

**EFFECTS OF VIRTUAL LABORATORY ON BASIC SIX PUPILS’  
KNOWLEDGE OF SCIENCE CONCEPTS AND PROCESS SKILLS IN  
IBADAN, NIGERIA**

**Ph.D. INTERIM REPORT**

**BY**

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**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF DOCTOR OF PHILOSOPHY IN SCIENCE EDUCATION**

**SUPERVISOR: PROF. ESTHER O. OMOSEWO**

## CERTIFICATION PAGE

This is to certify that this study was carried out by **AKINTUNDE, Zacchaeus Taiwo (08/68SC003)** in the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, in partial fulfilment of the award of Doctor of Philosophy (Ph.D) in Science Education.

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**BY**

**AKINTUNDE, Zacchaeus Taiwo**

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## **DEDICATION**

This work is dedicated to my Lord and Saviour Jesus Christ. It is also dedicated to my wife, Janet and my children: Joy, love, Goodness, and Meekness.

## **ACKNOWLEDGEMENTS**

I give my sincere thanks to the Almighty God who in His majesty and infinite mercy spared my life and made my dream of obtaining a Ph.D. degree a reality. I sincerely thank God for His protection, love, mercy and guidance before and during the struggle to achieve my life ambition.

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## **ABSTRACT**

Primary school science is considered all over the world to be the most important level because it is the foundation on which subsequent science teaching and learning at the secondary and tertiary levels of education is built. However students' performance in Basic Science and Technology is very low. Unfortunately this deficiency in Basic Science and Technology of which physics forms a component part is also reflected in the performance of students in the Senior School Certificate Examination in physics. The study therefore investigated the effects of virtual laboratory on basic six pupils' knowledge of science concepts (KSC) and science process skills (SPS) in Ibadan, Nigeria. Objectives of the study were to determine effects of (i) virtual laboratory (ii) virtual and physical laboratories combined and (iii) physical laboratory on pupils' KSC and SPS (iv) influence of gender, score levels and attitude on the three groups (v) interaction effect of treatment, gender and score levels.

The research adopted a pre-test, post-test, quasi-experimental design of  $3 \times 2 \times 2 \times 3$  factorial design. A purposive sampling and simple random sampling techniques were used to select three co-educational primary schools in Ibadan Oyo State. Three intact classes of 101 basic six pupils constituted the sample for the study. The experimental group I (EX GI), virtual laboratory only comprised 37 pupils (18 males and 19 females), the experimental group II (EX GII), virtual physical laboratories combined comprised of 36 pupils (16 males and 20 females),

and control group (CO G), physical laboratory only comprised 28 pupils (7 males and 21 females).

Pupils were stratified along gender (male and female), and score levels (low, medium and high). A researcher-designed Virtual Laboratory Instructional Package (VLIP) was developed based on the content of the Nigerian basic six curriculum. The Virtual Laboratory Instructional Package (VLIP), Basic Science Achievement Test (BSAT) and Basic Science Virtual Laboratory Attitude Questionnaire (BSVLAQ) were validated by experts. Basic Science Achievement Test (BSAT) and Basic Science Virtual Laboratory Attitude Questionnaire (BSVLAQ) were used to collect data. The reliabilities of BSAT and BSVLAQ were done using Kuder-Richardson's Formula 21 and Cronbach Alpha Coefficient respectively. Reliability coefficients of 0.88 and 0.91 were obtained respectively. The experiment lasted for six weeks. Data were analyzed using Mean, t-Test and Analysis of Covariance (ANCOVA). Scheffe's post hoc analysis was employed for locating where differences occurred. Findings from the study revealed that;

(i) There was a significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only (CO G) ( $F_{(2, 97)} = 12.88, p < 0.05$ ) in favour of EX GII. (ii) There was a significant difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI), virtual and Physical laboratories combined (EX GII) and

physical laboratory only (CO G) ( $F_{(2, 97)} = 7.70, p < 0.05$ ) in favour of EX GII. (iii) There was a significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G) ( $F_{(1, 62)} = 35.69, p < 0.05$ ) in favour of EX GI. (iv) There was also a significant difference in pupils' science process skills when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G) ( $F_{(1, 62)} = 8.99, p < 0.05$ ) in favour of EX GI. (v) There was a significant difference in pupils' knowledge of science concepts when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G) ( $F_{(1, 61)} = 8.69, p < 0.05$ ) in favour of EX GII. (vi) There was a significant difference in pupils' science process skills when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G) ( $F_{(1, 61)} = 13.68, p < 0.05$ ) in favour of EX GII. (vii) There were no significant effects of EX GI and EX GII on the knowledge of science concepts (KSC) and science process skills (SPS) of male and female pupils. (viii) There were no significant effects of EX GI and EX GII on KSC and SPS of low, medium and high score level pupils. (ix) There was no significant difference observed in pupils' attitude toward basic science and technology when exposed to the treatments against the physical laboratory (CO G) however, both groups demonstrated positive attitude. (x) There was no significant interaction effect of treatment, gender and score levels on pupils' KSC and SPS. The study

concluded that pupils' KSC and SPS who were taught physics components of basic science and technology using virtual and physical laboratories combined (EX GII) out-performed pupils in the other groups EX GI and CO G. The implication of this study is that pupils' performance in basic science and technology would be better, if they are taught using virtual laboratory together with physical laboratory.

## **TABLE OF CONTENTS**

|                    |       |
|--------------------|-------|
| Title Page         | i     |
| Certification Page | ii    |
| Copyright Page     | iii   |
| Dedication         | iv    |
| Acknowledgement s  | v     |
| Abstract           | vii   |
| Table of Contents  | x     |
| List of Tables     | xviii |
| List of Figures    | xxiv  |

## **CHAPTER ONE**

### **INTRODUCTION**

|                           |    |
|---------------------------|----|
| Background to the Problem | 1  |
| Statement of the Problem  | 22 |
| Purpose of the Study      | 24 |

|                                            |    |
|--------------------------------------------|----|
| Research Questions                         | 27 |
| Research Hypotheses                        | 29 |
| Scope of the Study                         | 32 |
| Significance of the Study                  | 33 |
| Clarification of Major Terms and Variables | 35 |

## **CHAPTER TWO**

### **REVIEW OF RELATED LITERATURE**

|                                                                                                                |    |
|----------------------------------------------------------------------------------------------------------------|----|
| Theoretical Framework for the Study                                                                            | 37 |
| The Objectives and Contents of Basic Six Sciences and Technology Curriculum                                    | 42 |
| Knowledge of Science Concepts and Science Process Skills                                                       | 47 |
| Empirical Studies on Effects of Virtual Laboratory on Knowledge of Science Concepts and Science Process Skills | 59 |
| Empirical Studies on Influence of Gender on Students' Academic Performance                                     | 72 |
| Empirical Studies on Students' Score Levels and Academic Performance                                           | 79 |

|                                                                            |    |
|----------------------------------------------------------------------------|----|
| Empirical Studies on Pupils' Attitude towards Basic Science and Technology | 83 |
| Appraisal of the Reviewed Literature                                       | 87 |

### **CHAPTER THREE**

#### **METHODOLOGY**

|                                            |     |
|--------------------------------------------|-----|
| Research Design                            | 90  |
| Population, Sample and Sampling Techniques | 93  |
| Research Instrument                        | 95  |
| Validation of Research Instrument          | 98  |
| Procedure for Data Collection              | 100 |
| Data Analysis Techniques                   | 102 |

### **CHAPTER FOUR**

#### **DATA ANALYSIS AND RESULTS**

|                       |          |
|-----------------------|----------|
| Research Question One | 106      |
| Research Question Two | 106      |
| Hypotheses            | 110- 147 |

|                     |     |
|---------------------|-----|
| Summary of Findings | 149 |
|---------------------|-----|

## **CHAPTER FIVE**

### **DISCUSSION, CONCLUSION AND RECOMMENDATIONS**

|                                                                                                                                                                                                                                 |     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Discussion                                                                                                                                                                                                                      | 153 |
| Findings on the effects of virtual laboratory only (EX GI), Virtual and physical laboratories combined (EX GII) and physical laboratory (CO G) on pupils' knowledge of science concepts (KSC) and science process skills (SPS). | 153 |
| Findings on the Effects of Treatments {(EX GI) and (EX GII)} on Male and Female Pupils' (KSC) and (SPS).                                                                                                                        | 156 |
| Findings on the Effects of Treatments (EX GI) and (EX GII) on Pupils' Score Levels                                                                                                                                              | 157 |
| Findings on the Effects of Treatments (EX GI) and (EX GII) against physical laboratory (CO G) on Pupils' Attitude                                                                                                               | 158 |
| Implications of the Findings                                                                                                                                                                                                    | 159 |
| Conclusions                                                                                                                                                                                                                     | 160 |
| Recommendations                                                                                                                                                                                                                 | 161 |

|                                 |     |
|---------------------------------|-----|
| Suggestions for Further Studies | 162 |
| REFERENCES                      | 163 |

## **APPENDICES**

|                                                                                                                                                     |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Appendix I: Curriculum for Basic Six Science and Technology                                                                                         | 182 |
| Appendix II: Budget Proposal                                                                                                                        | 190 |
| Appendix III: Teachers' Informed Concept Form                                                                                                       | 193 |
| Appendix IV: Parents' Informed Concept Form                                                                                                         | 195 |
| Appendix V: Headmasters' Informed Concept Form                                                                                                      | 197 |
| Appendix VI: Teaching Module Using the Conventional Method (Week 1)                                                                                 | 199 |
| Appendix VII: Teaching Module Using the Conventional Method (Week 2)                                                                                | 207 |
| Appendix VIII: Teaching Module Using the Conventional Method (Week 3)                                                                               | 213 |
| Appendix IX: Basic Science Achievement Test (BSAT) Pre-Test and<br>Post-Test                                                                        | 216 |
| Appendix X: Basic Science Virtual Laboratory Attitude Questionnaire<br>(BSVLAQ)                                                                     | 238 |
| Appendix XI: Examples on Knowledge of Science Concepts and Science<br>Process Skills Test Items in area of Simple Machines,<br>Forces and Magnetism | 240 |
| Appendix XII: Answers to Multiple-Choice and Practical Questions                                                                                    | 243 |

|                                                |     |
|------------------------------------------------|-----|
| Appendix XIII: Dissemination of Major Findings | 245 |
| Appendix XIV: Expert Validation Report         | 246 |
| Appendix XV: Postgraduate Research Plan        | 249 |

## LIST OF TABLES

|                                                                                                                                                     |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Table 1: Students' Enrolment and Performance in Basic Education<br>Certificate Examination in Basic Science in Oyo State from<br>year 2008 to 2016. | 10  |
| Table 2: Students' Enrolment and Performance in May/June WASSCE<br>in Biology, Chemistry and Physics in Nigeria from year 2007 to<br>2016.          | 14  |
| Table 3: The problems encountered by teachers in science courses and<br>solutions offered by virtual laboratories                                   | 18  |
| Table 4: Bloom's taxonomy of cognitive understanding                                                                                                | 51  |
| Table 5: Assessment tool on Students' Conceptual Understanding and<br>Science Process Skills                                                        | 53  |
| Table 6: Research Design Layout                                                                                                                     | 91  |
| Table 7: Distribution of the Pupils Sampled Based on Gender                                                                                         | 104 |
| Table 8: Distribution of the Pupils Sampled Based on core Levels                                                                                    | 106 |
| Table 9: Descriptive Statistics of Pupils' Scores (before and after the<br>Treatments)                                                              | 108 |
| Table 10: Mean Gain Scores of Pupils Taught Using Virtual Laboratory                                                                                |     |

|                                                                                                                                                                                                                             |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Only, Virtual laboratory + Physical laboratory, and Physical laboratory Only.                                                                                                                                               | 109 |
| Table 11: Analysis of Covariance Showing the Difference in Pupils' Knowledge of Science Concepts (KSC) When Taught Using Virtual Laboratory Only and Those Taught Using Physical Laboratory Only using pretest as covariate | 111 |
| Table 12: Pairwise Comparisons Analysis Showing the Effect of the Virtual Laboratory on Pupils' Knowledge of Science Concepts (KSC)                                                                                         | 111 |
| Table 13: Analysis of Covariance Showing the Difference in Pupils' Process Skills (SPS) When Taught Using Virtual Laboratory Only and Those Taught Using Physical Laboratory Only using pretest as covariate                | 114 |
| Table 14: Pairwise Comparisons Analysis Showing the Effect of the Virtual Laboratory on Pupils' Science Process Skills (SPS)                                                                                                | 115 |
| Table 15: Analysis of Covariance Showing the Difference in the Knowledge of Science Concept (KSC) of Male and Female Pupils When Taught Using Virtual Laboratory (EX GI)                                                    | 116 |
| Table 16: Mean gain scores in knowledge of science concepts of male and                                                                                                                                                     |     |

|                                                                                                                                                                                                     |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| female pupils taught using virtual laboratory only                                                                                                                                                  | 117 |
| Table 17: Analysis of Covariance Showing the Difference in Pupils’<br>Science Process Skills of Male and Female When Taught<br>Using Virtual Laboratory (EX GI)                                     | 119 |
| Table 18: Mean gain scores in science process skills of male and<br>female pupils taught using virtual laboratory only                                                                              | 120 |
| Table 19: Analysis of Covariance Showing the Difference in the<br>Knowledge of Science Concept (KSC) of Low, Medium and<br>High Score Levels pupils When Taught Using Virtual<br>Laboratory (EX GI) | 122 |
| Table 20: An Analysis of Covariance Showing the Difference in the<br>Science Process Skills of Pupils of Low, Medium and<br>High Score Levels When Taught Using Virtual Laboratory<br>(EX GI)       | 123 |
| Table 21: t-Test Statistics Showing the Difference in the Attitudes of<br>Pupils That Were Taught with Virtual Laboratory Only and<br>That of Pupils Taught with Physical Laboratory Only           | 125 |
| Table 22: Analysis of Covariance Showing the Difference in Pupils’<br>Knowledge of Science Concepts (KSC) When Taught Using                                                                         |     |

|                                                                                                                                                                                                                                                          |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Virtual laboratory + Physical Laboratory and Those Pupils<br>Taught Using Physical Laboratory Only using Pretest as<br>Covariate                                                                                                                         | 126 |
| Table 23: Pairwise Comparisons Analysis Showing the Effect of the<br>Virtual laboratory + Physical Laboratory on Pupils’<br>Knowledge of Science Concepts (KSC)                                                                                          | 127 |
| Table 24: Analysis of Covariance Showing the Difference in Pupils’<br>Science Process Skills (SPS) When Taught using Virtual<br>laboratory + Physical Laboratories and That of Pupils Taught<br>with Physical Laboratory Only using pretest as Covariate | 129 |
| Table 25: Pairwise Comparisons Analysis Showing the Effect of the<br>Virtual lab. + Physical Laboratories on Pupils’ Science Process<br>Skills.                                                                                                          | 130 |
| Table 26: Analysis of Covariance Showing the Difference in Male and<br>Female Pupils’ Knowledge of Science Concept (KSC) When<br>Taught using Virtual laboratory + Physical Laboratory using<br>pretest as Covariate                                     | 131 |
| Table 27: Mean gain scores in knowledge of science concepts of male<br>and female pupils taught using virtual laboratory + physical                                                                                                                      |     |

|                                                                                                                                                                                                                   |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| laboratory (EX GII)                                                                                                                                                                                               | 132 |
| Table 28: Analysis of Covariance Showing the Difference in Science<br>Process Skills of Male and Female Pupils When Taught<br>Using Virtual laboratory + Physical Laboratory                                      | 134 |
| Table 29: Mean gain scores in science process skills of male and<br>female pupils taught using virtual laboratory + physical<br>laboratory (EX GII)                                                               | 135 |
| Table 30: Analysis of Covariance Showing the Difference in the<br>Knowledge of Science Concept (KSC) of Low, Medium<br>and High Score Levels Pupils When Taught Using Virtual<br>laboratory + Physical Laboratory | 137 |
| Table 31: Analysis of Covariance Showing the Difference in the Science<br>Process Skills of Low, Medium and High Score Levels Pupils<br>When Taught with Virtual laboratory + Physical Laboratory<br>(EX GII)     | 138 |
| Table 32: t-Test Statistics Showing the Difference in the Attitudes of<br>Pupils That Were Taught with Virtual Laboratory Only and<br>That of Pupils Taught with Physical Laboratory Only                         | 139 |
| Table 33: Analysis of Covariance Showing the Difference in Knowledge                                                                                                                                              |     |

|                                                                                                                                                                                                                             |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| of Science Concepts (KSC) When Taught Using Virtual<br>Laboratory Only and Those Taught Using Virtual laboratory<br>+ Physical Laboratory Combined                                                                          | 140 |
| Table 34: Mean gain scores in knowledge of science concepts between EX<br>GI and EX GII pupils                                                                                                                              | 141 |
| Table 35: Analysis of Covariance Showing the Difference in Pupils’<br>Science Process Skills (SPS) When Taught Using Virtual<br>Laboratory Only and Those Taught Using Virtual laboratory<br>+ Physical Laboratory Combined | 143 |
| Table 36: Mean gain scores in science process skills between EX GI and<br>EX GII pupils                                                                                                                                     | 144 |
| Table 37: Analysis of Covariance Showing the Interaction Effect of<br>the Treatments, Gender and Score Levels on Pupils’ Knowledge<br>of Science Concepts                                                                   | 146 |
| Table 38: Analysis of Covariance Showing the Interaction Effect of the<br>Treatments, Gender and Score Levels on Pupils’ Science Process<br>Skills                                                                          | 148 |

## LIST OF FIGURES

|                                                                                                                                                                                                                                       |     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Figure 1: Graphical illustration of Students' Performance in Basic Education Certificate                                                                                                                                              | 11  |
| Figure 2: Graphical illustration of Students' Performance in May/June WASSCE in Physics from year 2007 to 2016.                                                                                                                       | 15  |
| Figure 3: Graphical illustration of Students' Enrolment in May/June WASSCE in Biology, Chemistry and Physics from year 2007 to 2016.                                                                                                  | 15  |
| Figure 4: Classification of variables in the study                                                                                                                                                                                    | 93  |
| Figure 5: Graphical Illustration of mean gain scores of pupils' knowledge of science concepts and science process skills taught using virtual laboratory only, virtual laboratory + physical laboratory and physical laboratory only. | 110 |
| Figure 6: Mean gain scores in knowledge of science concepts of male and female pupils taught using virtual laboratory only                                                                                                            | 118 |
| Figure 7: Mean gain scores in science process skills of male and female pupils taught using virtual laboratory only                                                                                                                   | 120 |
| Figure 8: Mean gain scores in knowledge of science concepts of male and                                                                                                                                                               |     |

female pupils taught using virtual laboratory + physical laboratory

(EX GII) 133

Figure 9: Mean gain scores in science process skills of male and female

pupils taught using virtual laboratory + physical laboratory

(EX GII) 136

Figure 10: Mean gain scores in knowledge of science concepts between

EX GI and EX GII pupils 142

Figure 11: Mean gain scores in science process skills between EX GI

and EX GII pupils 144

# **CHAPTER ONE**

## **INTRODUCTION**

### **Background to the Problem**

Science and Technology have become the major ingredients of economy and national advancement. The role of Science in national development cannot be over-emphasized. Olagunju and Femi (2010) asserted that the major distinction between a developed country and a developing one today is the difference in their levels of scientific and technological development. Consequently, the researchers stressed further that any nation that ignores the importance of science and technology will be doomed to stagnation and retrogression.

Hassan (2010) asserted that science and technology are inseparable since technology is the application of scientific principles to solve human problems. Again, the position and prestige of a nation in the world's politics depends on the extent to which the country advances in science and technology, which is the key that unlocks the door to sustainable development (Olaniyan, Omosewo & Nwankwo, 2015).

Science has been described in so many ways by various authors. According to Abimbola (2013), Science is a body of knowledge, a way of investigating and a way of thinking in the pursuit of an understanding of nature. Abimbola (2009) averred that science is a human activity which

people engage in daily. Therefore, teaching of science should deal more with what we can do with scientific knowledge to control our environment. Olagunju and Femi (2010) defined science as a systematic investigation of nature leading to the collection and unbiased treatments of data with a view to evolving meaningful generalizations that may engender further investigations. Furthermore, Robert and Henry (2008) opined that science is a formulation and testing of hypothesis based on observational evidence. Ekpeyong (2004) defined science as the study of the fundamental laws of nature. According to Sheldon (2008), science is intellectual activities carried on by human, which is designed to discover information about the natural world. This information can be organized into meaningful pattern.

Daramola (2004) opined that when science is studied for the purpose of understanding practical solution to life problems and application of scientific knowledge to improve the living standard of mankind, the science so studied is called applied science or technology. Michael (2006) opined that science is the foundation upon which present day technological breakthrough and innovations are built and every nation of the world is striving to develop and be relevant globally both scientifically and technologically

In this contemporary age of scientific and technological advancement, the need to keep pace with the global trend of development demands that people should be scientifically literate. Scientific literacy according to

Nwagbo (2006) is the use of scientific knowledge acquired by an individual to solve personal and civic problems confronting him in the society. Without scientific literacy among a sizeable proportion of the society, progress in achieving modernization will be difficult. Scientific literacy has such a dominant effect on people's lives that it is now considered essential for every citizen to be scientifically literate.

The researcher further stressed that while it is not expected that all citizens will become scientists, scientific literacy will help the leaders and policy makers to understand and propose suitable solutions to environmental problems, health problems, and other societal problems. It will also help the populace to understand and support policy decisions.

Primary science education is considered all over the world to be the most important level of education because it is the foundation on which subsequent science teaching and learning at the secondary and tertiary levels of education are built. The National Policy on Education put it more succinctly when it stated that "since the rest of the education system is built upon it, the primary level is the key to the success or failure of the whole system" (Federal Republic of Nigeria (FRN), 2004).

Primary education therefore forms the basis for a child's ability or inability to function well at post-primary levels. This implies that whatever achievement a child will make in his/her future academic endeavor depends

on the foundation laid for him/her at the primary level (Osuafor & Okigbo, 2010). Furthermore, the researchers stated that in this era of scientific and technological advancement, there is need for a solid foundation in science and technology education at the primary level of education so as to engage them at a young age. The Holy Scripture also corroborates the importance of foundation that “if the foundation be destroyed, what can the righteous do?” (Psalm 11: 3). Science therefore should be effectively taught at the primary school level to prepare children for further studies in science and technology at a higher level of education.

The primary objectives of teaching science at the primary level are to:

- lay a sound foundation for scientific and reflective thinking;
- provide the child with basic tools for further educational advancement, including preparation for trades and crafts for the locality and
- give the child opportunities for developing manipulative skills that will enable the child to function effectively in the society within the limits of the child’s capacity as stated by the Federal Republic of Nigeria (FRN, 2004).

These objectives cannot be achieved without a firm foundation in scientific knowledge at the primary school level. Tomorrow's problems can be analyzed and solved more easily if the primary school of today does a better job of preparing the child to face tomorrow's problems through appropriate teaching and learning of science.

Reiterating the importance of science teaching that will nurture scientific thinking skills and inculcate in children the desire and passion to learn, Eshach (2006) highlighted an overview of why science should be taught in early childhood as follows:

1. Children naturally enjoy observing and thinking about nature. A child's world is fresh, new and beautiful, full of wonder and excitement therefore children eagerly embrace all types of science activities because of their innate curiosity. What makes children ready particularly for science is the intrinsic motivation, which refers to doing an activity for its inherent satisfaction.
2. Early exposure to scientific phenomena leads to better understanding of the scientific concepts to be studied later in a formal way.
3. Development of attitudes towards science starts at the early stage of life. Exposing students to science in an environment where they can enjoy science develops positive attitude towards science.

4. Children can understand scientific concepts and reason scientifically.

Though there is no consensus on whether or not small children can think scientifically or whether they are mature enough to understand (abstract) scientific concepts, some research indicates that even young children show the ability to think scientifically and they are able to think about even complex concepts.

5. Since teaching science involves introducing the learners to the social language of school science, the use of scientifically informed language at an early age influences the eventual development of scientific concepts.

Against this background, Universal Basic Education (UBE) was introduced as a major policy innovation in Nigerian National Policy on Education for ensuring access to basic education for every Nigerian child of school age in line with the United Nations declaration on “Education For All”. This reform introduced a 9-year uninterrupted basic education program made up of three years of lower basic education, three years of middle basic education (both located in Primary School) and three years of upper basic education (Junior Secondary School level).

