmeter.
Step 17:	Join the free end of the wire to the positive terminal of the first lamp holder.
Step18:	Insert an electric bulb in the first lamp holder.
Step19:	Insert another electric bulb in the second lamp holder.
Step20:	Replace the plug of the key, K.
Step21:	Measure and record the ammeter and voltmeter readings I and V, respectively.

Step22: Repeat the procedure for values of E=3.0V (2batteries), 4.5V (3batteries), 6.0V(4batteries) and 7.5V (5batteries).

Step23: In each case, observe and record the ammeter and voltmeter readings I and V, respectively.

Results: Tabulate your readings as shown below.

Emf, E (V)	V (V)	I (A)
1.5		
3.0		
4.5		
6.0		
7.5		

Conclusion: What is the relationship between the values of V and I in the table above?

APPENDIX IX

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

LABORATORY EXPERIMENT REPORT FORMAT

SECTION A

Name of teacher/student:……………………………………………………….

School:…………………………………………………………………………...

Class:……………………………………………………………………………

Gender:…………………………………………………………………………

Subject:………………………………………………………………………….

Date of experiment ………………………………………………………………

Title of experiment:

Aim of experiment:

List of apparatus used:

Diagram(s) of experimental set up:

Experimental procedure:

Results:

Conclusion:

Precaution(s):

APPENDIX X

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

LABORATORY EXPERIMENT GRADING FORMAT

S/N	**Items**	**Percentage of total mark**
1	Observations	40%
2	Deduction(s)	15%
3	Precaution(s)	5%
	TOTAL	**60%**

APPENDIX XI

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

FUTURE CAREER INTEREST IN SCIENCE QUESTIONNAIRE (FCISQ)

Dear Students,

The purpose of this Future Career Interest in Science Questionnaire (FCISQ) is strictly for research. It is aimed at collecting information for a study titled "Effects of Simulated Laboratory and Enriched Laboratory Experiments on Students' Learning Outcomes in Basic Science in Oyo state". Thank you.

SECTION A

PERSONAL DATA

Name of student:

School:

Class: Subject:

Gender: Male ( ) Female ( )

SECTION B

Kindly, read the list of professions provided here-under carefully. Honestly select ONE and put a tick (√) in the appropriate column in front of the type of profession you are interested to go into after schooling. Please, do NOT choose more than one profession. Thanks for your cooperation.

S/N	Professions	Tick Here
1	Medicine	
2	Veterinary Medicine	
3	Dentistry	
4	Nursing	
5	Pharmacy	
6	Biochemistry	
7	Science Laboratory Technology	
8	Agriculture	
9	Microbiology	
10	Food Science and Technology	

11	Food Science	
12	Food Technology	
13	Petroleum Engineering	
14	Chemical Engineering	
15	Computer Engineering	
16	Aeronautic Engineering	
17	Mechanical Engineering	
18	Automobile Engineering	
19	Electrical Engineering	
20	Electronic Engineering	
21	Civil Engineering	
22	Architecture Engineering	
23	Building Construction	
24	Building Technology	
25	Computer Science	
26	Teaching	
27	Mathematics	
28	Statistics	
29	Business/Trading	
30	Salesmanship	
31	Marketing	
32	Accountancy	
33	Banking and Finance	
34	Business Administration	
35	Economics	
36	Law	
37	Mass Communication	
38	Theatre/Performing Art	

APPENDIX XII

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

ASSESSMENT SHEET FOR EVALUATING RESEARCH ASSISTANTS PERFORMANCE ON THE USE OF INSTRUCTIONAL GUIDE ON SIMULATED LABORATORY EXPERIMENTS

SECTION A

Name of teacher:………………………………………………….

School:…………………………………………………………...

Class:……………………………………………………………………………

Gender:…………………………………………………………………………..

Subject:………………………………………………………………………..

Topic;……………………………………………………………………………………

Date:…………………………………………………………………………………….

SECTION B

S/N	**Performance assessed**	**V. Good**	**Good**	**Average**	**Poor**	**V. Poor**
		5	4	3	2	1
1	Introduction of the simulated Laboratory Experiments					
2	Presentation of the package					
3	What level of mantery of the theory of the experiment displayed?					
4	Supervising the students during conduct of the experiment					
5	Evaluation.					

APPENDIX XIII

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

ASSESSMENT SHEET FOR EVALUATING RESEARCH ASSISTANTS PERFORMANCE ON THE USE OF INSTRUCTIONAL GUIDE ON ENRICHED LABORATORY GUIDE MATERIAL EXPERIMENTS

SECTION A

Name of teacher:……………………………………………………………………..

School:……………………………………………………………………………...

Class:……………………………………………………………………………

Gender:……………………………………………………………………………..

Subject:……………………………………………………………………………..

Topic;……………………………………………………………………………………

Date:…………………………………………………………………………………….

SECTION B

S/N	Performance assessed	V. Good	Good	Average	Poor	V. Poor
		5	4	3	2	1
1	Introduction of the experiments, how well?					
2	What level of mastery of the theory of the experiment displayed?					
3	Presentation: How systematic in the conduct of experiment?					
4	Summary: How concise was the summary of the lesson					
5	Evaluation.					

APPENDIX XIV

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

ASSESSMENT SHEET FOR EVALUATING RESEARCH ASSISTANTS PERFORMANCE ON THE USE OF INSTRUCTIONAL GUIDE ON CONVENTIONAL (EXPOSITORY) LABORATORY EXPERIMENTS

SECTION A

Name of teacher:………………………………………………………………………..

School:……………………………………………………………………………………...

Class:……………………… Gender: Male ( ) Female ( )

Subject:…………………………………………………………………………………..

Topic;……………………………………………………………………………………

Date:…………………………………………………………………………………….

SECTION B

S/N	Performance assessed	V. Good	Good	Average	Poor	V. Poor
		5	4	3	2	1
1	Introduction: How well does the teacher introduce the lessons					
2	What level of mastery of the theory of the experiment displayed?					
3	Presentation (a) How systematic in the conduct of experiments?					
4	Summary: How concise was the summary of the lesson					
5	Evaluation.					