Basic science and technology is designed for pupils at the lower basic and middle basic levels of primary education. Unfortunately, most of the

teachers handling Basic Science at the primary school level are Arts-oriented as they were not specially trained to teach science subjects at the primary school level as pointed out by Osuafor and Okigbo (2010). The researcher further added that each teacher is in charge of one class and teaches all the subjects offered by that class irrespective of his/her area of specialization and blamed this practice for being responsible for poor pupils' achievement especially in sciences at the primary education level.

In a study by Osuafor and Okigbo (2010) on the analysis of the performance of pupils taught primary science and mathematics by specialist and non- science specialist teachers, it was revealed that pupils taught primary science and mathematics by science and mathematics specialists performed better in their achievement test than those taught by non- science specialist teachers. The non-science specialist teachers presumably find it difficult to adequately impart scientific knowledge to their students.

Rawatee (2012) indicated that part of the reasons for pupils' disinterest in science at post-primary school is that children are turned – off by science at primary school level when they are quite young. Rezba, Sprague and Fiel (2002) opined that one of the weaknesses in primary school's education is insufficient learning of natural science subjects which might be due to the poor level of teaching, because most primary school teachers are not science oriented and consequently the inability of students to use science knowledge and to practice process skills. Maharaj – Sharma

(2007) argued why students develop disinterest in science is because many upper primary school teachers deliver science instruction through rote methods deliberately opting to ignore the use of exciting, relevant and engaging practical hand – on activities.

In addition, students are not often exposed to practice basic science process skills in an effective way due to shortage of tools and equipment in science laboratories in primary schools, which consequently affect science instruction in senior schools (Olagunju & Femi, 2010). This may be why Rezba, Sprague and Fiel (2002) argued that acquirement of pre-lab conceptual knowledge and science process skills are vital because they are essential foundations for science learning. More so, Hassan (2010) opined that scientific skills must be developed early in children before they get to the higher level in education. The pupils need good exposure to some basic scientific skills which must be entrenched into the curriculum so that as they grow older, the curriculum will be getting spirally wider with emphasis on scientific discoveries.

Mutlu and Temiz (2013) defined science process skills as the basis for scientific thinking and research. According to Karamustafaoglu (2011), science process skills are the thinking skills that we use to get information. Yakar (2014) opined that science teaching should be planned in a way to include teaching science process skills because they are among the most

frequently used thinking skills. These skills include: observation, classification, measurement, communication, prediction and inference.

Table 1 presents students' performance in Basic Education Certificate Examination (BECE) in Basic Science, Business Studies, Social Studies, English Language and Computer Education in Oyo State from year 2014 to 2016. From Table 1, it could be observed that the performance of students in Basic Science in all the subjects within the year under investigation had the least except for Computer Education in the year 2016 as illustrated in Figure I. Unfortunately this deficiency in Basic Science and Technology of which physics forms a component part is carried forward and also reflected in the performance of students in the May/June WASSCE in physics as shown in Table 2.

This problem of poor performance in natural sciences especially physics by students in Senior School Certificate Examinations (where their curriculum is getting wider) could be minimized if there is a solid foundation of scientific enquiry at the primary school level through appropriate teaching and learning of science (Osuafor & Okigbo, 2010).

Table 1

Students' Performance in Basic Education Certificate Examination in Basic Science, Business Studies, Social Studies, English Language and Computer Education in Oyo State from year 2014 to 2016.

| YEAR | BASIC SCIENCE % CREDIT PASSED | BUSINESS STUDIES % CREDIT PASSED | SOCIAL STUDIES % CREDIT PASSED | ENGLISH LANGUAGE % CREDIT PASSED | COMPUTER EDUCATION % CREDIT PASSED |
|------|-------------------------------|----------------------------------|--------------------------------|----------------------------------|------------------------------------|
| 2014 | 78.18                         | 98.43                            | 85.31                          | 82.24                            | 82.47                              |
| 2015 | 79.75                         | 93.55                            | 88.09                          | 81.17                            | 87.78                              |
| 2016 | 74.23                         | 97.79                            | 79.67                          | 93.03                            | 77.99                              |

Source: *Ministry of Education Science and Technology Schools Department*

*Ibadan, Oyo State of Nigeria.*

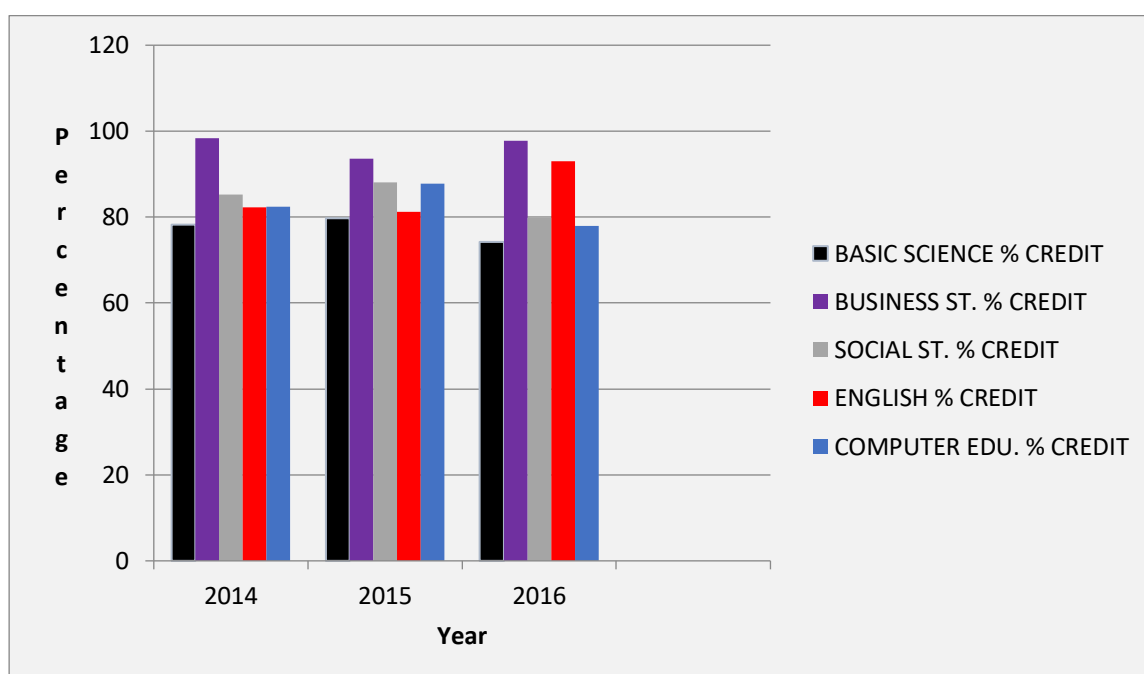


Figure 1: Graphical illustration of Students' Performance in Basic Education Certificate Examination in Basic Science, Business Study, Social Studies, English Language and Computer Education in Oyo State from 2014 to 2016.

Physics as one of the natural sciences plays an inevitable role in the technological development of a nation. Hence, its inclusion in the basic

science and technology curriculum at the level of primary education in Nigeria is to create a solid foundation for teaching and learning of science (Olagunju & Obi, 2010). It is defined as a branch of science that deals with energy and matter and their interactions. (Jegade & Adebayo, 2013). Adeyemo (2012) opined that physics serves as the bedrock upon which the science and technology advancement of any nation is built. Essentially science and technology would be incomplete without physics (Michael, 2006). It has proven its benefit to mankind as almost every human activity and virtually every profession involves some element of physics. The fields of medicine, engineering, communication, technology, architecture, agronomy among several others are based on the fundamental principle of physics (Gambari, 2010).

However, in spite of the importance of physics to technological development and as a requirement for many specialized science and engineering courses at higher institution of learning in Nigeria, students' performance and enrolment in physics at Senior School Certificate Examination (SSCE) is very low when compared with other science-based subjects such as biology and chemistry (Aina, 2012; WAEC, 2012). Adeyemo (2010) asserted that physics is perceived to be a difficult subject because of its abstract nature.

Omiwale (2012) submitted that physics is considered as the most problematic area within the realm of science and it traditionally attracts

fewer students than chemistry and biology. The poor performance and minimal increase of students' enrolment in physics is very disturbing and if not checked, may jeopardize the placement chances of students in tertiary institutions, not only in physics education but also in other physics related disciplines. This has serious implications for Nigeria economy, security, and manpower development.

Table 2 presents students' enrolment and performance in May/June WASSCE in biology, chemistry and physics in Nigeria from 2007 to 2016. From Table 2, it could be observed that in the years 2007, 2008 and 2013 students with credit pass in physics were below 50%. This implies that very few numbers of students would be having the opportunity of securing admission into science related course such as medicine, agriculture, pharmacy, geology, physical sciences, science education and engineering in the higher institutions. Also the improvement in the following years 2009, 2010, 2010, 2011, 2012, 2014, 2015 and 2016 are still not encouraging as about 40% are performing below average. This is illustrated in Figure 2. More so, within the years under investigation the enrolment of students is least in physics compared to biology and chemistry except for year 2015 in which the total entry is higher than chemistry as illustrated in Figure 3.

Table 2

*Students' Enrolment and Performance in May/June WASSCE in Biology,  
Chemistry and Physics in Nigeria from year 2007 to 2016.*

| Year | Biology   |                   |           | Chemistry |                   |           | Physics |                   |           |
|------|-----------|-------------------|-----------|-----------|-------------------|-----------|---------|-------------------|-----------|
|      | Total     | Credit            |           | Total     | Credit            |           | Total   | Credit            |           |
|      | Entry     | passed<br>(A1-C6) | %<br>PASS | Entry     | Passed<br>(A1-C6) | %<br>PASS | Entry   | passed<br>(A1-C6) | %<br>PASS |
| 2007 | 1,238,163 | 413,211           | 33.37     | 424,747   | 196,063           | 46.16     | 409,449 | 180,797           | 44.16     |
| 2008 | 1,259,964 | 427,644           | 33.94     | 456,980   | 202,762           | 44.37     | 408,237 | 200,345           | 49.08     |
| 2009 | 1,259,964 | 453,928           | 33.87     | 456,980   | 203,365           | 43.49     | 444,236 | 222,722           | 50.14     |
| 2010 | 1,300,418 | 427,644           | 32.88     | 465,643   | 263,059           | 50.70     | 463,755 | 237,756           | 51.27     |
| 2011 | 1,505,199 | 579,432           | 38.50     | 565,692   | 280,280           | 49.54     | 563,161 | 360,096           | 63.94     |
| 2012 | 1,646,150 | 587,044           | 35.66     | 627,302   | 270,570           | 43.13     | 624,658 | 429,415           | 68.74     |
| 2013 | 1,648,363 | 852,717           | 51.73     | 639,296   | 462,517           | 72.34     | 637,023 | 297,988           | 46.77     |
| 2014 | 1,365,384 | 766,971           | 56.17     | 636,268   | 397,649           | 62.49     | 635,729 | 386,270           | 60.76     |
| 2015 | 1,390,234 | 798,246           | 57.42     | 680,357   | 412,323           | 60.60     | 684,124 | 410,543           | 60.01     |
| 2016 | 1,200,367 | 740,345           | 61.68     | 706,873   | 408,122           | 57.74     | 705,125 | 415,655           | 58.95     |

Source: *West Africa Examination Council (2016).*

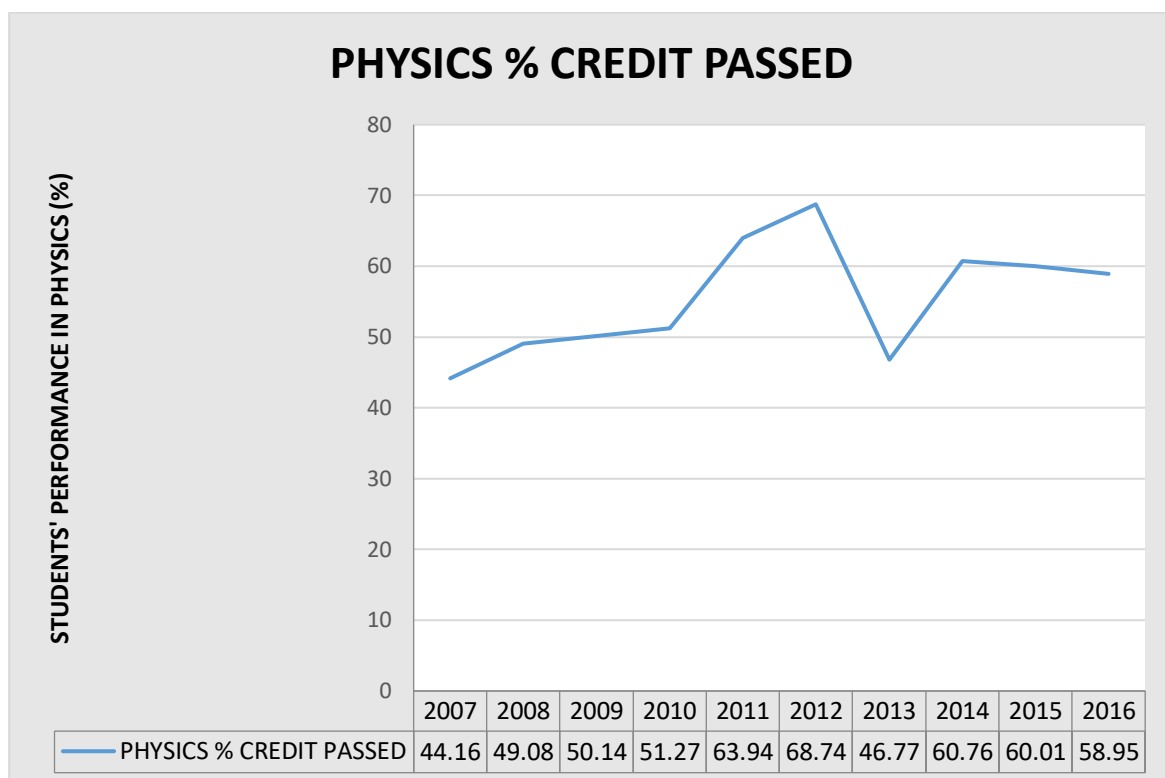


Figure 2: Graphical illustration of Students' Performance in May/June WASSCE in Physics from year 2007 to 2016.

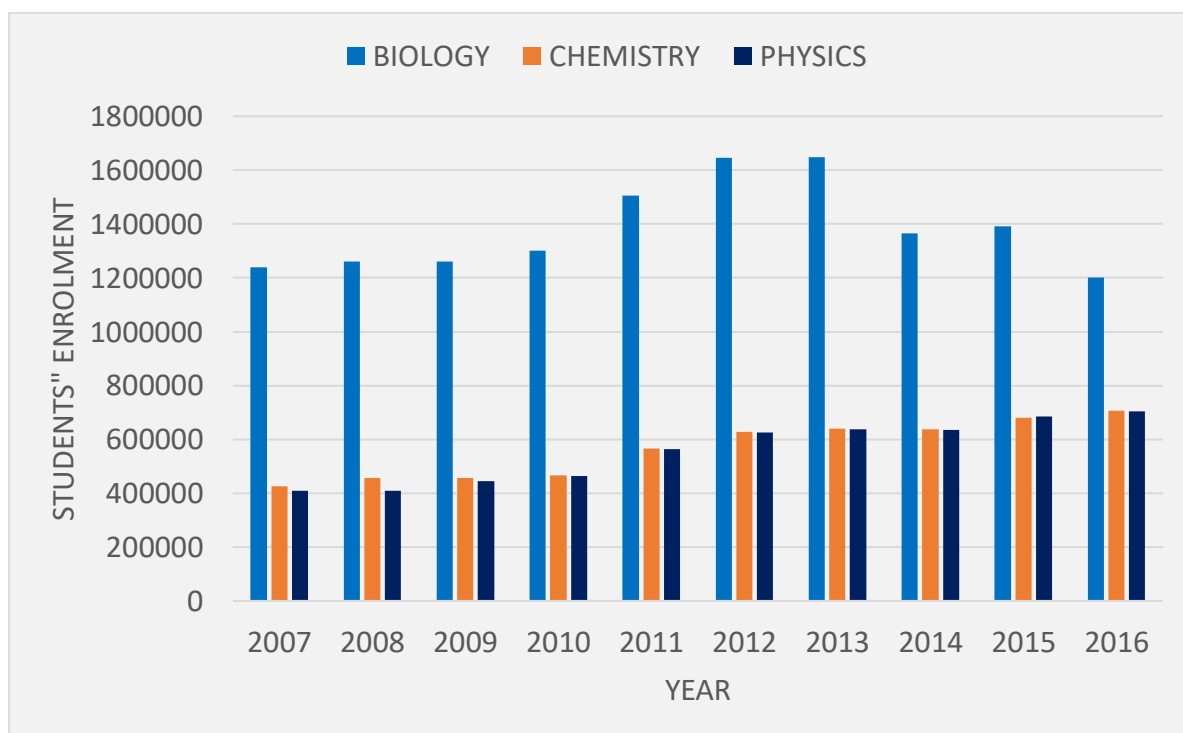


Figure 3: Graphical illustration of Students' Enrolment in May/June WASSCE in Biology, Chemistry and Physics from year 2007 to 2016.

Previous studies have attributed students' poor performance in sciences especially physics to lack of adequate infrastructure and facilities, safety concerns, lack of self-confidence, lack of laboratory practice, an excessive amount of time, limitation of space and effort required to conduct accurate experiments and many others (Njoku, 2007; Olorundare, 2014; Okebukola 2006; Yang & Heh, 2007). Nonetheless, these obstacles could possibly be overcome via an alternative learning environment, called a virtual laboratory (Branka & Dejan, 2016).

Virtual laboratory is a learning environment in which students convert their theoretical knowledge into practical knowledge by conducting experiments (Woodfield, 2005). Virtual laboratories simulate a real laboratory environment and processes. They provide students with meaningful virtual experiences and present important concepts, principles, and processes. By means of virtual laboratories, students have the opportunity of repeating any incorrect experiment or to deepen the intended experiences. Moreover, the interactive nature of such teaching methods offers a clear and enjoyable learning environment (Jeschke, Richter, & Zorn, 2010).

Onyesolu and Eze (2011) defined virtual laboratory as using the electronic models, simulations and a variety of instructional technologies for experimentation to replace or support real laboratory activities. The roles of virtual laboratory in teaching and learning process cannot be over-

emphasized because the rapid increase in the usage of educational computer has led to changes in the teaching and learning process, curricula and teachers' approach to instruction (Loveless & Ellis, 2002). These changes in instructional techniques are shaped by the fact that computer assisted learning increases students' motivation and creates better learning environments in which rote learning is minimized and meaningful learning can occur (Renshaw & Taylor, 2000). Gambari, Falode, Fagbemi and Idris (2012) were of the opinion that virtual laboratory makes students become active in their learning, provide opportunities for students to construct and understand difficult concepts more easily. In addition, virtual laboratories are useful for presenting science as a process and emphasizing science concepts (Liu, Amagai & Cordon, 2011).

Table 3 presents the problems encountered by teachers in science courses and solutions offered by virtual laboratories

Table 3

| Reason for teachers' lack of use of the lab | Alternatives offered by virtual laboratories                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Safety concerns                             | Experiments that involve risks in the real environment due to poisonous or unsavory gas releases can be safely performed in virtual laboratory environment/uncontrolled explosions (e.g.N13) have no real-world consequence, etc. Virtual laboratory (VL) is safer to use in secondary laboratories                                                                                                                                                                                                                                                                                  |
| Lack of self-confidence                     | Virtual laboratories help students and teacher with the little or no laboratory experience in terms of selecting laboratory equipment, setting up experimental apparatus, and completing the procedure. With the exception of starting the computer or accessing the website hosting the virtual environment software, virtual environments require no prior preparation of laboratory equipment, etc. Students could develop self-initiative                                                                                                                                        |
| Lack of equipment                           | As virtual laboratory equipment is not at risk of being broken or lost, users can use virtual laboratories freely. Experiments that cannot be conducted in a real laboratory due to shortages of equipment and materials can be repeated in a virtual lab without any loss. VL packages need no replacement therefore can be re-used                                                                                                                                                                                                                                                 |
| Time shortage                               | Time loss is reduced in virtual laboratories compared to time lost in real laboratories. The experimental procedure in virtual laboratories is similar to that of real laboratories. Understanding and following the experiments is easier in virtual media. After the experiment it is not necessary to devote time to tidying the virtual laboratory. Students who become accustomed to the virtual laboratory environment can easily repeat the same experiments in the real laboratory. It takes shorter time period to perform an experiment using VL                           |
| Weaknesses of confirmation method           | The interactive format of the virtual laboratory environment presents the problem case by arousing students' curiosity. They are made to put forward and test hypotheses, and are also given the opportunity to make generalizations. Since the subsequent experimental steps in the virtual laboratory are pre-planned based on algorithms, there is no risk of the experiment producing improper results or no results at all. The students are able to research freely within a largely determined framework (Dalgarno, Bishop, Adlong, & Bedgood, 2009 Yu; Brown & Billet, 2005) |

Source: Tatli and Ayas(2013,p160)

Aside from methods of instructions, students' score level is one of the factors that is responsible for differential learning outcome and it has attracted the attention of educational researchers. In Nigeria classroom, it is common to find students of mixed academic ability levels lumped together without considering their individual differences (Gambari, James & Olumorin, 2013). The capacity of students to engage themselves in any educational task which requires higher cognitive functioning depends on factors which include their academic potentiality. This could be tagged ability or level of academic attainment.

Students are not the same especially when we find out the rate at which facts and principles in sciences are being assimilated. This is to say that, there is disparity in the ability to perform specific tasks (Adesoji, 2008). Yusuf (2004) identified three ability levels in relation to teaching-learning situation viz: High, medium and low. High ability level learners are those that prefer isolation and social distance, theoretical and abstract ideas and are better than medium or low ability group. However, low ability group might be better in other tasks that have to do with the use of hands. Abakpa and Iji (2011) opined that the high ability group has greater ability to structure information and solve problems while medium ability level learners perform relatively better on learning activities involving social materials, and are more likely to require external defined goals and reinforcements.

Several studies have shown that learners are qualitatively different in their ability levels and in learning problems. For instance Gambari, Olumorin and Yusuf (2013), Gambari and Yusuf (2014) found that high ability learners are more intelligent than the low or medium ability learners in solving task in science courses. Based on this classification, students can be grouped based on their ability levels. Many of the previous studies did not consider the effects of ability grouping on gender.

Finally, gender differences also have historically been held responsible for divergence in academia and career success. Researchers contend that soon after children enter elementary school, females begin to fall behind males on standardized assessments (Freeman, 2004). Many argue that females are more likely to have better verbal abilities than males and conversely, males are more likely to have better mathematical skills than females (Skaalvik & Skaalvik, 2004). Meece, Glienke, and Burg (2006) reported that female students enrolled in more advanced high school science courses than males. In 2007, scores from the American College Test (ACT) indicated that females were less prepared for college science courses while males outperformed females in elementary, middle and high school in science achievement (Gender Differences in Science, 2009).

The West African Examination Council results in chemistry for the last five years indicate that good performance was by male students (WAEC, 2015). A study done by Sempala (2005) in USA showed that

gender inequities were most evident in laboratory assignment. Females are less likely to be involved in operating laboratory equipment. This discrepancy between male and female science achievements continues in postsecondary education where women are less likely to major in science disciplines (Britner, 2008; Miyake Kost-Smith, Finkelstein, Pollock, Cohen, & Ito, 2010).

From the foregoing, empirical researches on the influence of gender and score levels on students' performance in the sciences findings have been conflicting and inconclusive. It was against this background therefore that this study investigated the effects of virtual laboratory on basic six pupils' knowledge of science concepts and process skills with the interaction effects of gender, score level and attitude in Ibadan, Oyo State, Nigeria.

### **Statement of the Problem**

Rezba, Sprague and Fiel (2002) opined that one of the weaknesses in primary school's education is insufficient learning of natural science subjects which might be due to the poor level of teaching, because most primary school teachers are not science oriented. In addition students are not often exposed to practice basic science process skills in an effective way due to shortage of tools and equipment in science laboratories in primary schools, which consequently affect science instruction in senior schools

(Olagunju & Femi, 2010). The performance of students in Basic Science in all the subjects within the year under investigation had the least as earlier discussed in Table 1 and illustrated in Figure I. It is disturbing that this deficiency in Basic Science and Technology of which physics forms a component part is carried forward and also reflected in the performance of students in the May/June WASSCE in physics as shown in Table 2. This particular problem has prevented the educational system in Nigeria from producing required number of qualified scientist and technologist (Chukwu, 2000). More so Rafiu and Adetona (2007) submitted that the poor performance of students in science particularly in physics as a subject has implications on university admission; schools no longer produce adequate number of qualified candidates in science-based courses for university admission.

The poor performance of students in sciences have been attributed to lack of adequate infrastructure and facilities, safety concerns, lack of self-confidence, lack of laboratory practice, lack of qualified teachers and poor instructional strategies, an excessive amount of time, limitation of space and effort required to conduct accurate experiments and many others (Olorundare, 2014; Yang & Heh, 2007).

Research reports have shown that computer technology has been associated with improvement of performance in education (Branka & Dejan, 2016). Virtual learning is one of such technology, however, literatures on the

use of virtual laboratory demonstrations in science courses are scarce in Nigeria especially in primary school. Furthermore, there is no clear consensus among researchers on the advantage of virtual experiments over the real-world experiments (Gambari, Obielodan, & Kawu, 2017).

Some research literatures such as (Mohammed, 2016; Hassa, 2010; Gambari, Falode, Fagbemi & Idris, 2012; Lawrence, 2011; Dobson, 2009; Swan & O'Donnell, 2009) reported that students exposed to virtual laboratory performed better than the traditional laboratory demonstration. However, Stuckey-Mickell and Stuckey-Danner (2007) reported that students considered the real-world laboratory courses to be more effective than virtual laboratory simulation. Literatures on the findings on virtual laboratory and physical laboratory experiment have not been consistent.

From the literature reviewed so far however, much has not been done to examine the effects of virtual laboratory on physics components of Basic Science and Technology especially at primary school level in Nigeria. In addition most of the related studies reviewed were conducted in foreign countries. Also, the effects of virtual laboratory on pupils' knowledge of science concepts and process skills are scanty. Furthermore, findings on the influence of gender, attitude and score levels on students' achievements have not been concluded. Therefore this study investigated the effects of virtual laboratory on basic six pupils' knowledge of science concepts and process skills considering other related variables.

## **Purpose of the Study**

This study was to find out the effects of virtual laboratory instructional strategy on basic six pupils' knowledge of science concepts and process skills in Ibadan, Nigeria. Specifically, the study investigated the:

1. Difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only.
2. Difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only.
3. Difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI) and physical laboratory only(CO G)
4. Difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI) and physical laboratory only(CO G)
5. Difference in knowledge of science concepts (KSC) of male and female pupils when taught using virtual laboratory only (EX GI).
6. Difference in science process skills (SPS) of male and female pupils when taught using virtual laboratory only (EX GI).
7. Difference in knowledge of science concepts (KSC) of high, medium and low score level pupils when taught using virtual laboratory only

8. Difference in science process skills (SPS) of high, medium and low score level pupils when taught using virtual laboratory only
9. Difference in pupils' attitude when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G)
10. Difference in pupils' knowledge of science concepts (KSC) when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G)
11. Difference in pupils' science process skills (SPS) when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G)
12. Difference in knowledge of science concepts (KSC) of male and female pupils when taught using virtual and physical laboratories combined (EX GII)
13. Difference in science process skills (SPS) of male and female pupils when taught using virtual and physical laboratories combined (EX GII)
14. Difference in knowledge of science concepts (KSC) of high, medium and low score level pupils when taught using virtual and physical laboratories combined (EX GII)
15. Difference in science process skills (SPS) of high, medium and low score level pupils when taught using virtual and physical laboratories combined (EX GII)

16. Difference in pupils' attitude when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G)
17. Interaction effect of treatment, gender and score levels on pupils' knowledge of science concepts when taught using virtual laboratory
18. Interaction effect of treatment, gender and score levels on pupils' science process skills when taught using virtual laboratory

### **Research Questions**

The following research questions were answered in the study:

1. What is the difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only (CO G).
2. What is the difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only (CO G).
3. What is the difference in basic six pupils' knowledge of science concepts when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G)?.
4. What is the difference in basic six pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G)?

5. What is the difference in knowledge of science concepts (KSC) of male and female pupils when taught using virtual laboratory only?
6. What is the difference in science process skills (SPS) of male and female pupils when taught using virtual laboratory only?
7. What is the difference in knowledge of science concepts (KSC) of high, medium and low score level pupils when taught using virtual laboratory only?
8. What is the difference in science process skills (SPS) of high, medium and low score level pupils when taught using virtual laboratory only?
9. What is the difference in pupils' attitude when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G)?
10. What is the difference in pupils' knowledge of science concepts (KSC) when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G)?
11. What is the difference in pupils' science process skills (SPS) when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G)?
12. What is the difference in knowledge of science concepts (KSC) of male and female pupils when taught using virtual and physical laboratories combined (EX GII)?

13. What is the difference in science process skills (SPS) of male and female pupils when taught using virtual and physical laboratories combined (EX GII)?
14. What is the difference in knowledge of science concepts (KSC) of high, medium and low score level pupils when taught using virtual and physical laboratories (EX GII)?
15. What is the difference in science process skills (SPS) of high, medium and low score level pupils when taught using virtual and physical laboratories combined (EX GII)?
16. What is the difference in pupils' attitude when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G)?
17. What is the interaction effect of treatment, gender and score levels on pupils' knowledge of science concepts when taught using virtual laboratory?
18. What is the interaction effect of treatment, gender and score levels on pupils' science process skills when taught using virtual laboratory?

### **Research Hypotheses**

The following research null hypotheses were formulated and tested to answer the research questions at 0.05 level of significance.

**H<sub>01</sub>:** There is no significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only.

**H<sub>02</sub>:** There is no significant difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and physical laboratory only.

**H<sub>03</sub>:** There is no significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI) and physical laboratory only (CO G).

**H<sub>04</sub>:** There is no significant difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI) and physical laboratory only (CO G).

**H<sub>05</sub>:** There is no significant difference in the knowledge of science concepts (KSC) of male and female pupils taught using virtual laboratory only (EX GI).

**H<sub>06</sub>:** There is no significant difference in science process skills (SPS) of male and female pupils that were taught using virtual laboratory only (EX GI)

**H<sub>07</sub>:** There is no significant difference in the knowledge of science concepts (KSC) of low, medium and high score levels pupils taught using virtual laboratory only (EX GI).

**H<sub>08</sub>:** There is no significant difference in science process skills (SPS) of low, medium and high score levels pupils taught using virtual laboratory only (EX GI)

**H<sub>09</sub>:** There is no significant difference in the attitudes of pupils that were taught with virtual laboratory only (EX GI) and those taught physical laboratory only (CO G).

**H<sub>10</sub>:** There is no significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G).

**H<sub>11</sub>:** There is no significant difference in pupils' science process skills (SPS) when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G).

**H<sub>12</sub>:** There is no significant difference in the knowledge of science concepts (KSC) of male and female pupils taught using virtual and physical laboratories combined (EX G II)

**H<sub>13</sub>:** There is no significant difference in the science process skills (SPS) of male and female pupils when taught using virtual and physical laboratories combined (EX G II).

**H<sub>14</sub>:** There is no significant difference in the knowledge of science concepts (KSC) of low, medium and high score levels pupils taught using virtual and physical laboratories combined (EX G II).

**H<sub>15</sub>:** There is no significant difference in science process skills (SPS) of low, medium and high score levels pupils taught using virtual and physical laboratories combined (EX GII).

**H<sub>16</sub>:** There is no significant difference in the attitudes of pupils that were taught using virtual and physical laboratories combined (EX GII).

**H<sub>17</sub>:** There is no significant interaction effect of the independent variables (treatment, gender and score level) on pupils' knowledge of science concepts.

**H<sub>18</sub>:** There is no significant interaction effect of the independent variables (treatment, gender and score level) on pupils' science process skills.

### **Scope of the Study**

The study was limited to Ibadan, Oyo State, Nigeria. The study was conducted in three co-educational primary schools, namely school A, Immanuel primary school U.I Ibadan, school B, Polystaff primary school

Ijokodo Ibadan, school C, Methodist primary school I Bodija Ibadan. The choice of these three schools was based on special available features such as laboratories, facilities, and years of enrolment among others. The choice of the co-educational schools is to allow for the verification of the influence of the independent secondary variable of gender.

The study was limited to three physics topics in basic science and technology curriculum which are: (i) Simple Machines (ii) Forces (iii) Magnetism (NERDC, 2007). These concepts were chosen because they are designed to be taught in the second term of basic six. Therefore pupils were considered as having not been exposed to the topics. Furthermore, samples were restricted to basic six pupils. The study employed Basic Science Achievement Test (BSAT) as assessment tool to explore the effects of virtual laboratory on basic six pupils' knowledge of science concepts and process skills.

The independent secondary variables of this research included; learners' gender (male & female), learners' performance level (high, medium & low), learners' attitude (positive & negative), and the dependent variable is achievement scores at the posttest.

### **Significance of the Study**

The study could be significant to basic six pupils, teachers, basic six teacher trainees, curriculum developers for basic level of education.

Findings from the research are expected to have positive impact on the pupils' participation in science in the sense that the virtual laboratory packages could be readily available for the learners' use during and after the lesson. This may enable the learner to study a particular concept over and over again at his/her own pace. This procedure may provide for individual differences, eliminate tension, make learning easier, simpler, and more enjoyable and might culminate in better mastering of the subject matter contents. As a result there should be better enrolment of students in basic science and technology at the upper basic level and subsequently lead to better enrolment for physics at the senior school level.

The findings from the study could also stimulate and encourage science teachers' innovativeness, resourcefulness, ingenuity and challenge them to use computer as a tool for effective teaching and learning in this century. The basic six science teacher could benefit from this study, because it provides some positive approach to the teaching of abstract and complex science concepts.

It is also hoped that from the findings of this study, Basic six teacher trainee could incorporate the strategies of using virtual laboratory in their programs. Consequently, these could promote effective teaching and learning which will enhance high performance and better interest in the physics aspect of science.

Curriculum developers in charge of basic school could benefit from the findings of this study in that they should incorporate into the curriculum of basic science the need for virtual laboratory especially as a result of dearth of fund in Nigeria.

The findings from this research are expected to serve as a reference point to education researchers by providing empirical evidence in their quest for further research work on learning strategies.

### **Clarification of Major Terms and Variables**

**Physical Laboratory:** The normal teaching that takes place in the laboratory where pupils are taught by performing experiment.

**Virtual Laboratory:** This is a computer-based learning environment where learners are able to simulate experiments completed as in physical laboratory through the use of computers.

**Knowledge of science concept:** This is what learners can comprehend and do about the science topics. It is the generalizations that learners can develop about the nature or properties of the concepts considered which are: simple machines, forces and magnetism.

**Science Process Skills:** This is a series of mental actions necessary for pupils' knowledge of science such skills as observation, measurement, classification, prediction, inference and communication.

**Score Level:** High score level pupils are pupils whose score in the last term basic science and technology examination falls in the upper quartile 75% i.e. (75–100%) ,medium performance level pupils are those whose score is in the middle 50% i.e. (50–74.9%) while low performance level pupils are those whose score falls in lower quartile 25% i.e. (0–49.9%).

**Attitude:** This is the pupils' positive or negative interest towards basic science and technology.

**Pre-test Achievement Scores:** This refers to scores obtained in the Basic Science Achievement Test (BSAT) by the basic six pupils who participated in the study before the treatment.

**Post-test Achievement Scores:** This refers to scores obtained in the Basic Science Achievement Test (BSAT) by the basic six pupils who participated in the study after the treatment.

**Gender:** Students' sex which could be male or female

**B S A T:** Basic Science Achievement Test.

**B S V L A Q:** Basic Science Virtual Laboratory Attitude Questionnaire.

**Experimental group one (EX.GI):** This is a group of pupils taught using the virtual laboratory instructional package only.

**Experimental group two (EX.GII):** This is a group of pupils taught using the virtual laboratory instructional package with physical laboratory.

**Control group (CO.G):** This is a groups of pupils taught using physical laboratory (conventional method) only.

## **CHAPTER TWO**

### **REVIEW OF RELATED LITERATURE**

This chapter focuses on the review of related literature to the study.

The review has been carried out under the following headings.

- Theoretical Framework for the Study
- The Objectives and Content of Basic Six Science and Technology Curriculum
- Knowledge of Science Concepts and Science Process Skills
- Empirical Studies on Effects of Virtual Laboratory on Knowledge of Science Concepts and Science Process Skills
- Empirical Studies on Influence of Gender on Students' Academic Performance
- Empirical Studies on Students' Score Levels and Academic Performance
- Empirical Studies on Pupils' Attitude towards Basic Science and Technology
- Appraisal of the Reviewed Literature

#### **Theoretical Framework for the Study**

Learning theories and practice are very important as they provide the teachers with well-organized experiences necessary in facilitating learning. Learning theories are conceptual frameworks that describe how information is absorbed, processed, and retained during learning. Learning brings

together emotional and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views (Ormrod, 2012). Theories of learning are in three main categories; behaviourism, cognitivism and constructivism. While the behaviourism focuses on the objective observable aspects of learning, cognitive theories look beyond behaviour to explain brain-based learning, and constructivism on the other hand views learning as a process in which the learner actively constructs new ideas or concepts.

The theoretical framework for this present study is based on constructivism theory of learning. It is a theory of learning that lays emphasis on the ways that people create meaning of the world through a series of individual constructs. Simply stated, it is a learning process which allows a student to experience an environment first-hand, thereby, giving the student reliable, trust-worthy knowledge.

Student's construction of knowledge is a revolution in educational psychology built on the work of Piaget and Bruner. Constructivism emphasizes the importance of active involvement of learners in constructing knowledge for themselves (Bodner, 1986). Constructivism is a major learning theory that is particularly applicable to the teaching and learning of science. It promotes a student's free exploration within a given framework structure (Devries, 2003) while the teacher acts as a facilitator who

encourages students to discover principles for themselves and to construct knowledge based on current and past experience to solve realistic problems.

The teacher's role is to translate lesson resources into a form that the learner can understand, and to encourage and engage the learners in a dialogue. The instructional material is designed in a way that builds on what the pupils already know and develop with them (Ormrod, 2012). The student is required to act upon the environment to both acquire and test new knowledge. Constructivists are of the view that knowledge is not mechanically acquired, but actively constructed within the constraints and offerings of the learning environment (Liu & Mathews, 2005).

Cooperstein and Kocevar-Weidinger (2004) opined that in constructive learning the standard classroom procedure is turned upside down because there are no lectures, no demonstrations, no presentations. That is from the beginning, students engage in activities through which they develop skills and acquire concepts. Constructivist learning in most cases begins with a case or a problem and as learners work the problem, the intervention of the teacher, facilitator or instructor is only to guide students in the appropriate direction and not to directly impart knowledge. Learners construct their own meaning. In order to make knowledge use in a new situation, students must make a deliberate effort to make sense of the information that comes to them. They must manipulate, discover, and

create knowledge to fit their belief systems (Cooperstain & Kocevar-Weidinger, 2004).

Heinich, Moluda and Rusell (2002) generally present the viewpoints of constructivist in such a way that authentic activities should be part and parcel of instructional presentation. According to them, emphasis should be placed on packaging learning activities on media which learners can interact with and interpret according to their understanding. Constructivist approach suggests that active participation has crucial importance in students' learning process (Bernard et al., 2004; Edwards & Hammer, 2004).

In constructivist learning approach, students construct actively their knowledge by thinking, doing, and interacting with the environment (Yildirim, 2009; Tatli, 2011). For this reason, laboratory has been given a central and distinctive role in science education, and science educators have suggested that there are rich benefits in learning from using laboratory activities (Taşdelen, 2004). Laboratory approach is based on the idea that experiments to prove the basic information about science must be done in laboratory by the students. Individual differences would be eliminated in laboratory studies in a way because all equipments and methods used in doing experiments in laboratory studies are also elements of individual training (Tatli, 2009). In addition, use of laboratory as a method of teaching develops students' reasoning, critical thinking, scientific perspective and problem-solving abilities (Odubunni & Balagun, 1991;). With these skills,

the students are encouraged to think, study and perform experiments like a scientist (Ayas, Cepni & Akdeniz, 1994, Bozdogan & Yalcın, 2004).

Virtual laboratories as a supportive factor to real laboratories enriches learning experiences of students and offers students to do experiment, to control materials and equipment, to collect data, to perform the experiment interactively, and to prepare reports for the experiment as well as developing experimenting skills (Tatli & Ayas, 2012). In addition, students demonstrate active participation while doing an experiment in a virtual environment; they may carry out the experiment individually or in collaboration with colleagues.

Based on the summary above, a virtual laboratory has been developed related to physics aspect of basic six science and technology curriculum which are: simple machines, forces and magnetism by making use of the constructivist theory which is learners-centered in which they interact with the environment to construct their own meaning. Investigation of similarities and differences of learning and teaching process in virtual and real environments (laboratory) formed the basic problem of this study.

## **The Objectives and Content of Basic Six Science and Technology Curriculum**

Curriculum is said to have been derived from the Latin word “currere” meaning “a running course”. It means literally that curriculum is a running course leading to the attainment of a goal (Olagunju & Femi 2010). Curriculum has been defined by many scholars depending on their intention and the needs of the society. Tyler (1949) defined curriculum as all the learning of students which is planned and directed by the school to attain educational goals. Dada (1999) defines curriculum as a programme of learning planned for a target group of learners for a specific period of time in order to achieve certain predetermined educational goals, while Olorundare (2014) defined curriculum as the planned structured and sequential set of learning outcomes organized and carried out under auspices of the school directed experiences which include, the school subjects, classroom interaction, teaching methods, and organizational pattern of the school.

In line with government declaration for a 9 year Basic Education Programme, the Nigerian Educational Research and Development Council (NERDC) was directed by the National Council on Education (NCE) to re-structure and realign the existing primary and junior secondary school curriculum to meet the targets of the 9 year Basic Education in the context of National Economic Empowerment and Development Strategies (NEEDS)

and the Millennium Development Goals (MDGs).The NCE approved a new curriculum structure namely: Lower Basic Education Curriculum (Primaries 1 – 3); Middle Basic education Curriculum (Primaries 4 – 6) and Upper Basic Education Curriculum (J S 1 – 3) with subject's listings. The overall objectives of this curriculum are to enable the learners 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 (NERDC, 2007).

In order to achieve a holistic presentation of science and technology contents to learners, the thematic approach to content organization was adopted. Consequently, four themes were used to cover knowledge, skills and attitudinal requirements. These are:

1. You and Environment
2. Living and Non-living things
3. You and Technology
4. You and Energy (NERDC 2007).

For the purpose of this study the physics contents of the curriculum captioned under theme 4 (You and Energy) were considered as highlighted below:

- a) Simple Machines (Levers, Pulleys and Inclined Planes)
- b) Forces (Frictional Force)
- c) Magnetism

## BASIC SIX

### THEME 1: YOU AND ENVIRONMENT

- A. Synthetic and Naturally Occurring Drugs
- B. Drug Use
- C. Effects of Drug Abuse
- D. Earth and Sky Movement
- E. The Earth's Movement
- F. Our Weather II

### THEME 2: LIVING AND NON LIVING THINGS

- A. Improving Crop Yield
- B. Improving Crop Yield (Population and economic consequences)
- C. The Human Body (Blood Circulation and Reproduction)
- D. Responsible Parenthood
- E. Water Projects
- F. Air

G. Minerals

### THEME 3: YOU AND TECHNOLOGY

A. Colours

B. Door mat making

C. Use of drawing instruments (Board practice)

D. Introduction to Woodwork Hand Tools

E. Maintenance

F. Safety

### THEME 4: YOU AND ENERGY

A. Simple

(i) Machines

(ii) Levers

(iii) Pulleys

(iv) Inclined Planes

B. Forces

C. Frictional Force

D. Magnetism

For this study the physics contents of the curriculum captioned under theme 4 (You and Energy) were considered as highlighted below:

(a) Simple Machines

(i) Levers

- (ii) Pulleys
- (iii) Inclined Planes
- (b) Forces (Frictional Force)
- (c) Magnetism

Since the curriculum represents the total experiences to which all learners must be exposed, the contents, performance objectives, activities for both teachers and learners, teaching and learning materials and evaluation guide are provided as shown in appendix 1. The use of guided inquiry method of teaching and learning is implied in the activities prescribed under each topic in order to promote learning by doing and skills development (NERDC, 2007).

In the light of curricula, science is considered in terms of the natural science curriculum as a means of knowing, a process for increasing the knowledge and understanding of the natural world. In this frame, students should be active learners. It is not sufficient for students to read about science, they have to realize science. They should observe, classify, inquire, infer, communicate, analyze etc. Students should have active experiences all over the instructed science curriculum; they should use science process skills and understand important science concepts and the nature of science, in addition to communicate effectively using science language and reasoning (Duschl, Schweignruber, & Shouse, 2007).

## **Knowledge of Science Concepts and Science Process Skills**

Scientific concepts and science process skills are central components in science education. The purpose of science education is for students to be able to function in an increasingly scientific and technological world and for citizens who would apply scientific thinking in all parts of their life (Irez, 2009). Cobble and Koballa (1996) pointed out that majority of students graduated from high school knowing science facts without understanding the evolution of ideas and how science affects and be affected by world culture and societies. Additionally, the practice of science instruction has emphasized knowing a lot of science and teachers merely drilling students with scientific knowledge to enable them pass the tests thus compromising understanding.

However, students need to understand the concepts, principles, and theories central to the different science disciplines so that the knowledge acquired is meaningful and beneficial. This will make students view science not as magical or mysterious, but as a powerful and productive means of answering questions about the world and themselves. Cobble and Koballa (1996) further stressed that a person possessing understanding should be able to think scientifically and apply the knowledge and skills of science when confronting with both individual and societal problems. Learning science is not about learning facts by rote, but about understanding.

Egyptian Ministry of Education (2003) recommended that scientific concepts should be presented in a way to allow learners to recognize relationships, link new concepts to previously taught ones, and to employ concepts in new settings in order to improve the learning process. However to develop new conceptual understanding, students need to build connection with other concepts that they already know.

Bloom's taxonomy of educational objectives uses the acronym KCAASE (pronounced "case") to identify the key elements in his theory, which describes level of learning and cognitive activity. KCAASE stands for: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation as discussed below.

- I. Knowledge – remembering of previously learned material. The learner knows common terms, specific facts, methods and procedure, basic concepts and principles. Behavioural verbs are: define, describe, identify, list, name, distinguish, state, label, underline etc.
- II. Comprehension—this is ability to grasp the meaning of material. The learner can translate material from one form to another (word to numbers), can explain or summarize. This level goes beyond remembering and is the lowest level of understanding. Behavioural verbs are: covert, defend, explain, give examples, rewrite etc.
- III. Application—this is ability to use learned material in new and concrete situations. The learner demonstrates correct usage of a method of procedure,

solves mathematical problems, and applies laws and principles to new situations. Learning at this level requires a higher level of understanding than achieved at comprehension level. Behavioural verbs are change, demonstrate, prepare, solve, use, operate, show calculate etc.

- IV. Analysis—this ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of the parts, analysis of the relationship of the parts. Behavioural verbs are: breakdown, illustrate differentiate analyze, separate, calculate, etc.
- V. Synthesis— this ability to put parts together to form a new whole. This involves the production of a unique plan, a new recipe or menu. This level stresses creative behaviours such as combine, compose, plan, construct, explain, rearrange etc.
- VI. Evaluation— this is the ability to judge the value of material for a given purpose. Learning at this level involves elements of all other levels. Behavioural verbs are: appraise, criticize, justify, contrast, conclude, compares, summarize, asses etc. (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956)

Concepts can be understood and used at different levels. In order to assess the different levels of understanding science concept, Oversby (2002) considered a variety of ways among others are problem solving and concept mapping. These are the two important and mostly used kinds of tests or

assessment tools for judging how well someone understands science concepts. In addition, the researcher opined that when defining conceptual understanding in terms of problem solving, objective questions are used to select single correct answer from four or five possible responses.

Furthermore, science understanding could be characterized at different level by Bloom's taxonomy of cognitive understanding. A modified version of hierarchy according to Bloom's taxonomy of cognitive understanding with brief explanation and examples of the kinds of question is shown in table 4.

Table 4

*Bloom's taxonomy of cognitive understanding*

| Level         | How concept can be used                                                            | Example of questions                                                                                                               |
|---------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Recognition   | The concept has been meet before                                                   | Have you heard of the term frequency?                                                                                              |
| Recall        | The concept can be distinguished from similar concepts and recalled                | What do you call sound with frequency more than 20Khz?                                                                             |
| Comprehension | The concept can be understood in familiar and unfamiliar contexts.                 | Explain resonance?                                                                                                                 |
| Application   | The concepts can be used in new contexts to develop general ideas.                 | By considering the forces on a tennis ball thrown into the air, explain its motion from leaving the hand until it hits the ground? |
| Analysis      | The concept can be used to tease out meaning of a set of data or related concepts. | Explain how you predict a given object will sink or float in water?                                                                |

|            |                                                                                                      |                                                                                                                                |
|------------|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Synthesis  | The concept is used to integrate a collection of ideas.                                              | By considering all forces acting on an object submerged in water, explain how to determine the up thrust acting on the object? |
| Evaluation | The concept can be compared with other related concept for the same phenomena for explanatory power. | Compare the use of renewable energy to that of non-renewable energy sources?                                                   |

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Source: Adopted from Oversby, (2002)

Congruently, Hassan (2010) assessed students' conceptual understanding using the first four levels of Bloom's taxonomy of educational objectives in the cognitive domain and science process skills using the six basic science process skills. Problem solving approach as assessment tool was used as presented on table 5. The intended learning outcomes describe the main concepts and science process skills in the area of lab tools, warning symbols and matter using V Lab program for 4th grade students.

Table 5

*Assessment tool on Students' Conceptual Understanding and Science Process Skills.*

1. Comprehending Science Concepts

| Learning Objective                                                 | Level         |
|--------------------------------------------------------------------|---------------|
| Distinguish between measuring tools and elements for measuring     | Analysis      |
| Distinguish between heating tools and warning symbols              | Analysis      |
| Choose appropriate instruments to measure length, volume, and mass | Analysis      |
| Estimate the density of substances.                                | Analysis      |
| Situate examples of how to use a microscope to check an object.    | Comprehension |
| Name basic warning symbols.                                        | Knowledge     |
| Explain examples of lab warning symbols.                           | Comprehension |
| Determine the uses of main lab tools.                              | Knowledge     |
| Describe the physical change in matter.                            | Comprehension |
| Identify features of a chemical change in matter.                  | Comprehension |

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|                                                                                       |               |
|---------------------------------------------------------------------------------------|---------------|
| Infer relationships between chemical changes in matter and physical changes in matter | Application   |
| Compare the states of matter.                                                         | Analysis      |
| Demonstrate that the combustion of paper is a chemical change.                        | Comprehension |

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## 2. Using Science Process Skills

| Learning Objective                                                                                   | Skill          |
|------------------------------------------------------------------------------------------------------|----------------|
| Observe main lab tools.                                                                              | Observation    |
| Observe lab warning symbols.                                                                         | Observation    |
| Make predictions and inferences based upon experiment                                                | Inferring      |
| Categorize and group main concepts of lab tools.                                                     | Classification |
| Compare between solids, gas, and liquids.                                                            | Classification |
| Apply instruments to measure length, volume and mass using appropriate units.                        | Measurement    |
| Predict the result for measuring set up.                                                             | Prediction     |
| Organize main concepts by making concept map.                                                        | Communication  |
| Calculate density based on given data.                                                               | Measurement    |
| Determine the relationship between elapsed time and time until<br>according to different temperature | Measurement    |
| Identifying similarities and differences in features of matter cases                                 | Observation    |
| Illustrate states of matter according to graph.                                                      | Communication  |
| Collect information by observing and measuring mass and volume.                                      | Inferring      |
| Use observations to construct a reasonable explanation of chemical change                            | Inferring      |
| Infer the concept of melting.                                                                        | Inferring      |
| Group examples of lab warning symbols.                                                               | Classification |

Source: Adopted from Hassan (2010)

Mutlu and Temiz (2013) defined science process skills as the basis for scientific thinking and research. According to Karamustafaoglu (2011), science process skills are the thinking skills that we use to get information. Pedilla (1990) defined science process skills as a set of skills that are reflective of the behaviour of scientists, that are appropriate to many scientific fields, and that are broadly transferable to other situations. This scientific research process can be taught using science process skills (Feyzioglu, Demirdag, Akyildiz & Altun, 2012). Hassan (2010) submitted that the purpose of science education is to enable individuals to use scientific process skills; in other words, to be able to define the problems around them, to conclude, to generalize and to apply the information they have with the necessary skills.

Yakar (2014) opined that science teaching should be planned in a way to include teaching science process skills because they are among the most frequently used thinking skills. Hilal and Omer (2008) opined that scientific process skills (SPS) include skills that every individual could use in each step of his/her daily life by being scientifically literate and increasing the quality and standard of life by comprehending the nature of science. Therefore, these skills affect the personal, social, and global lives of individuals. The SPS are a necessary tool to produce and use scientific information to perform scientific research, and to solve problems.

Huppert, Lomask and Lazarowitz (2002) opined that acquisition of these skills is one of the most important aims of science teaching. The researchers stressed further therefore, that these skills are not only for scientist but everyone should acquire it. Kazeni (2005) confirmed that the development of science process skills enable students to gain the skills necessary to solve everyday problems, otherwise the individuals who cannot use science process skills will have difficulty succeeding in daily life. Ewers (2001) reported that when science process skills are not acquired, it will be an obstacle to science literacy due to the fact that science literacy is not limited to reading and hearing; instead it requires efficient use of science process skills.

Science process skills deals with identifying a problem, formulating a hypothesis about the problem, making valid predictions, identifying and defining variables, designing an experiment to test the hypothesis, gathering and analyzing data (Fraenkel & Wallen, 2006). There are different viewpoints related to the taxonomy of science process skills. Science process skills are classified into basic, intermediate and advanced levels (Charlesworth & Lind 1995). Basic process skills provide a base for more complex skills and appropriate to develop young learners in elementary science classroom. These skills include: observation, classification, measurement, communication, prediction and inference.

In other related literatures science process skills are categorized into two: basic and integrated process skills (Chabalengula, Mumba & Mbewe, 2012; Ergin, Sahin-Pekmez, and Ozgelen (2012) confirmed that basic science process skills can be acquired from the pre-school and primary schools while integrated process skills which are important skills for solving problems or doing science experiments can be acquired in secondary school. Hence the acquisition of science process skills becomes deeper in higher stages (Cepni & Cil, 2009).

It is evident that, not all students will become practicing scientists, but there is a desire to instill scientific attitudes that are favourable for all individuals. The basic science process skills (BSPS) provide the intellectual ground work for scientific inquiry, such as the ability to order and describe natural objects and events. The literature on BSPS presents six dimensions of basic science process skills (Yakar, 2014) including:

Observation: - Students observe using their senses to gather information about objects or events. This is the most fundamental of all the process skills and the primary approach through which students obtain information. For example, a student could describe a test tube as round, and transparent. Students can also use scientific instruments to aid in their observations such as thermometers, rulers and balances.

Communication: - Communication can take many forms including using words, actions or graphic symbols to describe an action or event. It needs students to use information that they have gathered from observations.

Inference: - Making inference involves using proof to explain events that have taken place or things that have been observed. It is important to help students to distinguish between their observation and inference. For example, students may observe water vapour and conclude the physical change in the state of water. They may observe the size, shape, and direction of movement, but when they provide explanations for the observation, they are making inference. For example students may infer that the change of water from one state to another is a physical change when observing water vapour coming out from the beaker, which is able to condense and convert again to water droplets.

Classification: - This involves setting objects in groups according to some ordinary characteristics. For example, students are able to sort a collection of lab tools into different groups, i.e. measuring tools, heating tools, warning symbols and so on according to observable characteristics.

Measurement: - Measuring consists of using both standard and non-standard measures to explain the dimensions of a tool, as in, identifying length, volume, and mass according to the ability of the instrument

Prediction: - In making predictions, students suggest the outcome of future event using observations and previous discoveries. Since predictions are best guesses based on available information, the more information students have, the more accurate their predictions can become. In the present study the researcher adapted from Oversby (2002) and Hassan (2010) problem solving approach as assessment tool for students' understanding of concepts and science process skills as included in Appendix XI.

## **Empirical Studies on Effects of Virtual Laboratory on Students'**

### **Knowledge of Science Contents and Process Skills**

Harry and Edward (2005) defined virtual laboratory as laboratory experiment without real laboratory with its walls and doors. It enables the learner to link between the theoretical aspect and the practical one, without papers and pens. It is electronically programmed in computer in order to simulate the real experiments inside the real laboratories. The researcher further explained that virtual laboratory is a virtual studying and learning environment aims at developing the lab skills of students. (Zaiton 2005) defined virtual laboratory as virtual studying and learning environment that stimulates the real lab that provides the students with tools, materials and lab sets on computer in order to perform experiments subjectively or within a group at anywhere and anytime. These experiments are saved on CDs or on web site. A number of studies have been carried out on the effects of

virtual laboratory demonstration on students' achievement. The procedures and findings of such investigations are discussed.

Mohammed (2016) carried out a quasi-experimental study. Three schools were purposively sampled and from which three intact classes of senior school II physics students took part in the study. A total of 172 students comprising of three groups, experimental group one (EG1=68), experimental group two (EG2=51) and control group (CG=53) were involved. The instrument used was virtual physics laboratory test. Pearson Product Moment Correlation Statistic was used to test the reliability using the split half method. The coefficients were 0.61 and 0.60 for pretest and posttest items respectively. Five research questions were answered and three hypotheses were tested using frequency count and percentage, t-test and Analysis of Covariance respectively. Findings from the study revealed that;

- (i) There was a significant difference in the achievement of students who were taught physics using virtual physics laboratory package (VPLP) only (EG1), those that were taught using VPLP and physical laboratory (EG2) and those taught with physical laboratory only (CG),  $F(2, 171)=42.59$ ;  $p < 0.05$  in favour of those taught with VPLP and physical laboratory only;
- (ii) There was no significant difference in the achievement of male and female students who were taught physics using VPLP only, VPLP and physical laboratory only, and physical laboratory only  $F(2, 171)=0.02$ ;  $p > 0.05$

(iii) There was a significant difference in the achievement of high, medium and low scorers who were taught physics using VPLP only, VPLP and physical laboratory, and physical laboratory only in favour of low scorers,  $F(2,171) = 196.45$ ;  $P < 0.05$ . The study concluded that students who were taught physics using virtual physics laboratory together with physical laboratory (EG2) out-performed students in the other groups (EG1) and (CG). The implication of this study is that students' achievement in physics would be better, if they are taught using virtual laboratory together with physical laboratory.

Hassan, (2010) also conducted a study to compare the impact of a Web-based Virtual Laboratory (WVL) environment with that of traditional educational experience in relation to conceptual understanding and science process skills in natural science for fourth grade primary school students. The sample used in the study consisted of 70 students from two primary language schools in Mansoura City, Dakahlyia Governorate, Egypt. The sample was divided into an experimental group and a control group. The author used an experimental design wherein the experimental group was exposed to the WVL, while the control group studied in a traditional setting and performed related activities. The findings of the post-test highlighted the following points.

- a) Students in the experimental group had significantly higher mean scores in conceptual understanding especially in two of cognitive levels.

- b) The experimental group performed better in science process skills, especially in five of these skills.
- c) There was no significant difference in the performance of boys and girls within the experimental group for science process skills.
- d) The estimation of the effect sizes (indication of the level of difference between the post-test scores of the experimental and control group) revealed that, the effect size was large for two skills, medium for three skills and small for only one skill. It was concluded that the WVL provided considerable support for fourth grade students and helped them to improve their conceptual understanding in science and science process skills.

Tatli and Ayas (2013) carried out a study to examine the effect of a virtual chemistry laboratory (VCL) on students' Achievement. Participating students were randomly assigned to one of three groups: experimental group (EG, n = 30), control – 1group (CG – 1, n = 30) and control – 11 groups (CG – 11, n = 30). The experimental group performed all the experiments in chemical changes unit using the virtual chemistry laboratory (VCL), the CG – 1 and CG – 11 groups were not manipulated, and the teacher taught the unit using conventional method. The implementation took six weeks during the spring semester of the 2009 – 2010 academic years and was conducted at an Anatolian secondary school located in the city center of Trabzon. In order to assess the effect of virtual chemistry lab on students' achievement, chemical changes unit achievement test (CCUA) and

Laboratory Equipment Test (LET) were administered. Pre-and post-test scores of CG -1, CG – 11, and EG groups were statistically different. The SPSS 16.0 statistical analysis was used to analyze the data. It was concluded that the developed virtual chemistry laboratory software is at least as effective as the real laboratory, both in terms of student achievement in the unit and students' ability to recognize laboratory equipment.

Natasa and Branka (2016) carried out a didactic experiment to test the effectiveness of a virtual laboratory that enables dynamic visualization. The experiment involved seventh-grade pupils (N = 109) from five different primary schools in Slovenia. The study aimed at finding out whether the learning outcomes of pupils are better when they use a virtual laboratory rather than in science classes without a virtual laboratory where dynamic visualization at the sub-microscopic and sub-micro levels are only explained by means of static demonstrations.

The results of the didactic experiment showed that, in terms of knowledge acquisition, using a virtual laboratory is better than science classes without visualization elements. Liu et al. (2010) also combined virtual experiment technique and physical experiment technique in their studies. The control group was taught with traditional method and experimental method while experimental group was taught with that combined method. The results were in favor of experimental method.

Zacharias, Marios, Giorgos and Vasoula (2014) investigated the effect of experimenting with Physical Manipulatives (PM), Virtual Manipulatives (VM), and a blended combination of PM and VM on sixth graders' understanding of concepts in the domain of Electric Circuits. A pre-post comparison study design was used for the purposes of this study that involved 55 participants assigned to three conditions.

The first condition consisted of 18 students that used PM, the second condition consisted of 18 students that used VM, and the third condition consisted of 19 students that used the blended combination of PM and VM. All conditions used the same inquiry oriented curriculum materials and procedures. A conceptual test was administered to assess students' understanding before and after teaching. Results revealed that the use of the blended combinations enhanced students' conceptual understanding in the domain of Electric Circuits more than the use of PM or VM alone.

Nataša, Milena and Dejan (2014) carried out a teaching experiment in order to assess the effectiveness of using a virtual laboratory as a visualization element when addressing chemical contents within science classes. In addition, two questions were addressed: whether the dynamic visualization enabled by the use of a virtual laboratory has a positive effect on the learning outcomes of pupils, and how successful are the pupils when solving tasks that involve visualization elements. Pupils from five different schools who were attending the seventh grade (N = 109), participated in the

study. The pupils were divided into experimental and control groups. The results from the didactic experiment showed, that in terms of knowledge acquisition, the use of a virtual laboratory was more effective than classes without the use of dynamic visualization elements.

Özge and Serkan (2015) conducted a study to identify the effects of virtual experiment technique on seventh grade students' electricity achievement and attitudes towards science laboratory. The subjects were 69 seventh grade students in two classes of the same teacher. Randomly assigned experimental group students received virtual experiments oriented instruction, whereas control group students performed physical experiments. Achievement test and attitude scales were given as pretests prior to instruction and as posttests after four weeks of instruction. Two separate covariance analysis were conducted in this study and both of them indicated statistical significant differences. In accordance with these significant results, it was concluded that virtual experiments have a substantial role in education by providing safe medium and interactive genuine models for students.

Omilani, Ochanya and Aminu (2016) examined the effect of virtual laboratory when it is combined with real laboratory on students' achievement in practical Chemistry. The sample for this study was 120, senior secondary school three science students. The instrument used for data collection was Chemistry Practical Achievement Test (CPAT). The result

showed that virtual laboratory combined with traditional laboratory had a significant main effect on students' achievement in Chemistry practical.

In a preliminary investigation on virtual laboratory for learning Biology carried out by Murniza, Halimah and Azlina (2010), a group of form five (Seventy-two students) from two secondary schools comprising of 38 girls and 34 boys who had gone through form four biology syllabus and biology teachers who were teaching in the selected schools were sampled. The difficult topic chosen is cell Division and the learning objective to be focused in developing the virtual laboratory is "Describe the application of knowledge on mitosis in cloning". The steps taken in this preliminary investigation, contributed in identifying the suitable contents for learning biology via virtual laboratory.

Thus, the researchers hope that virtual laboratory for biology can support students to explore and visualize the abstract concepts in learning biology especially in "Describing the application of knowledge on mitosis in cloning". The findings show that the steps taken in this preliminary investigation, contributed in identifying the suitable contents for learning biology via virtual laboratory. Thus the researchers hope that virtual laboratory for biology can support to explore and visualize the abstract concept in learning biology especially in "Describing the application of knowledge on mitosis in cloning.

Gambari, Obielodan and Kawu (2017) investigated the effects of virtual laboratory on the achievement levels and gender of secondary school chemistry students in individualized and collaborative settings in Minna, Nigeria. Five hypotheses were formulated and tested at 0.05 level of significance. 120 Senior Secondary Class Two (SS II) chemistry Students were stratified along gender and achievement levels. Sixty students (male,  $n = 30$  & female,  $n = 30$ ) were randomly selected from each school. The study employed a quasi-experimental involving pretest, posttest, and control group design. A validated Chemistry Achievement Test (CAT) made-up of twenty multiple-choice items was used for data collection.

A reliability coefficient of 0.91 was obtained from the pilot test using Kuder Richardson (KR-20). Mean and ANCOVA were employed in analyzing the data. The results showed that: (i) Students exposed to chemistry virtual laboratory package in collaborative learning setting outperformed their counterparts in individualized setting; (ii) there was significant difference in the mean achievement scores of male and female students taught using Chemistry using Virtual Laboratory in Individualized Setting; (iii) There was no significant difference in the mean achievement scores of male and female students taught chemistry using virtual laboratory in collaborative learning setting; (iv) there was no significant difference in the mean achievement scores of high, medium and low students taught

using chemistry virtual laboratory in collaborative, and individualized settings respectively.

Efe and Efe (2011) examined the effects of computer simulation on secondary biology instruction. Bloom's taxonomy was utilized for the design of the study and the interpretation of its findings. Participants were 91 (Male = 55, Female = 36) year nine students studying at faith secondary school in Diyarbakir, Turkey. The control and experimental groups were selected at random. Students in the control group were taught using traditional teacher centered methods, whereas students in experimental group were taught with the assistance of relevant computer simulations. An achievement test consisting of five questions in each of Bloom's six domains (that is, knowledge, comprehension, application, analysis, synthesis and evaluation) was given to both the control and experimental groups as a pre-and post-test. The data were analyzed using SPSS 15.00 package program (t-test and ANOVA).

Findings suggest that students who had access to the computer simulations scored higher on the post-tests. Findings revealed that students who were taught with the help of computer simulations made statistically significant improvements in their test scores on all six levels (knowledge, comprehension, application, analysis, synthesis and evaluation) of Bloom's taxonomy. It can therefore be concluded that the use of computer simulations to teach cell-related topics in secondary curricula will help

students to visualize processes that seem abstract and complex (example, fluid mosaic model, transportation in and out of the cell membrane, functions of the organelles). In addition to enhancing the ability of students to learn complex cell processes, computer simulations was also found to be helpful to teachers in eliminating the difficult and time-consuming practicalities associated with laboratory experiments.

Abdullah and Shariff (2008) also investigated the effects of inquiry-based computer simulation with cooperative learning on scientific thinking and conceptual understanding of Gas Laws. A quasi-experimental method was employed and three hundred and one (301) form four students from twelve (12) pure science classes in four Malaysian Smart Schools were randomly selected and assigned to treatment and control groups. The results showed that students in the treatment group significantly outperformed their counterparts in the other group. The findings of the study suggest that the inquiring –based computer simulation with heterogeneous-ability cooperative learning method is effective in enhancing scientific reasoning and conceptual understanding for students of all reasoning abilities, and for maximum effectiveness, cooperative learning groups should be composed of students of heterogeneous abilities.

Yang and Heh (2007) explored the effect of internet virtual Physics laboratory (IVPL) instruction on tenth grade students' academic achievement levels in Physics, performance of science process skills, and

computer attitudes in comparison to traditional laboratory instruction. The result indicated that, computer-based learning facilitated students' academic achievement and acquisition of science process skills in physics. Clarke (2010) confirmed that using technology as a learning tool has significant value because such techniques increased content knowledge and process skills. Huppert et al. (2002) explored the effect of using technology to teach science process skills. The results indicated that simulated activities had a positive effect on students of the experimental group who performed better than those in the control group.

A virtual laboratory may sometimes be a preferable alternative, or simply a supportive learning environment, to real laboratories. It provides students with opportunities such as enriching their learning experiences; conducting experiments as if they were in real laboratories; and improving their experiment related skills such as manipulating materials and equipment, collecting data, completing experiment process in an interactive way and preparing experiment reports (Tatli, & Ayas, 2013). Researchers have determined that instructions carried out with virtual laboratories significantly increase student achievement levels (Dalgarno, Bishop, Adlong, & Bedgood, 2009). Virtual environments let students observe the process in more detail, compared to board and chalk activities of the traditional classroom or partially completed experiments of the real laboratory environment.

In addition, virtual environments foster attention and motivation towards the course by supporting a discussion platform among partners, peers, and among students and teacher (Dobson, 2009; Lawrence, 2011). Furthermore, some researchers even argue that performing experiments within a virtual environment is more effective than performing experiments in real laboratories (Gambari, Fagbemi, Falode & Idris, 2014; Swan & O'Donnell, 2009). Virtual learning environments enable learners to repeat the events several times without hesitation, to zoom in and out, and to watch in slow motion being questioned in any way (Tuyuz, 2010).

Majority of the reviewed literature demonstrated that students allowed to utilize technology, especially computer based learning proved positive results in respect to achievement and science process skills in comparison to students in a control group. In line with various studies reviewed, this study found out the effects of virtual laboratory on pupils' knowledge of science concepts and science process skills.

### **Empirical Studies on Influence of Gender on Students Academic Performance**

Gender differences have historically been held responsible for divergence in academia and career success and studies on the influence of gender on achievement have not produced conclusive result. Some findings indicated that significant difference existed between the performances of

male and female students while other findings showed that gender factor has no influence on students' performance (Yusuf, 2004). Many argue that females are more likely to have better verbal abilities than males and conversely, males are more likely to have better mathematical skills than females (Skaalvik & Skaalvik, 2004)

In a study conducted by Gambari and Mogbo (2006) the effect of computer-Aided learning package on students' physics achievement at senior secondary school in Minna, Nigeria was investigated. The findings revealed that there was no significant difference between the mean achievement scores of students taught with the CAI package based on their gender. Anagbodu and Exelexiora (2007) conducted a research to examine gender differences in scientific performance of boys and girls in some selected secondary schools in Awka Education zone, in Anambra State using the study of Anagbogu (1988). The boys and girls were assigned to experimental and control groups respectively.

The research instrument was a combination of three level tests namely, cognitive skill test, effective skills test, and psychomotor skills test. The three levels were predominantly visual materials related to school science practical material capable of eliciting student's attention. In order to test the hypothesis the scores of boys and girls were subjected to analysis of covariance (ANCOVA) on the pre test and post test scores. The study

showed that girls performed better than boys by using strategies that are human oriented.

The gender difference effect on computer technology achievement was examined by Ogunwale (2008). Random sampling technique was used to select a total of 64 students (32 males, 32 females) from the four computer science department of the polytechnics sampled. The results revealed that gender difference influenced students' achievement in computer technology. In this study, two experiments were involved and in experiment one, girls performed better than boys while experiment two revealed that a significant difference exist in their performance in favour of boys. Thus, experiment two however was in the area of practical aspect of computer. It could therefore be concluded that boys are better in practical aspect. Aina and Akintunde (2013) analyzed physics students' results in four colleges of education in Kwara State using pro forma. It was revealed that there is no significant correlation between male and female performance in physics.

Ifamuyiwa (2004) examined the relationship between students' performance in JSS Mathematics and SSS Mathematics, Further-Mathematics and Physics. A total number of 228 senior secondary students comprising 164 boys and 124 girls were selected from 4 public secondary schools in Eti-Osa Local Government Area of Lagos State. Results of the analysis of collected data for the study showed that a significant correlation

exists between students' performance in JSS Mathematics and their performance in SSS Mathematics, Further-Mathematics and Physics respectively. The study found that while there is no significant gender difference in students' performance in JSS Mathematics, their performance in SSS mathematics is significant in favour of the boys.

Geist and King (2008) reviewed the assessment data, literature and research on gender difference in mathematics. The question of whether boys are better at mathematics has been an issue in education for the past 5 years. The assumption is that there is a biological difference between boys and girls that make boys pre-disposed to do better in Mathematics. Data from the National Assessment of Educational Progress (NAEP) disputes this assumption. The NAEP shows a gap of only 2 points between girls and boys and that has developed only in the last decade. Findings from the reviewed literature and research on differences in boys and girls concludes that there are differences in the way boys and girls learn and process mathematics and that this difference is not being taken into account by our educational system.

Orabi (2007) examined the gender difference in student academic performance and attitudes toward their education and themselves in an introductory engineering course. Student academic performance was evaluated by comparing course work scores between the two genders using assignments, projects, exams and class participation. Analysis of the

academic performance and attitude of 52 male students and 49 female students enrolled in an introduction to engineering course taught by the same instructor was carried out in four semesters.

The results showed that there was no significant difference between mean scores in the academic performance of the genders in the course, and this was evident in the coursework and examination performance analysis. Average marks scored by students of either gender were almost equal. The attitude survey showed that men reported higher gains than women on the technical skills, including confidence on engineering knowledge as a career and problem-solving skills while women indicated higher gains in team work and design skills. Female students were able to learn the materials as effectively as the male students.

Rodger, Munay and Cummings (2007) investigated gender difference on achievement for 50 female and 50 male university students who were randomly assigned to either cooperative or competitive teaching methods. After viewing a videotaped instruction on research design, participants completed a mini-assignment either individually in the competitive condition or with a same-gender partner in the cooperative condition. All participants individually completed a multiple-choice test to assess achievement. Although no differences were found on the multiple-choice test, on the mini-assignment, women scored significantly higher in the

cooperative than in the competitive condition, whereas men performed equally in both conditions.

Researchers contend that soon after children enter elementary school, females begin to fall behind males on standardized assessment (Meece, Glienke, and Burg (2006) `reported that female students enrolled in more advanced high school science courses than males. In 2007, scores from the American College Test (ACT) indicated that females were less prepared for college science courses (Gender Differences in Science, 2009). The West African Examination Council results in Chemistry for the last five years indicate that good performance was by male students (WAEC, 2015). A study done by Sempala (2005) in USA, showed that gender inequities were most evident in laboratory assignment, females are less likely to be involved in operating laboratory equipment. This discrepancy between male and female science achievements continues in post secondary education where women are less likely to major in science disciplines (Britner, 2008; Miyake Kost-Smith, Finkelstein, Pollock, Cohen, & Ito, 2010). Thus, in line with the various studies reviewed this study investigated the effect of gender on pupils' knowlegde of science concepts and process skills when exposed to virtual laboratory package.

### **Empirical Studies on Students' Score Levels and Academic Performance**

In the eighteen century performance was converted unto a single score called intelligence quotient, or IQ. The IQ was computed by dividing mental age by the actual chronological age of the person taking the test and then multiplies by 100 to get rid of the decimal point (Detterman, 2007). IQ score expressed a person's mental age relative to his or her chronological age. On the contrary, modern intelligent test gives a score that reflects how far the person's performance deviates from the average performance of others who are of the same age. Students' score level is one of the factors responsible for differential learning outcome and it has attracted the attention of educational researchers.

In Nigeria classroom, it is common to find students of mixed academic score levels lumped together without considering their individual differences (Gambari, James & Olumorin, 2013). The capacity of students to engage themselves in any educational task which requires higher cognitive functioning depends on factors which include their academic potentiality. This could be tagged score or level of academic attainment. Students are not the same especially when we find out the rate at which facts and principles in sciences are being assimilated. This is to say that, there is disparity in the ability to perform specific tasks (Adesoji, 2008). Score levels describe the success or performance a student has achieved in the previous achievement assessment exercises.

Yusuf (2004) was of the opinion that various outstanding characteristics differentiate learner's ability in school. This is because children differ in achievement level, gender, rate of growth, background, experience, interest, development, social and emotional maturity and in many other characteristics which influence their academic achievement. The researcher identified three score levels in relation to teaching-learning situation viz: High, medium and low. High ability level learners are those that prefer isolation and social distance, theoretical and abstract ideas (akin to field independent learners). According to him, high score/ ability individuals are better than medium or low score/ ability group might be better in other tasks that have to do with the use of hands.

Many studies have shown that learners are qualitatively different in their score levels and in learning problems. For instance, Gambari, Olumorin and Yusuf (2013), Gambari and Yusuf (2014) found that high ability learners are more intelligent than the low or medium ability learners in solving task in science courses. Adesoji (2008) investigated students' ability levels and effectiveness of problem solving instructional strategy. The performances of students in high, medium and low ability level in a problem task were compared to teachers' directed problem solving instruction. The data collected were analyzed using ANCOVA. Finding revealed that there was no significant difference in the performance of the different ability level after the treatment. Method of instruction was found

to influence academic achievement of low achievers. The researcher recommended that science teachers should make use of good instructional strategy like problem solving skill for students of varying ability.

Adeyemo (2010) examined students' ability level and their competence in problem solving task in Physics. The samples used for this study were 200 students randomly selected from four secondary schools in Kosofe Local Government Area of Lagos State. The instrument used for the study were questionnaire and students achievement test. The data collected were analyzed using simple regression analysis. The result of the findings showed that students' ability have significant influence on problem solving task.

In another investigation, Yusuf (2004) examined the influence of ability grouping on the performance of students taught using either cooperative or competitive instructional strategies in social studies. The two experimental groups were made up of 48 students who had earlier been stratified along gender and ability level. Achievement test was administered to the three (3) groups as pretest. Findings revealed that the scoring ability levels of the students did not influence the performance of students taught using cooperative instructional strategy, while on the contrary scoring ability levels of the students influence the performance of students taught using competitive instructional strategy. Thus, in line with the various studies reviewed on score level this study found out the effect of students'

score level on pupils' understanding of science concepts and process skills when exposed to virtual laboratory package.

### **Empirical Studies on Pupils' Attitude toward Basic Science and Technology.**

Wikipedia free encyclopedia online defines attitude as a favourable or unfavourable evaluation of something. Attitudes are generally positive or negative views of a person, place, thing or event. Human attitude according to Zacharias (2003) is a mental concept that depicts favourable or unfavourable feelings towards an object. While beliefs affect attitude, attitudes in turn affect intentions and behaviours. An individual attitude is an important variable in the learning process.

A number of researchers have conducted significant research in the area of the affective domain and they found out that some of the problems students face today can be attributed deeply to attitudes and emotional responses that they bring to the learning environment. The difference in attitude about computer technology was explained by some individuals as an outcome of the socialization process. The use of computer simulations also has been successful in promoting development of favourable attitudes towards science across fields (Weller, 2004).

Zacharias (2003) investigated whether the use of computer simulations in a conceptual change learning environment will promote more

positive attitude towards physics and the use of computer for instructional purposes. Findings indicated that the use of simulation in a college introductory physics course significantly influenced students' attitudes towards physics. Not only students' attitudes toward physics was positive, students' attitudes toward computer simulations were also positive. In addition, students' responses indicated overwhelmingly positive ratings of the appropriateness and instructional effectiveness of computer simulations and computer-assisted instruction. Simulation has emerged as one of the most popular instructional tools for delivering quality instruction. The use of realistic simulation often requires students' to apply newly acquired skills while motivating them toward advanced learning (Moreno & Mayer, 2007).

Kelvin and Rod (2012) investigated virtual and physical experimentation in inquiry-based science laboratory: attitudes, performance, and access. The study took place over a 2-year period; assessment data and attitudinal data were gathered and analyzed to measure the instructional value of physical and virtual laboratory experiences in terms of student performance and attitudes. Student attitudes towards virtual experiences in comparison to physical laboratory experiences were measured using newly created Virtual and Physical Experimentation Questionnaire (VPEQ). VPEQ was specially developed for this study, and included new scales of usefulness of laboratory, and equipment usability which measured attitudinal dimensions in virtual and physical laboratory experiences.

Findings revealed that students showed positive attitudes towards physical and virtual experiences, and demonstrated a reference towards inquiry-based experiences, physical or virtual.

Gülsüm and Didem (2017) investigated the impact of virtual laboratory experiences on attitudes towards physics laboratories. The opinions of students in terms of the virtual laboratory were also examined. The study involved 42 students who were divided into two groups (21 treatment, 21 control). Students were randomly assigned to both groups. In the research, the pre-test and post-test control group design was used. The treatment group used the virtual laboratory. On the other hand, the control group used the physical laboratory. The research data were obtained via the “physics laboratory attitude scale” and semi-structured interviews. The result of this study demonstrated that the virtual laboratory experiences had positive effects on the students’ attitudes. Additionally, semi-structured interviews determined that they had positive opinions regarding the virtual physics laboratory experiences.

Tuysuz (2010) examined the effect of the virtual laboratory on students’ achievement and attitude in chemistry. In this study, a virtual laboratory related to “separation of matter” unit for 9<sup>th</sup> grade students was prepared and its effects on students’ achievements and attitudes were investigated. For this aim 16 virtual experiments prepared by using flash program were used in the experimental group. Result of this study showed

that virtual laboratory applications made positive effects on students' attitude when compared to traditional teaching methods. Thus, in line with the various studies reviewed on pupils' attitude toward virtual laboratory this study examined the effect of pupils' attitude towards virtual laboratory package on their knowledge of science concepts and process skills.

### **Appraisal of the Reviewed Literature**

In the literature reviewed, issues that were related to the focus of this study have been discussed. From the review of literature carried out on theoretical framework for the study, behaviorism, cognitivism and constructivism theories of learning are essential to follow while carrying out researches having similarities to this present investigation. Researchers like Liu & Mathew (2005) opined that constructivism theory of learning requires a student to act upon the environment to both acquire and test new knowledge.

The objectives and contents of basic six science and technology curriculum were reviewed. The curriculum represents the total experiences to which all learners must be exposed therefore the use of guided inquiry method of teaching and learning is implied in the activities prescribed under each topic in order to promote learning by doing and skills development. The review of literature on empirical studies on effects of virtual laboratory demonstrations on students' academic performance revealed that researchers

such as Mohammed (2016), EFe and Efe (2011), Mahmoud and Zoltan (2009), Maldarelli, et al. (2009) and Abdullah and Sheriff (2008) among others recommended the use of virtual laboratory as a supplement to classroom instruction due to its effectiveness but not as a replacement for conventional teaching.

The review of literature carried out on influence of gender on students' academic performance revealed that while some studies show that gender does not influence students' academic performance as revealed by Gambari and Mogbo (2006), Onasanya, et al. (2006) and Ifamuyiwa (2004) some revealed that it influences but in favour of male gender while some go in favour of female gender as revealed by Jacobs, et al. (2002). As a result of series of reviewed literature, this current researcher does not feel that gender influences students' academic performance.

The review of literature carried out on influence of achievement level on students' academic performance revealed that though it is common to find students with mixed achievement levels in the same class, yet those with high levels will significantly perform better than those with low achievement levels as revealed by Gambari (2010). The literature reviewed on influence of attitude towards virtual laboratory on students' academic performance revealed that students with positive attitudes towards the use of computer for other activities also have positive attitudes in its usage in teaching and learning process. Authors and researchers like Weller (2004)

and Zacharias (2003) believed that the positive attitude towards virtual laboratory in teaching and learning process will definitely influence the academic performance of such students positively.

## **CHAPTER THREE**

### **METHODOLOGY**

This chapter discusses procedures that were employed in carrying out the study. These were discussed under the following sub headings: Research Design, Population, Sample and Sampling Techniques, Research Instruments, Validation of Research Instruments, Procedure for Data Collection, and Data Analysis Techniques.

#### **Research Design**

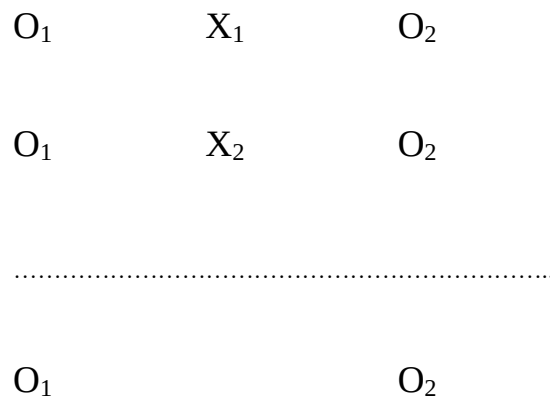
The research design adopted for this study was a quasi-experimental design of 3 x 2 x 2 x 3 factorial design was employed in this study. Three levels of independent primary variables (two treatment and a control), two levels of gender (male and female), three levels of academic performance (high, medium, and low score levels), and two levels of attitude (positive and negative). Both the experimental and control groups were given the pretest and posttest on Basic Science Achievement Test (BSAT). The design layout is as shown in Table 6.

Table 6

*Research Design Layout*

| <b>Groups</b>         | <b>Pre-test</b> | <b>Treatment</b>      |                |         | <b>Post test</b> |
|-----------------------|-----------------|-----------------------|----------------|---------|------------------|
| Experimental Group I  | O <sub>1</sub>  | Virtual only          | Laboratory     | Package | O <sub>2</sub>   |
| Experimental Group II |                 | Virtual with Physical | Laboratory     | Package |                  |
| Control Group         | O <sub>1</sub>  | No treatment only)    | (physical lab. |         | O <sub>2</sub>   |

The schematic representation of this research layout is a shown below



Where;

O<sub>1</sub> represents the pre-testing of the experimental group I

O<sub>2</sub> represents the post-testing of the experimental group I

- $O_1$  represents the pre-testing of the experimental group II
- $O_2$  represents the post-testing of the experimental group II
- $O_1$  represents the pre-testing of the control group
- $O_2$  represents the post-testing of the control group
- $X_1$  represents the treatment (virtual laboratory package) for the Experimental group I
- $X_2$  represents the treatment (virtual laboratory package and physical laboratory package) for the Experimental group II

The independent variables in this study were the virtual laboratory package and the physical (conventional) laboratory instructions while the dependent variables were the post-test performance on knowledge of science concepts and science process skills of the pupils. The moderator variables in the study were: gender, score levels and attitude of pupils. The graphic classification of variables of the study is represented in Figure 4:

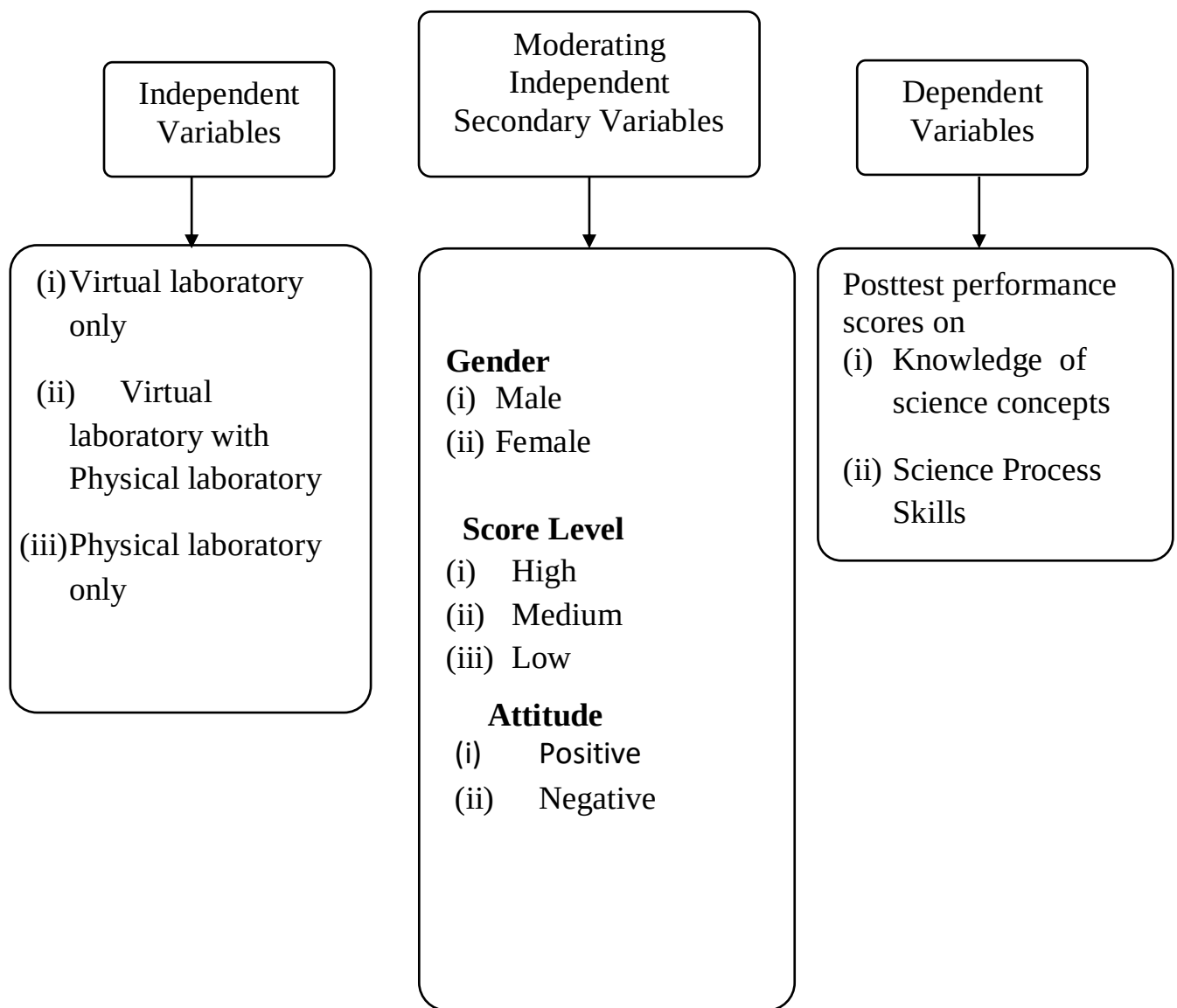


Figure 4: Classification of variables in the study

Source: Adapted from Gambari (2010).

### Population, Sample and Sampling Technique

The population for this study was made up of all basic six pupils in public schools located in Ibadan. The choice of basic six pupils was based on the following premises.

- (1) The pupils were exposed to basic science and technology even right from basic one; hence they were familiar with the subject.
- (2) The selected physics topics (Simple machines, Forces and Magnetism) of the basic science and technology curriculum were designed for basic six curriculum. (NERDC, 2007).

Based on the nature of this research two-stage sampling techniques were employed. First, a purposive sampling technique was adopted to obtain three primary schools from the population. These schools were purposively sampled based on certain criteria: equivalence science laboratories, facilities (functional computers /projector, source of electricity, personnel), school type (public schools), gender composition (mixed schools), and candidates' enrolment (enrolling pupils for common entrance examination for a minimum of five years). Secondly, the selected three equivalent mixed schools were randomly assigned to each of the two experimental and control group using simple random sampling technique.

The sample for this study comprised of intact classes of three public schools in Ibadan. There were two experimental groups (EX.Gs) and one control group (CO.G) of intact classes. Experimental group I was exposed to virtual laboratory package only, experimental group II was exposed to both virtual laboratory package and physical laboratory, while the control group was exposed to physical laboratory only.

Pupils were stratified into score levels (high, medium and low) based on their performance in the last term examination in basic science and technology. The high score level pupils in this study were those whose average score in previous school examination in basic science and technology falls in the upper quartile 75% i.e. within 75% and above. The medium score level pupils were the ones whose score falls within 50% - 74.99% while pupils whose score falls in the lower quartile 25% i.e. within 0% - 49.99% were classified as pupils in low score level.

### **Research Instrument**

The research instruments for this study were:

- (i) Treatment Instrument
- (ii) Expert Validation Form
- (iii) Teaching Modules
- (iv) Test Instrument
- (v) Questionnaire

(i) Treatment Instrument: The treatment was virtual laboratory instructional package developed by the researcher and a programmer. It consisted of the three physics topics designed for basic six pupils in basic science and technology curriculum which are: simple machines, forces, and magnetism. Both practical and theory were developed for each of the topics in the package, and was used to teach the pupils each topic per week. The

necessity for researcher-made virtual laboratory package was based on the fact that the commercially produced virtual laboratory package is not common in Nigeria. When they are available, they may not be directly relevant to the topics or objectives to be achieved in a lesson. Moreover, using imported software to implement virtual laboratory instruction in Nigeria may not be culturally relevant. As a result of this, developing a virtual laboratory package for use by the researcher was inevitable.

(ii) Expert Validation Form: These are forms that the researcher gave out to experts to comment on various aspect of the package in terms of its appropriateness, legibility, suitability, content coverage, colour used and so on. The experts were: Computer programmers, physics experts and educational technology specialists. Their suggestions were effected which greatly improved on the package.

(iii) Teaching Modules: These were the lesson notes equivalent in contents, instructional materials and procedures to virtual laboratory package prepared by the researcher which contained instructional guide on the selected topics to teach the pupils.

(iii) Test: The test items used in collecting data for this study was researcher adopted Basic Science Achievement Test (BSAT). This Basic Science Achievement Test (BSAT) consisted of 20 multiple choice objective items drawn from past common entrance examination questions, which were

modified by experts. The Basic Science Achievement Test was based on physics topics of basic six science and technology curriculum on concepts of simple machines, forces and magnetism.

The test items which reflected Knowledge of Science Concept Test (KSCT) was designed to assess the first four levels (Knowledge, Comprehension, Application, and Analysis) of Bloom's taxonomy of educational objectives in the cognitive domain. The Basic Science Achievement Test (BSAT) also reflected Science Process Skills Test (SPST) items which were also designed to assess the performance of the students' science process skills on observation, inference, classification, measurement, prediction and communication).

The BSAT contained two major sections: Section A dealt with demographic data of the pupils such as name of school, class, age and sex while section B was divided into two parts. Part 1 consisted of 20 multiple choice objective questions. Each item of the instrument was a multiple-choice objective question with four plausible options (A – D). Part 2 consisted of 25 short answer questions on practical. The instrument was administered to both the experimental and control groups as pre-test and for the post-test. To reduce the retest effect, the questions were reshuffled and administered in a different random order in the pre-test and post-test. On the scoring of the multiple-choice items, '1' was awarded for each correct answer and '0' for each wrong answer.

(iv) The Questionnaire: The instrument used for the field trial validation of the package was a researcher-developed questionnaire called Basic Science Virtual Laboratory Attitude Questionnaire (BSVLAQ). The questionnaire consisted of two sections, Section A consisted of the bio data of the students; age, gender, and so on. Section B consisted of 10 positive-response questions on the students' attitude towards basic science and technology. The attitude questionnaire was administered to the experimental groups before and after the treatment in order to examine change in attitude of the pupils towards the effect of virtual laboratory in teaching basic science and technology. A 3- point rating scales consisting of 10 questions was used in the questionnaire, namely, 1 for NO, 2 for NOT SURE, and 3 for YES

### **Validation of Research Instrument**

Treatment: - The validation of the research instrument (virtual laboratory instructional package) took place in three phases.

- a) Experts' validation
- b) Content validation and
- c) Field validation by students.

Experts' Validation: The developed virtual laboratory package was given to three computer programmers to determine the appropriateness of the package in terms of language, typography, legibility, navigation,

interface, animation, functionality, packaging, and durability. Similarly, three educational technology experts were requested to validate the package in terms of its suitability, unity among illustrations, emphasis on key concepts, colour used and text. Three physics lecturers also validated the package in terms of its appropriateness, clarity, suitability for the level of the pupils and content coverage. Their suggestions and recommendations were used to modify the package.

**Content Validation:** Three secondary and three primary schools teachers who were qualified and were currently teaching physics and basic science and Technology respectively were requested to validate the instructional guide and the procedures contained in the treatment. They helped to ensure that all the contents, instructional and learning items were derived from the subject's curriculum and suitable for basic six pupils.

**Field Trial Validation:** - The virtual laboratory instructional package was trial –tested on basic six pupils from two primary schools in Ibadan which were part of research population, but did not take part in the actual study.

Teaching module validation and Test instrument validation of Basic Science Achievement Test (BSAT) was done by the researcher's supervisor and two other lecturers in the Department of Science Education who are experts in the science subjects. The experts were requested to critically

examine all the items in the test instrument with reference to appropriateness of the content and the extent to which the contents cover the topics they were meant to cover. Comments, opinions and suggestions of the experts were used to make necessary modifications on the instrument.

Questionnaire: - In order to validate the questionnaire, it was given to three educational technology experts to ascertain the face and content validities. Following the validation reports, some items in the questionnaire were modified while some were dropped.

The virtual laboratory package was pilot tested on basic six pupils from two primary schools in Ibadan who were parts of the research population but they were not selected for the real study. The reliability of (BSAT) was done using Kuder-Richardson's Formula 21 while (BSVLAQ) reliability was computed using Cronbach Alpha Coefficient. The reliability coefficients of 0.88 and 0.91 were obtained respectively which implies that the instruments were considered adequate for the study.

### **Procedure for Data Collection**

The researcher collected a letter of introduction from the Department of Science Education to the head teachers of the sampled schools for permission to use their schools for the study. The procedure for data collection lasted for the period of six weeks. During the first week, the researcher examined the facilities in the selected schools to determine their

suitability for the study and sought for official permission and cooperation of the school management to make use the schools. The cooperation of the pupils and staff in the selected schools were sought and their efforts, contributions and scores were treated anonymously and for the purpose of this study only.

In the second week, the Basic Science Achievement Test (BSAT) was administered to the control and experimental groups as pre-test. In the next three weeks, the lessons were taught to the experimental and control groups using the virtual laboratory package and conventional method respectively. Three periods per week were allotted for the whole lesson (simple machines, forces and magnetism) in each group. The duration for each period was fifty minutes. Two periods were allocated for teaching basic science and technology on the time table as scheduled by Oyo State Government. In order to cover the selected topics, the researcher solicited for an addition of a period which was welcomed and granted since those topics form part of what should be taught that term.

The experimental group I (EX GI) which comprised 37 pupils (18 males, 19 females) was taught using virtual laboratory only, the experimental group II (EX GII) which comprised 36 pupils (16 males, 20 females) was taught using both virtual laboratory + physical laboratory concurrently, while the control group (CO G) which comprised 28 pupils (7 males, 21 females) was taught using physical laboratory only. The three

groups performed related activities in contents, instructional materials and procedures. Post test was administered to all the groups in the sixth week.

### **Data Analysis Techniques**

The data gathered from both the experimental and the control groups were analyzed using percentage and mean to answer the research questions while the corresponding hypotheses were tested using Analysis of Covariance (ANCOVA) and t-test inferential statistics at 0.05 level of significance. The interaction effect of treatment, gender and score level was also tested. Scheffe's test was used to indicate the direction of the differences. Graphical representation was also drawn to show the mean gain scores of the pupils. The Statistical Package for Social Sciences (SPSS) version 20 was used to analyze the data.

## **CHAPTER FOUR**

### **DATA ANALYSIS AND RESULTS**

This chapter presents the analysis and results of the data collected for this study.

#### **Demographic Information of the Groups**

Table 7 shows the demographic information of the groups (experimental groups I, and II and the control group). Out of 101 pupils sampled for this study, 37 of them formed the experimental group I (Virtual Laboratory only) from which 18 were males and 19 were females; 36 of the respondents were in the experimental group II (Virtual and Physical Laboratories Combined) out of which 16 were males and 20 were females; and 28 of the respondents constituted the control group (Physical Laboratory only) seven were males and 21 were females.

Table 7

*Distribution of the Pupils Sampled Based on Gender*

| <b>Groups</b>                                                | <b>Gender</b> | <b>Frequency</b> | <b>Sub-Total</b> |
|--------------------------------------------------------------|---------------|------------------|------------------|
| Experimental Group I<br>( <i>Virtual Laboratory only</i> )   | Male          | 18               | 37               |
|                                                              | Female        | 19               |                  |
| Experimental Group II<br>( <i>Virtual and Physical Lab</i> ) | Male          | 16               | 36               |
|                                                              | Female        | 20               |                  |
| Control Group<br>( <i>Physical Laboratory only</i> )         | Male          | 7                | 28               |
|                                                              | Female        | 21               |                  |
| <b>Total</b>                                                 |               |                  | <b>101</b>       |

From Table 8 out 37 of the pupils that were in the experimental group I, 11 had low score level of Knowledge of Science Concept; 25 were of medium score level of Knowledge of Science Concept and only 1 had high score level of Knowledge of Science Concept while 25 of the pupils had low level of Science Process Skills with only 10 having medium score level of Science Process Skills and 2 of the pupils in the experimental group I were for high score level of Science Process Skills.

Also, out 36 of the pupils that were in the experimental group II, 12 of them were of low score level of Knowledge of Science Concept; 23 were of medium score level of knowledge of Science concept and only 1 was for high score level of knowledge of Science concept. However, 22 of the

pupils in the experimental group II were of low score level of Science Process Skills; 10 were of medium score level and 4 were for high level. In addition, out of 28 pupils in the control group, 14 were of low score level in knowledge of Science concept 11 were medium score level of knowledge of Science concept and 3 pupils were for high score level of knowledge of Science concept. Again, out of 28 pupils in the control group 16 10 and 2 were of low medium and high score level of Science Process Skills respectively.

Table 8

*Distribution of the Pupils Sampled Based on Score Levels*

| Groups                                            |                                    | Score Levels |        |      | Sub-Total  |
|---------------------------------------------------|------------------------------------|--------------|--------|------|------------|
|                                                   |                                    | Low          | Medium | High |            |
| Experimental Group I<br>(Virtual Lab only)        | Knowledge of Science Concept (KSC) | 11           | 25     | 1    | 37         |
|                                                   | Science Process Skills (SPS)       | 25           | 10     | 2    |            |
| Experimental Group II<br>(Virtual & Physical Lab) | Knowledge of Science Concept (KSC) | 12           | 23     | 1    | 36         |
|                                                   | Science Process Skills (SPS)       | 22           | 10     | 4    |            |
| Control Group<br>(Physical Lab only)              | Knowledge of Science Concept (KSC) | 14           | 11     | 3    | 28         |
|                                                   | Science Process Skills (SPS)       | 16           | 10     | 2    |            |
| <b>Total</b>                                      |                                    |              |        |      | <b>101</b> |

**Answering of Research Questions**

**Research Questions One:** What is the difference in basic six pupils' knowledge of science concepts when taught using virtual laboratory only, virtual and physical laboratories combined and physical laboratory only?

**Research Question Two:** What is the difference in basic six pupils' science process skills when taught using virtual laboratory only, virtual and physical laboratories combined and physical laboratory only?

As revealed in Table 9, the scores of pupils (both the experimental and control groups) in the post-test were higher than their scores in the pre-

test. In the post test, the mean scores (14.38) and (16.38) of pupils in the knowledge of science concepts and science process skills respectively when taught with virtual and physical laboratories (EX GII) were higher than those that were taught with virtual laboratory (EX GI) only who had mean scores (13.63) and (15.78) for the knowledge of science concepts and science process skills respectively followed by those that were taught with physical laboratory (CO G) only whose mean scores (12.32) and (13.25) for the knowledge of science concepts and science process skills respectively were fair.

Table 9

## Pupils' Scores before and after the Treatment

| <b>Groups</b>                                                  |     |           | <b>Mean</b> | <b>S.D.</b> | <b>Min</b> | <b>Max</b> | <b>Remark</b> |
|----------------------------------------------------------------|-----|-----------|-------------|-------------|------------|------------|---------------|
| <b>Experimental I</b><br><b>(Virtual Lab. Only)</b>            | KSC | Pre-test  | 8.41        | 2.38        | 4.00       | 15.00      | Low           |
|                                                                |     | Post test | 13.63       | 1.94        | 9.00       | 17.00      | High          |
|                                                                | SPS | Pre-test  | 4.32        | 1.00        | 2.00       | 8.00       | Low           |
|                                                                |     | Post test | 15.78       | 2.93        | 10.00      | 20.00      | High          |
| <b>Experimental II</b><br><b>(Virtual &amp; Physical Lab.)</b> | KSC | Pre-test  | 8.32        | 2.54        | 3.00       | 19.00      | Low           |
|                                                                |     | Post test | 14.38       | 1.49        | 10.00      | 17.00      | High          |
|                                                                | SPS | Pre-test  | 3.30        | 0.82        | 2.00       | 5.00       | Low           |
|                                                                |     | Post test | 16.38       | 3.48        | 9.00       | 23.00      | High          |
| <b>Control</b><br><b>(Physical Lab. Only)</b>                  | KSC | Pre-test  | 7.53        | 1.73        | 4.00       | 12.00      | Low           |
|                                                                |     | Post test | 12.32       | 1.36        | 10.00      | 15.00      | Fair          |
|                                                                | SPS | Pre-test  | 2.92        | 0.85        | 2.00       | 5.00       | Low           |
|                                                                |     | Post test | 13.25       | 2.15        | 9.00       | 19.00      | Fair          |

Table 10 shows the mean gain scores of the pupils after the treatment. Pupils taught with virtual laboratory (EX GI) only had the mean gain score of 5.22 and 11.46 in their knowledge of science concept and science process skills respectively. Pupils taught with virtual laboratory and physical laboratory (EX GII) had the mean gain score of 6.06 and 13.08 in their knowledge of science concept and science process skills respectively. Pupils taught with physical laboratory (CO G) only had the mean gain score of 4.79 and 10.33 in their knowledge of science concept and science process skills respectively. Therefore the three groups had improvement in learning

after treatment and teaching as observed in their posttest. The difference in the mean gain score between the groups (virtual laboratory only, virtual and physical laboratories combined and physical laboratory only) is illustrated in figure 5.

Table 10

*Mean Gain Scores of the Pupils Taught with Virtual Laboratory Only, Virtual and Physical Laboratories and Physical Laboratory Only*

| Groups                                                           |     | Pre-test | Post-test | Mean Gain Scores |
|------------------------------------------------------------------|-----|----------|-----------|------------------|
| <b>Experimental G I</b><br><b>(Virtual Lab. Only)</b>            | KSC | 8.41     | 13.63     | 5.22             |
|                                                                  | SPS | 4.32     | 15.78     | 11.46            |
| <b>Experimental G II</b><br><b>(Virtual &amp; Physical Lab.)</b> | KSC | 8.32     | 14.38     | 6.06             |
|                                                                  | SPS | 3.30     | 16.38     | 13.08            |
| <b>Control</b><br><b>(Physical Lab. Only)</b>                    | KSC | 7.53     | 12.32     | 4.79             |
|                                                                  | SPS | 2.92     | 13.25     | 10.33            |

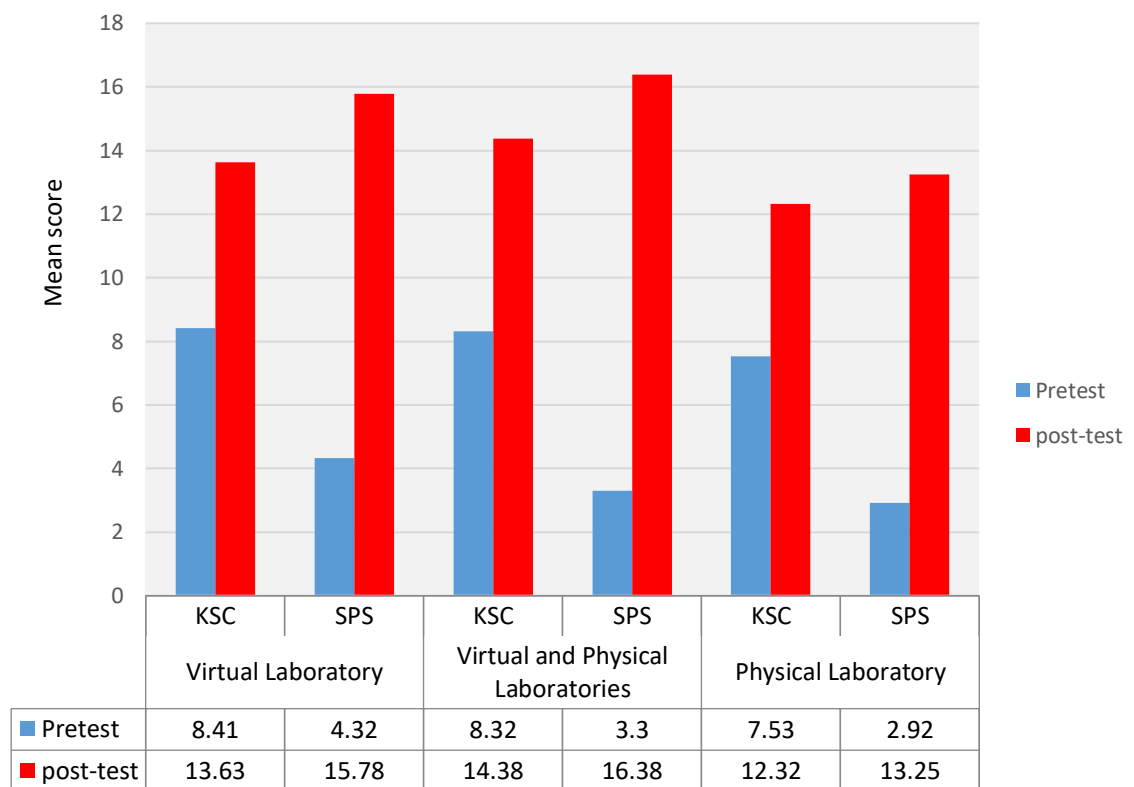


Figure 5. Graphical Illustration of mean gain scores of pupils' knowledge of science concepts and science process skills taught using virtual laboratory only, virtual and physical laboratories combined and physical laboratory only.

## Hypotheses Testing

**H<sub>01</sub>:** *There is no significant difference in pupils' knowledge of Science Concepts when taught using virtual laboratory only, virtual and Physical laboratories combined and physical laboratory only*

Result in Table 11 reveals that the F-value of 12.88 was obtained with a p-value of 0.000 computed at 0.05 alpha level. Since p-value (0.000) is less than alpha level (0.05), the null hypothesis one was rejected. The results

revealed that the strategies of instruction produced a significant effect on the posttest knowledge of science concepts scores of pupils when covariate effect (pretest) was controlled ( $F_{(2, 97)} = 12.88, p < 0.05$ ).

Table 11

*Analysis of Covariance Showing the Difference in Pupils' Knowledge of Science Concepts When Taught using Virtual Laboratory Only, Virtual and Physical Laboratories Combined and Physical Laboratory Only*

| Source          | Type III Sum<br>of Squares | df  | Mean<br>Square | F       | Sig. |
|-----------------|----------------------------|-----|----------------|---------|------|
| Corrected Model | 69.460 <sup>a</sup>        | 3   | 23.153         | 8.585   | .000 |
| Intercept       | 1397.659                   | 1   | 1397.659       | 518.266 | .000 |
| KSC Pretest     | 1.526                      | 1   | 1.526          | .566    | .454 |
| Treatments      | 69.459                     | 2   | 34.730         | 12.878  | .000 |
| Error           | 261.590                    | 97  | 2.697          |         |      |
| Total           | 18860.000                  | 101 |                |         |      |
| Corrected Total | 331.050                    | 100 |                |         |      |

a. R Squared = .210 (Adjusted R Squared = .185)  
p<0.05

Table 12 depicts the multiple comparison analysis to show the actual difference (effect of the treatment on pupils' knowledge of science concept). As shown in Table 12, pupils that were taught with virtual and physical laboratories (Experimental Group II) had highest mean score 14.38 followed by pupils taught using virtual laboratories only (Experimental Group I) with the mean score 13.63 while those pupils taught with physical laboratory had the least mean score 12.32 in their knowledge of science concepts. Thus, the

effect of the treatments on pupils' knowledge of science concept is shown by the mean difference 2.06, 1.31 and 0.75 respectively. This implies that a significant difference exists between the three groups in favour of EX GII.

Table 12

*Pairwise Comparisons Analysis Showing the Effect of the Virtual Laboratory Only; Virtual and Physical Laboratories Combined and Physical Laboratory Only on Pupils' knowledge of Science Concepts*

| (I) treatment             | (J) treatment             | Mean  | Mean Diff. (I-J) | Std. Error | Sig. <sup>b</sup> | 95% Confidence Interval for Difference <sup>b</sup> |             |
|---------------------------|---------------------------|-------|------------------|------------|-------------------|-----------------------------------------------------|-------------|
|                           |                           |       |                  |            |                   | Lower Bound                                         | Upper Bound |
| Virtual Laboratory        | Virtual and Physical Lab. | 14.38 | 2.06             | .385       | .177              | -.202                                               | 1.671       |
|                           | Physical Lab.             | 12.32 | -2.06            | .415       | .000              | 1.088                                               | 3.112       |
| Virtual and Physical Lab. | Virtual Lab.              | 13.63 | 1.31             | .385       | .177              | -1.671                                              | .202        |
|                           | Physical Lab.             | 12.32 | -1.31            | .419       | .005              | .346                                                | 2.386       |
| Physical Laboratory       | Virtual Laboratory        | 13.63 | -.75             | .415       | .000              | -3.112                                              | -1.088      |
|                           | Virtual and Physical Lab. | 14.38 | .75              | .419       | .005              | -2.386                                              | -.346       |

Based on estimated marginal means

\*, The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni

**H<sub>02</sub>:** *There is no significant difference in pupils' Science Process skills when taught using virtual laboratory only, virtual and Physical laboratories combined and physical laboratory only*

Result in Table 13 reveals that the F-value of 7.70 was obtained with a p-value of 0.001 computed at 0.05 alpha level. Since p-value (0.001) is less than alpha level (0.05), the null hypothesis two was rejected and thus, there was a significant difference in pupils' science process skills when taught using virtual laboratory only, virtual and Physical laboratories combined and physical laboratory only ( $F_{(2, 97)} = 7.703$ ,  $p < 0.05$ ).

Table 13

*Analysis of Covariance Showing the Difference in Pupils' Science Process Skills When Taught using Virtual Laboratory Only, Virtual and Physical Laboratories Combined and Physical Laboratory Only*

| Source                                          | Type III Sum of Squares | df  | Mean Square | F       | Sig. |
|-------------------------------------------------|-------------------------|-----|-------------|---------|------|
| Corrected Model                                 | 188.929 <sup>a</sup>    | 3   | 62.976      | 7.271   | .000 |
| Intercept                                       | 1080.739                | 1   | 1080.739    | 124.776 | .000 |
| SPS Pretest                                     | 19.916                  | 1   | 19.916      | 2.299   | .133 |
| Treatments                                      | 133.445                 | 2   | 66.723      | 7.703   | .001 |
| Error                                           | 840.160                 | 97  | 8.661       |         |      |
| Total                                           | 24663.000               | 101 |             |         |      |
| Corrected Total                                 | 1029.089                | 100 |             |         |      |
| a. R Squared = .184 (Adjusted R Squared = .158) |                         |     |             |         |      |
| $p < 0.05$                                      |                         |     |             |         |      |

Table 14 depicts the multiple comparison analysis to show the actual difference (effect of the treatment on pupils' science process skills). As shown in Table 14, pupils that were taught using virtual and physical laboratories combined (Experimental Group II) had highest mean score

16.38 followed by pupils taught using virtual laboratories only with the mean score 15.78 (experimental Group I) while those pupils taught using physical laboratory only (Control Group) had the least scores 13.25 in their science process skills. Thus, the effect of treatments on pupils' science process skills is shown by the mean difference 3.13, 2.53 and 0.60 respectively. This implies that a significant difference exists between the three groups in favour of EX GII.

Table 14

*Pairwise Comparisons Analysis Showing the Effect of the Virtual Laboratory Only; Virtual and Physical Laboratories Combined and Physical Laboratory Only on Pupils' Science Process Skills*

| (I) treatment             | (J) treatment             | Mean  | Mean Diff. (I-J) | Std. Error | Sig. <sup>b</sup> | 95% Confidence Interval for Difference <sup>b</sup> |             |
|---------------------------|---------------------------|-------|------------------|------------|-------------------|-----------------------------------------------------|-------------|
|                           |                           |       |                  |            |                   | Lower Bound                                         | Upper Bound |
| Virtual Laboratory        | Virtual and Physical Lab. | 16.38 | 3.13             | .767       | .447              | -2.982                                              | .753        |
|                           | Physical Lab.             | 13.25 | -3.13            | .869       | .112              | -.282                                               | 3.953       |
| Virtual and Physical Lab. | Virtual Lab.              | 15.78 | 2.53             | .767       | .447              | -.753                                               | 2.982       |
|                           | Physical Lab.             | 13.25 | -2.53            | .752       | .000              | 1.118                                               | 4.782       |
| Physical Laboratory       | Virtual Laboratory        | 15.78 | -.60             | .869       | .112              | -3.953                                              | .282        |
|                           | Virtual and Physical Lab. | 16.38 | .60              | .752       | .000              | -4.782                                              | -1.118      |

Based on estimated marginal means

\*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni

**H<sub>03</sub>:** *There is no significant difference in pupils' knowledge of science concepts when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G).*

Table 15 shows the ANCOVA comparison of posttest knowledge of science concepts scores between (EX GI) and (CO G). The results of the analysis reveals F-value of 35.69 with a p-value of 0.000 computed at 0.05 alpha level. Since p-value (0.00) is less than alpha level (0.05), the null hypothesis one was rejected which indicates that the main effect (treatment) was significant ( $F_{(1, 62)} = 35.69, p < 0.05$ ). The results revealed that the strategies of instruction produced a significant effect on the posttest knowledge of science concepts scores of pupils when covariate effect (pretest) was controlled.

Table 15

*Analysis of Covariance Showing the Difference in Pupils' Knowledge of Science Concepts (KSC) When Taught Using Virtual Laboratory Only and Those Taught Using Physical Laboratory Only using pretest as covariate*

| Source                               | Type III<br>Sum of<br>Squares | df | Mean<br>Square | F      | Sig. |
|--------------------------------------|-------------------------------|----|----------------|--------|------|
| Corrected Model                      | 72.901 <sup>a</sup>           | 2  | 36.450         | 18.030 | .000 |
| Intercept                            | 957.241                       | 1  | 957.24         | 473.48 | .000 |
|                                      |                               |    | 1              | 4      |      |
| Pre-test<br>(Covariate)              | 5.465                         | 1  | 5.465          | 2.703  | .105 |
| Virtual Lab.<br>(KSC)<br>(Treatment) | 72.156                        | 1  | 72.156         | 35.691 | .000 |
| Error                                | 125.345                       | 62 | 2.022          |        |      |

|                                                 |           |    |
|-------------------------------------------------|-----------|----|
| Total                                           | 12031.000 | 65 |
| Corrected Total                                 | 198.246   | 64 |
| a. R Squared = .368 (Adjusted R Squared = .347) |           |    |
| <hr/>                                           |           |    |
| P<0.5                                           |           |    |

Table 16 depicts the multiple comparison analysis to show the actual difference (effect of the virtual laboratory on pupils' knowledge of Science concepts). As shown in Table 12, pupils that were taught using virtual laboratory (Experimental Group I) had higher mean score 13.62 in their knowledge of science concepts than those that were taught using physical Laboratory (Control Group) with the mean score 12.32. Thus, the effect of virtual laboratory on pupils' knowledge of science concepts is shown by the mean difference 1.30. This implies that a significant difference exists between the two groups in favour of EX GI.

Table 16

*Pairwise Comparisons Analysis Showing the Effect of the Virtual Laboratory on Pupils' knowledge of Science Concepts (KSC)*

| Treatment                                       | Mean               | Mean Diff. (I-J)   | Std. Error | Sig. <sup>b</sup> | 95% Confidence Interval for Difference <sup>b</sup> |             |
|-------------------------------------------------|--------------------|--------------------|------------|-------------------|-----------------------------------------------------|-------------|
|                                                 |                    |                    |            |                   | Lower Bound                                         | Upper Bound |
| Virtual Lab. (I)<br>(Knowledge of Sci. Concept) | 13.63 <sup>a</sup> | 1.31 <sup>*</sup>  | 0.36       | 0.00              | 1.43                                                | 2.88        |
| Physical Lab (J)<br>(Knowledge of Sci.          | 12.32 <sup>a</sup> | -1.31 <sup>*</sup> | 0.36       | 0.00              | -2.88                                               | -1.43       |

Concept)

**Grand Mean = 12.98**

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\* the mean difference is significant at 0.05 level

b. Adjustment for Multiple Comparisons: Bonferroni

**H<sub>04</sub>:** *There is no significant difference in pupils' science process skills (sps) when taught using virtual laboratory only (EX GI) and physical laboratory only (CO G).*

Table 17 shows the ANCOVA comparison of posttest science process skills scores between (EX GI) and (CO G). The results of the analysis reveals F-value of 8.99 with a p-value of 0.004 computed at 0.05 alpha level. Since p-value (0.004) is less than alpha level (0.05), the null hypothesis two was rejected which indicates that the main effect (treatment) was significant ( $F_{(1, 62)} = 8.99, p < 0.05$ ). The results revealed that the virtual laboratory produced a significant effect on the posttest science process skills scores of pupils when covariate effect (pretest) was controlled.

Table 17

*Analysis of Covariance Showing the Difference in Pupils' Science Process Skills (SPS) When Taught Using Virtual Laboratory Only and Those Taught Using Physical Laboratory Only using pretest as covariate*

| Source                                          | Type III<br>Sum of<br>Squares | df | Mean<br>Square | F      | Sig. |
|-------------------------------------------------|-------------------------------|----|----------------|--------|------|
| Corrected Model                                 | 102.404 <sup>a</sup>          | 2  | 51.202         | 7.290  | .001 |
| Intercept                                       | 825.052                       | 1  | 825.05         | 117.47 | .000 |
|                                                 |                               | 2  | 4              |        |      |
| Pre-test (Covariate)                            | .078                          | 1  | .078           | .011   | .916 |
| Virtual Lab. (SPS)<br>(Treatment)               | 63.127                        | 1  | 63.127         | 8.988  | .004 |
| Error                                           | 435.442                       | 62 | 7.023          |        |      |
| Total                                           | 14569.000                     | 65 |                |        |      |
| Corrected Total                                 | 537.846                       | 64 |                |        |      |
| a. R Squared = .190 (Adjusted R Squared = .164) |                               |    |                |        |      |
| P<0.05                                          |                               |    |                |        |      |

Table 18 depicts the multiple comparison analysis to show the actual difference (effect of the virtual laboratory on pupils' science process skills). As shown in Table 18, pupils that were taught using virtual laboratory only (Experimental Group I) had higher mean score 15.78 in their science

process skills than those taught using physical Laboratory only (Control Group) with the mean score 13.25. Thus, the effect of virtual laboratory on pupils' science process skills is shown by the mean difference 2.53. This implies that a significant difference exists between the two groups in favour of EX GI.

Table 18

*Pairwise Comparisons Analysis Showing the Effect of the Virtual Laboratory on Pupils' Science Process Skills (SPS)*

| Treatment                                       | Mean               | Mean Diff.<br>(I-J) | Std.<br>Error | Sig. <sup>b</sup> | 95% Confidence<br>Interval for<br>Difference <sup>b</sup> |                |
|-------------------------------------------------|--------------------|---------------------|---------------|-------------------|-----------------------------------------------------------|----------------|
|                                                 |                    |                     |               |                   | Lower<br>Bound                                            | Upper<br>Bound |
| Virtual Lab. (I)<br>(Science<br>Process Skills) | 15.78 <sup>a</sup> | 2.53 <sup>*</sup>   | 0.83          | 0.00              | 0.83                                                      | 4.14           |
| Physical Lab (J)<br>(Science<br>Process Skills) | 13.25 <sup>a</sup> | -2.53 <sup>*</sup>  | 0.83          | 0.00              | -4.14                                                     | -0.83          |
| <b>Grand Mean = 14.52</b>                       |                    |                     |               |                   |                                                           |                |

\* the mean difference is significant at 0.05 level

b. Adjustment for Multiple Comparisons: Bonferroni

**H<sub>05</sub>:** *There is no significant difference in knowledge of science concepts (ksc) of male and female pupils taught using virtual laboratory only (EX GI)*

The hypothesis was tested using the pretest mean knowledge of science concepts scores of male and female as covariate for the analysis of

Covariance. Result in Table 19 reveals F-value of 0.44 with a p-value of 0.51 computed at 0.05 alpha level. Since p-value (0.51) is greater than alpha level (0.05), the null hypothesis three was not rejected and thus, there was no significant difference in the knowledge of science concept of male and female pupils that were taught using virtual laboratory ( $F_{(1, 34)} = 0.44$ ,  $p > 0.05$ ). This implies that male students' knowledge of science concepts did not significantly differ from that of female students when both were taught using virtual laboratory only.

Table 19

*Analysis of Covariance Showing the Difference in the Knowledge of Science Concept (KSC) of Male and Female Pupils When Taught Using Virtual Laboratory (EX GI)*

| Source                  | Type III Sum<br>of Squares | df | Mean<br>Square | F       | Sig. |
|-------------------------|----------------------------|----|----------------|---------|------|
| Corrected Model         | 4.733 <sup>a</sup>         | 2  | 2.367          | 1.059   | .358 |
| Intercept               | 725.824                    | 1  | 725.824        | 324.842 | .000 |
| Pretest<br>(Covariate)  | 4.215                      | 1  | 4.215          | 1.886   | .179 |
| Gender (Main<br>Effect) | .974                       | 1  | .974           | .436    | .514 |
| Error                   | 75.969                     | 34 | 2.234          |         |      |
| Total                   | 7730.000                   | 37 |                |         |      |
| Corrected Total         |                            | 36 |                |         |      |
|                         | 80.703                     |    |                |         |      |

a. R Squared = .059 (Adjusted R Squared = .003)

To further show the improvement in learning after treatment, the mean gain scores between the pretest and posttest knowledge of science concepts of male and female pupils are shown in Table 20. Result from Table 20 reveals that male and female pupils' knowledge of science concepts were improved after posttest. Male pupils had mean gain scores of 4.68 while female pupils had mean gain scores of 5.76. This shows that both groups benefited from the treatment as illustrated in figure 6.

Table 20

*Mean gain scores in knowledge of science concepts of male and female pupils taught using virtual laboratory only*

| <b>Gender</b> | <b>Pretest</b> | <b>Posttest</b> | <b>Mean<br/>Score</b> | <b>Gain</b> |
|---------------|----------------|-----------------|-----------------------|-------------|
| Male          | 8.72           | 13.40           | 4.68                  |             |
| Female        | 8.10           | 13.86           | 5.76                  |             |

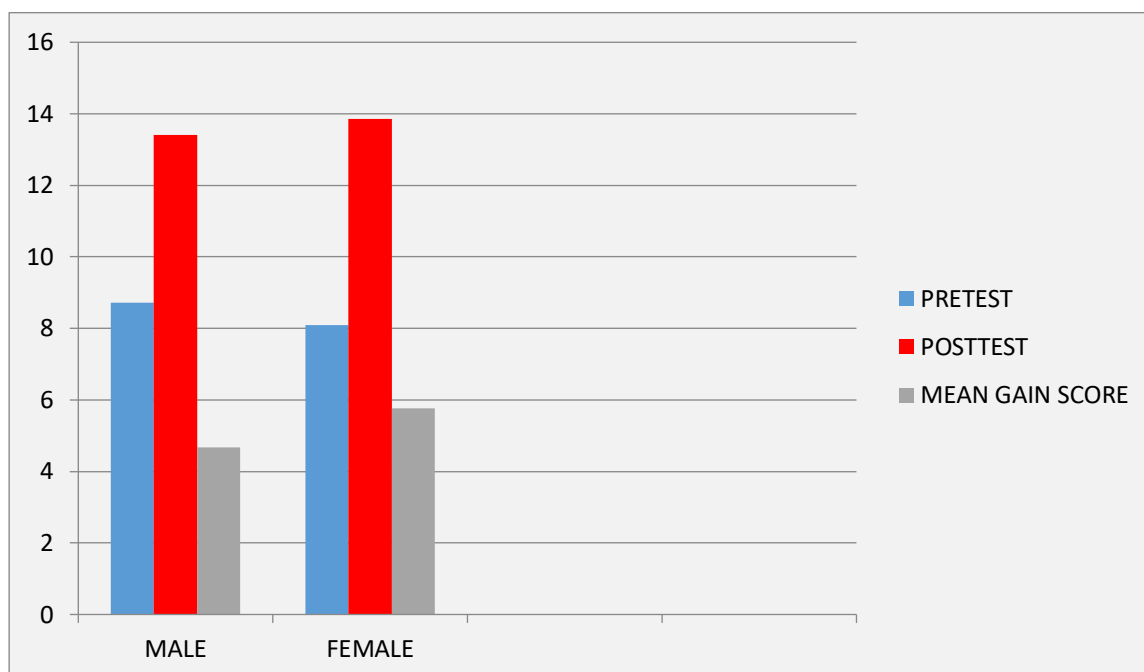


Figure 6: Mean gain scores in knowledge of science concepts of male and female pupils taught using virtual laboratory only

**H<sub>06</sub>:** *There is no significant difference in science process skills of male and female pupils that were taught using virtual laboratory only (EX GI)*

Table 21 reveals the result of hypothesis six. The hypothesis was tested using the pretest mean science process skills scores of male and female as covariate for the analysis of covariance. The F- value of 0.19 was not significant since p-value (0.66) is greater than alpha level (0.05). ( $F_{(1, 34)} = 0.19, p > 0.05$ ). This shows that there was no significant difference in science process skills of male and female pupils taught using virtual laboratory only. On this basis, hypothesis six was therefore not rejected. This implies that male pupils' science process skills did not significantly differ from that of female pupils when both were taught using virtual laboratory only.

Table 21

*Analysis of Covariance Showing the Difference in Pupils' Science Process Skills of Male and Female When Taught Using Virtual Laboratory (EX GI)*

| Source               | Type III Sum of Squares | df | Mean Square | F      | Sig. |
|----------------------|-------------------------|----|-------------|--------|------|
| Corrected Model      | 2.937 <sup>a</sup>      | 2  | 1.468       | .162   | .851 |
| Intercept            | 501.720                 | 1  | 501.720     | 55.505 | .000 |
| Pre-test (Covariate) | 1.111                   | 1  | 1.111       | .123   | .728 |
| Gender (Main Effect) | 1.800                   | 1  | 1.800       | .199   | .658 |
| Error                | 307.333                 | 34 | 9.039       |        |      |
| Total                | 9528.000                | 37 |             |        |      |
| Corrected Total      | 310.270                 | 36 |             |        |      |

a. R Squared = .009 (Adjusted R Squared = -.049)

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p>0.05

To further show the improvement in learning after treatment, the mean gain scores between the pretest and posttest science process skills of male and female pupils are shown in Table 22. Result from Table 22 reveals that male and female pupils' science process skills were improved after posttest. Male pupils had mean gain scores of 11.74 while female pupils had

mean gain scores of 11.18. This shows that both groups benefited from the treatment as illustrated in figure 7

Table 22

*Mean gain scores in science process skills of male and female pupils taught using virtual laboratory only*

| <b>Gender</b> | <b>Pretest</b> | <b>Posttest</b> | <b>MeanGain Score</b> |
|---------------|----------------|-----------------|-----------------------|
| Male          | 4.24           | 15.98           | 11.74                 |
| Female        | 4.40           | 15.58           | 11.18                 |

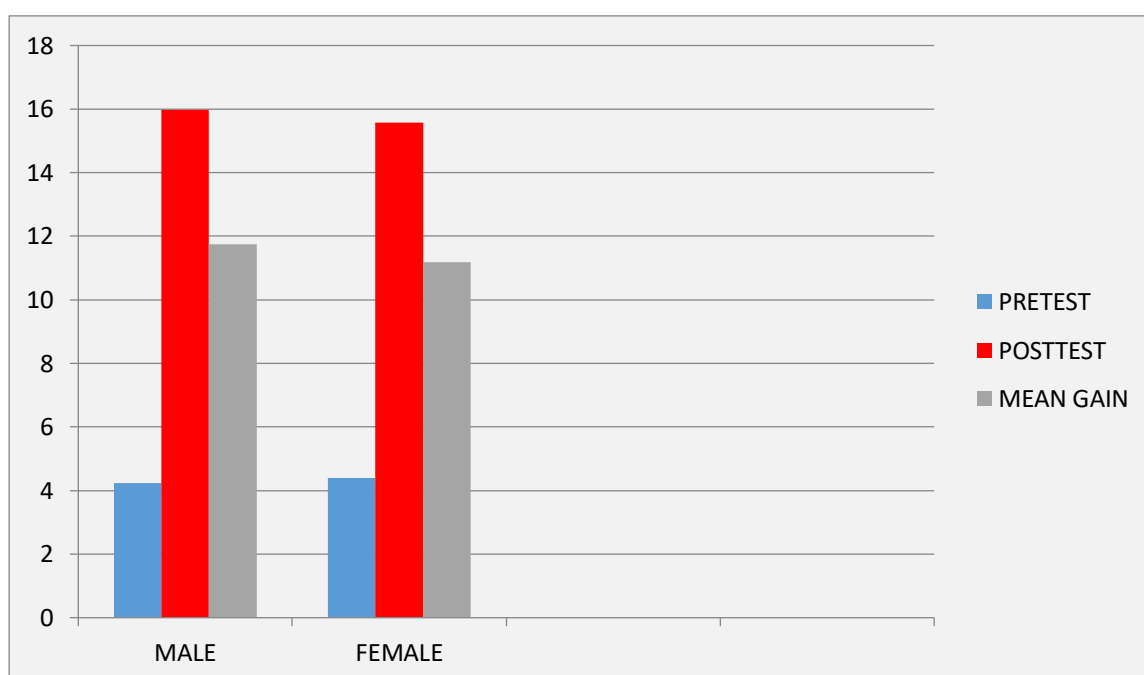


Figure 7: Mean gain scores in science process skills of male and female pupils taught using virtual laboratory only

**H<sub>07</sub>:** *There is no significant difference in the knowledge of science concept of low, medium and high score levels pupils taught using virtual laboratory only (EX GI)*

Table 23 presents the result of the analysis of covariance using the pretest scores of students in the three score levels as covariates. The result showed that F - value of 0.02 for the main effect with a p-value of 0.98 computed at 0.05 was not significant since p-value (0.98) is greater than alpha level (0.05) i.e. ( $F_{(2, 33)} = 0.02, p > 0.05$ ). This implies that there was no significant difference in the knowledge of science concepts of low, medium and high score level pupils taught using virtual laboratory only. On this basis, hypothesis five was not rejected.

Table 23

*Analysis of Covariance Showing the Difference in the Knowledge of Science Concept (KSC) of Low, Medium and High Score Levels pupils When Taught Using Virtual Laboratory (EX GI)*

| Source                                           | Type III<br>Sum of<br>Squares | df | Mean<br>Squar<br>e | F      | Sig. |
|--------------------------------------------------|-------------------------------|----|--------------------|--------|------|
| Corrected Model                                  | 3.848 <sup>a</sup>            | 3  | 1.283              | .551   | .651 |
| Intercept                                        | 82.341                        | 1  | 82.341             | 35.356 | .000 |
| Pre-test (Covariate)                             | 1.131                         | 1  | 1.131              | .486   | .491 |
| Score Level (Main<br>Effect)                     | .089                          | 2  | .044               | .019   | .981 |
| Error                                            | 76.855                        | 33 | 2.329              |        |      |
| Total                                            | 7730.000                      | 37 |                    |        |      |
| Corrected Total                                  | 80.703                        | 36 |                    |        |      |
| a. R Squared = .048 (Adjusted R Squared = -.039) |                               |    |                    |        |      |
| p>0.05                                           |                               |    |                    |        |      |

**H<sub>08</sub>:** *There is no significant difference in science process skills of low, medium and high score levels pupils taught using virtual laboratory only (EX GI)*

Result in Table 24 reveals the analysis of covariance using the pretest scores of pupils in the three score levels as covariates. The result showed that F-value of 0.24 for the main effect with a p-value of 0.63 computed at 0.05 was not significant since p-value (0.63) is greater than alpha level

(0.05) i.e. ( $F_{(1, 34)} = 0.24, p > 0.05$ ). This implies that there was no significant difference in the science process skills of low, medium and high score level pupils taught using virtual laboratory only. On this basis, hypothesis six was not rejected.

Table 24

*An Analysis of Covariance Showing the Difference in the Science Process Skills of Pupils of Low, Medium and High Score Levels When Taught Using Virtual Laboratory (EX GI)*

| Source                     | Type III Sum of Squares | df | Mean Square | F      | Sig. |
|----------------------------|-------------------------|----|-------------|--------|------|
| Corrected Model            | 3.275 <sup>a</sup>      | 2  | 1.638       | .181   | .835 |
| Intercept                  | 113.435                 | 1  | 113.435     | 12.563 | .001 |
| Pre-test(Covariate)        | .005                    | 1  | .005        | .001   | .981 |
| Score Levels (Main Effect) | 2.139                   | 1  | 2.139       | .237   | .630 |
| Error                      | 306.995                 | 34 | 9.029       |        |      |
| Total                      | 9528.000                | 37 |             |        |      |
| Corrected Total            | 310.270                 | 36 |             |        |      |

a. R Squared = .011 (Adjusted R Squared = -.048)

p>0.05

**H<sub>09</sub>:** *There is no significant difference in the attitudes of pupils that were taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G) towards basic science and technology.*

As revealed in Table 25, the t-value of 1.29 was obtained with a p-value of 0.28 computed at 0.05 alpha level. Since p-value (0.28) is greater than alpha level (0.05), the null hypothesis seven was not rejected and thus, there was no significant difference in the attitudes of pupils that were taught using virtual laboratory only and those taught using physical laboratory only towards basic science and technology ( $t_{(63)} = 1.28$ ,  $p > 0.05$ ). However, the positive mean values reveal that both groups demonstrated positive attitudes towards basic science and technology.

Table 25

*t-Test Statistics Showing the Difference in the Attitudes of Pupils That Were Taught with Virtual Laboratory Only and That of Pupils Taught with Physical Laboratory Only Towards Basic Science and Technology*

|                      | Groups          | N  | Mean   | S. D. | df | t-<br>value | Sig.  |
|----------------------|-----------------|----|--------|-------|----|-------------|-------|
| Pupils’<br>Attitudes | Virtual Lab     | 37 | 27.264 | 1.635 | 63 | 1.297       | 0.275 |
|                      | Physical<br>Lab | 28 | 26.957 | 1.339 |    |             |       |
| p>0.05               |                 |    |        |       |    |             |       |

**H<sub>10</sub>:** *There is no significant difference in pupils' knowledge of science concepts when taught using virtual and physical laboratories (EX GII) and those taught using physical laboratory only (CO G).*

Table 26 shows the ANCOVA comparison of posttest knowledge of science concepts scores between (EX GII) and (CO G). The results of the analysis reveals F-value of 8.69 with a p-value of 0.005 computed at 0.05 alpha level. Since p-value (0.005) is less than alpha level (0.05), the null hypothesis eight was rejected which indicates that the main effect (treatment) was significant ( $F_{(1, 61)} = 8.69, p < 0.05$ ). The results revealed that the strategies of instruction produced a significant effect on the posttest

knowledge of science concepts scores of pupils when covariate effect (pretest) was controlled.

Table 26

*Analysis of Covariance Showing the Difference in Pupils' Knowledge of Science Concepts (KSC) When Taught Using Virtual and physical Laboratories and Those Pupils Taught Using Physical Laboratory Only using Pretest as Covariate*

| Source                                          | Type III<br>Sum of<br>Squares | df | Mean<br>Squar<br>e | F      | Sig. |
|-------------------------------------------------|-------------------------------|----|--------------------|--------|------|
| Corrected Model                                 | 27.346 <sup>a</sup>           | 2  | 13.673             | 4.573  | .014 |
| Intercept                                       | 687.601                       | 1  | 687.60             | 229.95 | .000 |
|                                                 |                               |    | 1                  | 0      |      |
| Pre-test (Covariate)                            | .009                          | 1  | .009               | .003   | .956 |
| Virtual & Physical Lab.<br>(KSC) (Main Effect)  | 25.993                        | 1  | 25.993             | 8.693  | .005 |
| Error                                           | 182.404                       | 61 | 2.990              |        |      |
| Total                                           | 11130.000                     | 64 |                    |        |      |
| Corrected Total                                 | 209.750                       | 63 |                    |        |      |
| a. R Squared = .130 (Adjusted R Squared = .102) |                               |    |                    |        |      |
| p<0.05                                          |                               |    |                    |        |      |

Table 27 depicts the multiple comparison analysis to show the actual difference (effect of the treatment on pupils' knowledge of science concepts). As shown in Table 27, pupils that were taught with virtual and

physical laboratories (Experimental Group II) had higher mean score 14.38 in their knowledge of science concepts than those that were taught using physical laboratory (Control Group) with the mean score 12.32. Thus, the effect of virtual and physical laboratories combined on pupils' knowledge of science concepts is shown by the mean difference 2.06. This implies that a significant difference exists between the two groups in favour of EX GII.

Table 27

*Pairwise Comparisons Analysis Showing the Effect of the Virtual and Physical Laboratories on Pupils' knowledge of Science Concepts (KSC)*

| Treatment                                                                  | Mean               | Mean Diff.<br>(I-J) | Std.<br>Error | Sig. <sup>b</sup> | 95% Confidence<br>Interval for<br>Difference <sup>b</sup> |                |
|----------------------------------------------------------------------------|--------------------|---------------------|---------------|-------------------|-----------------------------------------------------------|----------------|
|                                                                            |                    |                     |               |                   | Lower<br>Bound                                            | Upper<br>Bound |
| Virtual lab with<br>Physical Lab. (I)<br>(Knowledge of<br>Science Concept) | 14.38 <sup>a</sup> | 2.06 <sup>*</sup>   | 0.445         | 0.01              | 0.422                                                     | 2.20           |
| Physical Lab (J)<br>(Knowledge of<br>Science Concept)                      | 12.32 <sup>a</sup> | -2.06 <sup>*</sup>  | 0.445         | 0.01              | -2.20                                                     | -0.422         |
| <b>Grand Mean = 13.35</b>                                                  |                    |                     |               |                   |                                                           |                |

\* the mean difference is significant at 0.05 level

b. Adjustment for Multiple Comparisons: Bonferroni

**H<sub>11</sub>:** *There is no significant difference in pupils' science process skills (SPS) when taught using virtual and Physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G).*

Table 28 shows the ANCOVA comparison of posttest science process skills scores between (EX GII) and (CO G). The results of the analysis reveals F-value of 13.68 with a p-value of 0.000 computed at 0.05 alpha level. Since p-value (0.000) is less than alpha level (0.05), the null hypothesis nine was rejected which indicates that the main effect (treatment) was significant ( $F_{(1, 61)} = 13.68, p < 0.05$ ). The results revealed that the strategies of instruction produced a significant effect on the posttest science process skills scores of pupils when covariate effect (pretest) was controlled.

Table 28

*Analysis of Covariance Showing the Difference in Pupils' Science Process Skills (SPS) When Taught using Virtual and Physical Laboratories combined and Pupils Taught using Physical Laboratory Only using pretest as Covariate*

| Source                                          | Type III Sum of Squares | df | Mean Square | F      | Sig. |
|-------------------------------------------------|-------------------------|----|-------------|--------|------|
| Corrected Model                                 | 204.298 <sup>a</sup>    | 2  | 102.149     | 12.445 | .000 |
| Intercept                                       | 553.440                 | 1  | 553.440     | 67.427 | .000 |
| Pre-test (Covariate)                            | 49.119                  | 1  | 49.119      | 5.984  | .017 |
| Virtual & Physical Lab (SPS) (Main Effect)      | 112.316                 | 1  | 112.316     | 13.68  | .000 |
| Error                                           | 500.686                 | 61 | 8.208       |        |      |
| Total                                           | 15135.000               | 64 |             |        |      |
| Corrected Total                                 | 704.984                 | 63 |             |        |      |
| a. R Squared = .290 (Adjusted R Squared = .267) |                         |    |             |        |      |
| p<0.05                                          |                         |    |             |        |      |

Table 29 depicts the multiple comparison analysis to show the actual difference (effect of the treatment on pupils' knowledge of science concept). As shown in Table 29, pupils that were taught using virtual laboratory + physical laboratory (Experimental Group II) had higher mean score 16.38 in their science process skills than those taught using physical Laboratory (Control Group) only with the mean score 13.25. Thus, the effect of virtual and physical laboratories on pupils' science process skills is shown by the

mean difference 3.13. This implies that a significant difference exists between the two groups in favour of EX GII.

Table 29

*Pairwise Comparisons Analysis Showing the Effect of the Virtual lab.  
+ Physical Laboratories on Pupils' Science Process Skills*

| Treatment                                                       | Mean               | Mean<br>Diff. (I-J) | Std.<br>Error | Sig. <sup>b</sup> | 95% Confidence<br>Interval for<br>Difference <sup>b</sup> |                |
|-----------------------------------------------------------------|--------------------|---------------------|---------------|-------------------|-----------------------------------------------------------|----------------|
|                                                                 |                    |                     |               |                   | Lower<br>Bound                                            | Upper<br>Bound |
| Virtual and<br>Physical Lab. (I)<br>(Science Process<br>Skills) | 16.38 <sup>a</sup> | 3.13 <sup>*</sup>   | 0.740         | 0.00              | 1.258                                                     | 4.218          |
| Physical Lab (J)<br>(Science Process<br>Skills)                 | 13.25 <sup>a</sup> | -3.13 <sup>*</sup>  | 0.740         | 0.00              | -4.218                                                    | -1.258         |
| <b>Grand Mean = 14.81</b>                                       |                    |                     |               |                   |                                                           |                |

\* the mean difference is significant at 0.05 level

b. Adjustment for Multiple Comparisons: Bonferroni

**H<sub>12</sub>:** *There is no significant difference in knowledge of science concepts (KSC) of male and female pupils taught using virtual and physical laboratories combined (EX G II)*

The hypothesis was tested using the pretest mean knowledge of science concepts scores of male and female as covariate for the analysis of Covariance. Result in Table 30 reveals that the F-value of 0.84 was obtained

with a p-value of 0.37 computed at 0.05 alpha level. Since p-value (0.37) is greater than alpha level (0.05), the null hypothesis twelve was not rejected ( $F_{(1, 33)} = 0.84, p > 0.05$ ). This implies that male pupils' knowledge of science concepts did not significantly differ from that of female pupils when both were taught using virtual and physical laboratories combined (EX GII).

Table 30

*Analysis of Covariance Showing the Difference in Male and Female Pupils' Knowledge of Science Concept (KSC) When Taught using Virtual and Physical Laboratories combined using pretest as Covariate*

| Source                  | Type III<br>Sum of<br>Squares | Df | Mean<br>Square | F       | Sig. |
|-------------------------|-------------------------------|----|----------------|---------|------|
| Corrected Model         | 4.172 <sup>a</sup>            | 2  | 2.086          | .537    | .589 |
| Intercept               | 435.266                       | 1  | 435.26         | 112.100 | .000 |
|                         |                               | 6  |                |         |      |
| Pre-test<br>(Covariate) | 1.104                         | 1  | 1.104          | .284    | .598 |
| Gender (Main<br>Effect) | 3.266                         | 1  | 3.266          | .841    | .366 |
| Error                   | 128.134                       | 33 | 3.883          |         |      |
| Total                   | 6829.000                      | 36 |                |         |      |
| Corrected Total         | 132.306                       | 35 |                |         |      |

a. R Squared = .032 (Adjusted R Squared = -.027)

P>0.05

To further show the improvement in learning after treatment, the mean gain scores between the pretest and posttest knowledge of science concepts of male and female pupils are shown in Table 31. Result from Table 31 reveals that male and female students' knowledge of science concepts were improved after posttest. Male students had mean gain scores of 6.64 while female students had mean gain scores of 5.48. This shows that both groups benefited from the treatment as illustrated in figure 8.

Table 31

*Mean gain scores in knowledge of science concepts of male and female pupils taught using virtual laboratory +physical laboratory (EX GII)*

| <b>Gender</b> | <b>Pretest</b> | <b>Posttest</b> | <b>MeanGain<br/>Score</b> |
|---------------|----------------|-----------------|---------------------------|
| Male          | 8.04           | 14.68           | 6.64                      |
| Female        | 8.60           | 14.08           | 5.48                      |

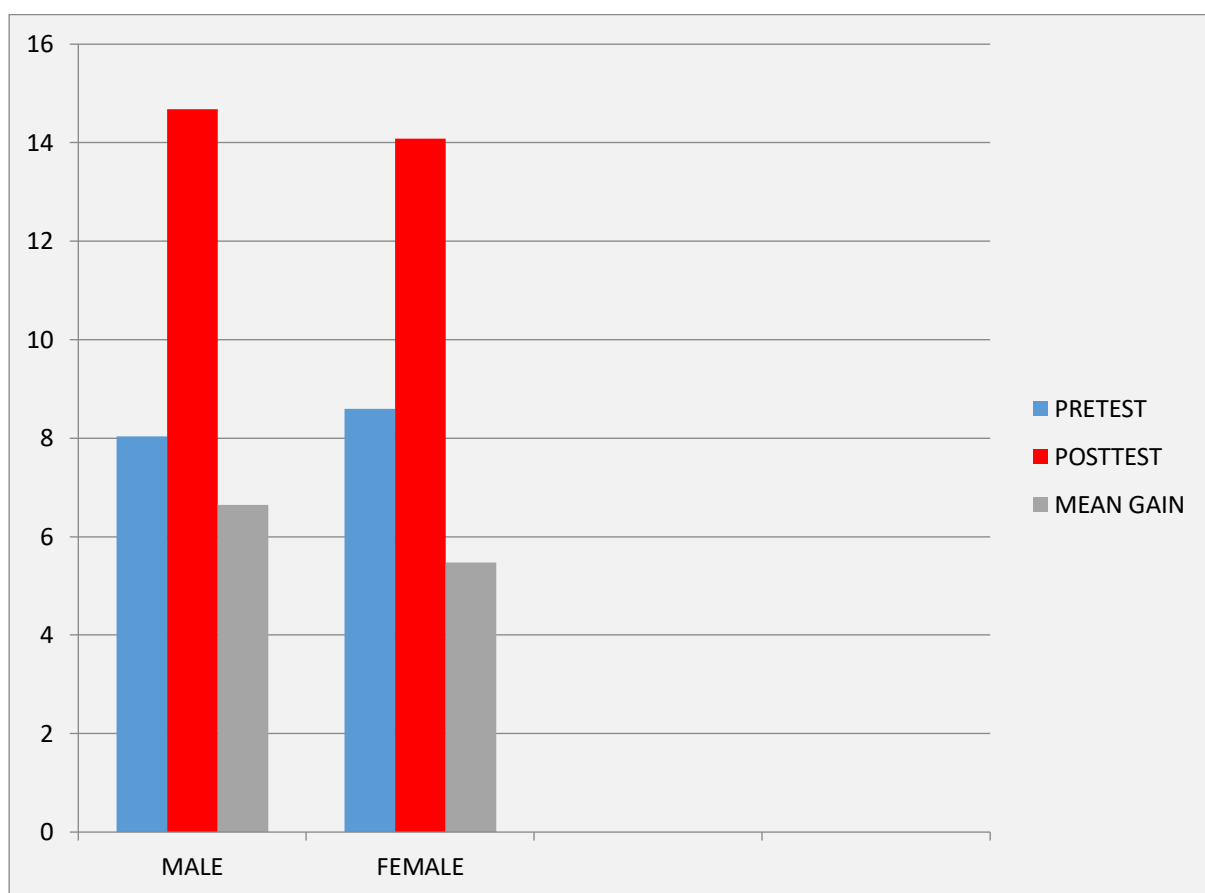


Figure 8: Mean gain scores in knowledge of science concepts of male and female pupils taught using virtual and physical laboratories combined (EX GII)

**H<sub>13</sub>:** *There is no significant difference in science process skills of male and female pupils when taught using virtual and physical laboratories combined (EX G II)*

The hypothesis was tested using the pretest mean science process skills scores of male and female as covariate for the analysis of Covariance. Result in Table 32 reveals F-value of 0.15 with a p-value of 0.70 computed

at 0.05 alpha level. Since p-value (0.70) is greater than alpha level (0.05), the null hypothesis eleven was not rejected ( $F_{(1, 33)} = 0.15$ ,  $p > 0.05$ ). This implies that male pupils' science process skills did not significantly differ from that of female pupils when both were taught using virtual and physical laboratories combined (EX GII).

Table 32

*Analysis of Covariance Showing the Difference in Science Process Skills of Male and Female Pupils When Taught Using Virtual laboratory + Physical Laboratory*

| Source                  | Type III<br>Sum of<br>Squares | df | Mean<br>Square | F       | Sig. |
|-------------------------|-------------------------------|----|----------------|---------|------|
| Corrected Model         | 2.024 <sup>a</sup>            | 2  | 1.012          | .079    | .924 |
| Intercept               | 1805.259                      | 1  | 1805.259       | 140.992 | .000 |
| Pre-test<br>(Covariate) | .018                          | 1  | .018           | .001    | .970 |
| Gender (Main<br>Effect) | 1.929                         | 1  | 1.929          | .151    | .700 |
| Error                   | 422.532                       | 33 | 12.804         |         |      |
| Total                   | 10094.000                     | 36 |                |         |      |
| Corrected Total         | 424.556                       | 35 |                |         |      |

a. R Squared = .005 (Adjusted R Squared = -.056)

$p > 0.05$

To further show the improvement in learning after treatment, the mean gain scores between the pretest and posttest science process skills of male and female pupils are shown in Table 33. Result from Table 33 reveals that male and female pupils' science process skills were improved after posttest. Male students had mean gain scores of 12.98 while female pupils had mean gain scores of 13.18. This shows that both groups benefited from the treatment as illustrated in figure 9.

Table 33

*Mean gain scores in science process skills of male and female pupils taught using virtual laboratory + physical laboratory (EX GII)*

| <b>Gender</b> | <b>Pretest</b> | <b>Posttest</b> | <b>MeanGain<br/>Score</b> |
|---------------|----------------|-----------------|---------------------------|
| Male          | 3.10           | 16.08           | 12.98                     |
| Female        | 3.50           | 16.68           | 13.18                     |

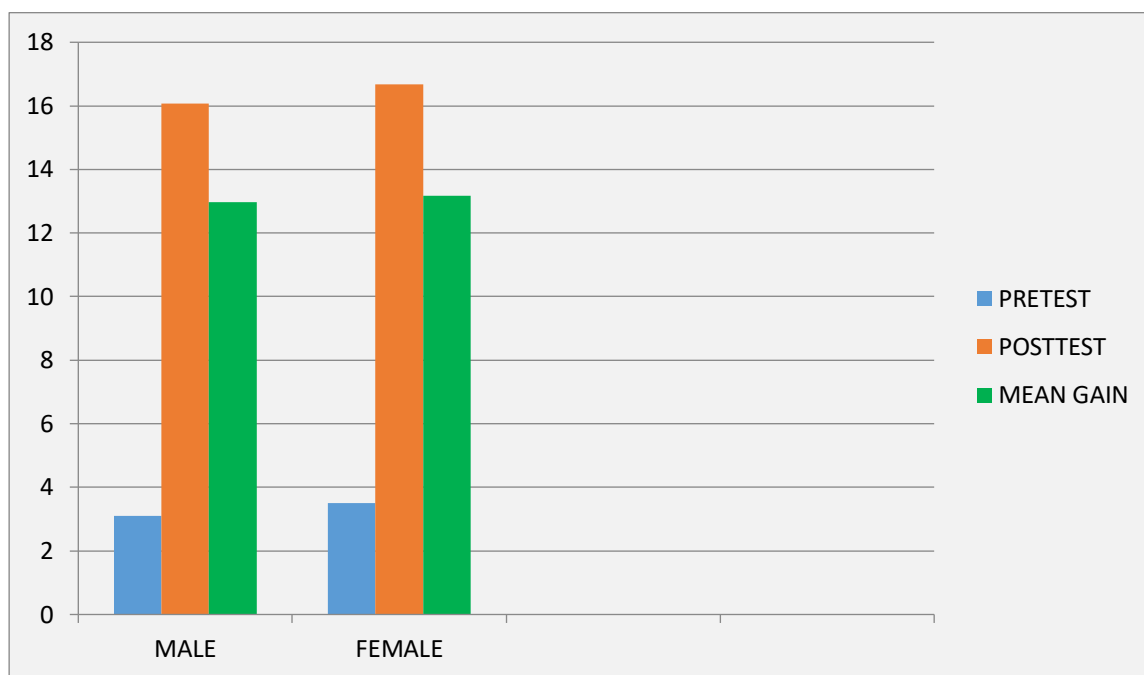


Figure 9: Mean gain scores in science process skills of male and female pupils taught using virtual and physical laboratories combined (EX GII)

**H<sub>14</sub>:** *There is no significant difference in knowledge of science concepts of low, medium and high score levels pupils taught using virtual and physical laboratories combined (EX G II)*

Table 34 presents the result of the analysis of covariance using the pretest scores of pupils in the three score levels as covariates. The result shows that F - value of 0.51 for the main effect with a p-value of 0.60 computed at 0.05 was not significant since p-value (0.60) is greater than alpha level (0.05) i.e. ( $F_{(2, 33)} = 0.51, p > 0.05$ ). This implies that there was no statistical significant difference in the knowledge of science concepts of low, medium and high score level pupils taught using virtual laboratory + physical laboratory (EX GII). On this basis, hypothesis twelve was not rejected.

Table 34

*Analysis of Covariance Showing the Difference in the Knowledge of Science Concept (KSC) of Low, Medium and High Score Levels Pupils When Taught Using Virtual and Physical Laboratories combined*

| Source               | Type III Sum of Squares | Df | Mean Square | F      | Sig. |
|----------------------|-------------------------|----|-------------|--------|------|
| Corrected Model      | 4.995 <sup>a</sup>      | 3  | 1.665       | .419   | .741 |
| Intercept            | 127.927                 | 1  | 127.927     | 32.155 | .000 |
| Pre-test (covariate) | .965                    | 1  | .965        | .243   | .626 |
| Score Levels         | 4.089                   | 2  | 2.045       | .514   | .603 |
| Error                | 127.311                 | 32 | 3.978       |        |      |
| Total                | 6829.000                | 36 |             |        |      |
| Corrected Total      | 132.306                 | 35 |             |        |      |

a. R Squared = .038 (Adjusted R Squared = -.052)

p>0.05

**H<sub>15</sub>:** *There is no significant difference in science process skills of low, medium and high score levels pupils taught using virtual and physical laboratories combined (EX GII)*

Result in Table 35 reveals the analysis of covariance using the pretest scores of pupils in the three score levels as covariates. The result shows that

F-value of 2.67 for the main effect with a p-value of 0.11 computed at 0.05 was not significant since p-value (0.11) is greater than alpha level (0.05) i.e. ( $F_{(1, 33)} = 2.67, p > 0.05$ ). This implies that there was no significant difference in the science process skills of low, medium and high score level pupils taught using virtual and physical laboratories combined. On this basis, hypothesis fifteen was not rejected.

Table 35:

*Analysis of Covariance Showing the Difference in the Science Process Skills of Low, Medium and High Score Levels Pupils When Taught with Virtual and Physical Laboratories combined (EX GII)*

| Source                  | Type III Sum<br>of Squares | df | Mean<br>Square | F     | Sig. |
|-------------------------|----------------------------|----|----------------|-------|------|
| Corrected Model         | 31.831 <sup>a</sup>        | 2  | 15.916         | 1.337 | .276 |
| Intercept               | 30.897                     | 1  | 30.897         | 2.596 | .117 |
| Pre-test<br>(covariate) | 27.876                     | 1  | 27.876         | 2.342 | .135 |
| Score levels            | 31.736                     | 1  | 31.736         | 2.667 | .112 |
| Error                   | 392.725                    | 33 | 11.901         |       |      |
| Total                   | 10094.000                  | 36 |                |       |      |
| Corrected Total         | 424.556                    | 35 |                |       |      |

a. R Squared = .075 (Adjusted R Squared = .019)

---

p>0.05

**H<sub>16</sub>:** *There is no significant difference in the attitudes of pupils that were taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G).*

As revealed in Table 36 the t-value of 1.27 was obtained with a p-value of 0.22 computed at 0.05 alpha level. Since p-value (0.22) is greater than alpha level (0.05), the null hypothesis sixteen was not rejected and thus, there was no significant difference in the attitudes of pupils that were taught with virtual and physical laboratories and that of pupils taught with physical laboratory only ( $t_{(62)} = 1.27, p > 0.05$ ). However, the positive mean values reveal that both groups demonstrated positive attitudes towards basic science and technology.

Table 36:

*t-Test Statistics Showing the Difference in the Attitudes of Pupils That Were Taught with Virtual Laboratory + physical laboratory (EX GII) and That of Pupils Taught with Physical Laboratory Only (CO G)*

|                   | Groups                 | N  | Mean   | S. D. | df | t-value | Sig.  |
|-------------------|------------------------|----|--------|-------|----|---------|-------|
| Pupils' Attitudes | Virtual & Physical Lab | 36 | 26.355 | 1.635 | 62 | 1.269   | 0.219 |
|                   | Physical Lab           | 28 | 25.957 | 1.339 |    |         |       |
| p>0.05            |                        |    |        |       |    |         |       |

**H<sub>17</sub>:** *There is no interaction effect of treatments, gender and score levels on pupils' Knowledge of Science Concept.*

As revealed in Table 37, the F-value 1.36 with a p-value 0.26 was obtained when computed at 0.05 alpha level. Therefore the null hypothesis seventeen was not rejected. Since the p-value 0.26 is greater than 0.05 alpha level, there was no interaction effect of treatments, gender and score levels on pupils' Knowledge of Science Concept ( $F_{(2, 86)} = 1.36, p > 0.05$ ).

Table 37

*Analysis of Covariance Showing the Interaction Effect of the Treatments, Gender and Score Levels on Pupils' Knowledge of Science Concept*

| Source                                   | Type III Sum of Squares | df       | Mean Square  | F            | Sig.        |
|------------------------------------------|-------------------------|----------|--------------|--------------|-------------|
| Corrected Model                          | 92.469 <sup>a</sup>     | 14       | 6.605        | 2.381        | .008        |
| Intercept                                | 262.219                 | 1        | 262.219      | 94.521       | .000        |
| KSC pretest                              | 3.780                   | 1        | 3.780        | 1.362        | .246        |
| Treatment                                | 30.987                  | 2        | 15.494       | 5.585        | .005        |
| Gender                                   | .468                    | 1        | .468         | .169         | .682        |
| Score Levels                             | 2.243                   | 2        | 1.121        | .404         | .669        |
| Treatment * Gender                       | 1.278                   | 2        | .639         | .230         | .795        |
| Treatment * Score Levels                 | 5.317                   | 2        | 2.659        | .958         | .388        |
| Gender * Score Levels                    | .225                    | 1        | .225         | .081         | .776        |
| <b>Treatment * Gender * Score Levels</b> | <b>7.560</b>            | <b>2</b> | <b>3.780</b> | <b>1.363</b> | <b>.261</b> |
| Error                                    | 238.580                 | 86       | 2.774        |              |             |
| Total                                    | 18860.000               | 101      |              |              |             |
| Corrected Total                          | 331.050                 | 100      |              |              |             |

a. R Squared = .279 (Adjusted R Squared = .162)

**H<sub>18</sub>:** *There is no interaction effect of treatments, gender and score levels on pupils' Science Process Skills.*

As revealed in Table 38, the F-value 0.44 with a p-value 0.50 was obtained when computed at 0.05 alpha level. Therefore, the null hypothesis eighteen was not rejected. Since the p-value 0.50 is greater than 0.05 alpha

level, there was no interaction effect of treatments, gender and score levels on pupils' Science Process Skills ( $F_{(1, 89)} = 0.44, p > 0.05$ ).

Table 38

*Analysis of Covariance Showing the Interaction Effect of the Treatments, Gender and Score Levels on Pupils' Science Process Skills*

| Source                                   | Type III Sum of Squares | df       | Mean Square  | F           | Sig.        |
|------------------------------------------|-------------------------|----------|--------------|-------------|-------------|
| Corrected Model                          | 243.872 <sup>a</sup>    | 11       | 22.170       | 2.513       | .008        |
| Intercept                                | 959.685                 | 1        | 959.685      | 108.775     | .000        |
| SPS Pretest                              | 13.527                  | 1        | 13.527       | 1.533       | .219        |
| Treatment                                | 31.370                  | 2        | 15.685       | 1.778       | .175        |
| Gender                                   | 13.259                  | 1        | 13.259       | 1.503       | .223        |
| Score Levels                             | 2.771                   | 1        | 2.771        | .314        | .577        |
| Treatment * Gender                       | 6.791                   | 2        | 3.395        | .385        | .682        |
| Treatment * Score Levels                 | 4.496                   | 2        | 2.248        | .255        | .776        |
| Gender * Score Levels                    | 37.680                  | 1        | 37.680       | 4.271       | .042        |
| <b>Treatment * Gender * Score Levels</b> | <b>3.966</b>            | <b>1</b> | <b>3.966</b> | <b>.449</b> | <b>.504</b> |
| Error                                    | 785.217                 | 89       | 8.823        |             |             |
| Total                                    | 24663.000               | 101      |              |             |             |
| Corrected Total                          | 1029.089                | 100      |              |             |             |

a. R Squared = .237 (Adjusted R Squared = .143)

## Summary of the Findings

Findings obtained from this study are summarized as follows;

1. There was a significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G) ( $F_{(2, 97)} = 12.878$ ,  $p < 0.05$ ). in favour of (EX GII).
2. There was a significant difference in pupils' science process skills (SPS) when taught using virtual laboratory only (EX GI), virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G) only ( $F_{(2, 97)} = 7.703$ ,  $p < 0.05$ ) in favour of (EX GII).
3. There was a significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G) ( $F_{(1, 62)} = 35.69$ ,  $p < 0.05$ ) in favour of (EX GI).
4. There was a significant difference in pupils' science process skills when taught using virtual laboratory only (EX GI) and those taught using physical laboratory only (CO G) ( $F_{(1, 62)} = 8.99$ ,  $p < 0.05$ ) in favour of (EX GI).
5. There was a significant difference in pupils' knowledge of science concepts when taught using virtual and physical laboratories

combined (EX GII) and those taught using physical laboratory only (CO G) ( $F_{(1, 61)} = 8.69, p < 0.05$ ).

6. There was a significant difference in pupils' science process skills when taught using virtual and physical laboratories combined (EX GII) and those taught using physical laboratory only (CO G) ( $F_{(1, 61)} = 13.68, p < 0.05$ ).
7. There was no significant difference in knowledge of science concept (KSC) of male and female pupils that were taught using virtual laboratory only ( $F_{(1, 34)} = 0.44, p > 0.05$ ).
8. There was no significant difference in science process skills of male and female pupils that were taught using virtual laboratory only ( $F_{(1, 34)} = 0.19, p > 0.05$ ).
9. There was no significant difference in the knowledge of Science concept (KSC) of low, medium and high score levels pupils that were taught using virtual laboratory only (EX GI) ( $F_{(2, 33)} = 0.02, p > 0.05$ ).
10. There was no significant difference in the science process skills (SPS) of low, medium and high score levels pupils that were taught using virtual laboratory only (EX GI) ( $F_{(1, 34)} = 0.24, p > 0.05$ ).
11. There was no significant difference in the attitudes of pupils that were taught using virtual laboratory only and those taught using physical laboratory only ( $t_{(63)} = 1.28, p > 0.05$ ).

12. There was no significant difference in the knowledge of science concept of male and female pupils that were taught using virtual laboratory + physical laboratory only (EX GII) ( $F_{(1, 33)} = 0.84$ ,  $p > 0.05$ ).
13. There was no significant difference in the science process skills of male and female pupils that were taught using virtual laboratory + physical laboratory only (EX GII) ( $F_{(1, 33)} = 0.15$ ,  $p > 0.05$ ).
14. There was no significant difference in the knowledge of science concept of low, medium and high score levels pupils that were taught using virtual laboratory + physical laboratory only (EX GII) ( $F_{(2, 32)} = 0.51$ ,  $p > 0.05$ ).
15. There was no significant difference in the science process skills of low, medium and high score levels pupils that were taught using virtual laboratory + physical laboratory only (EX GII) ( $F_{(1, 33)} = 2.67$ ,  $p > 0.05$ ).
16. There was no significant difference in the attitudes of pupils that were taught with virtual laboratory + physical laboratory (EX GII) and that of pupils taught with physical laboratory only (CO G) ( $t_{(62)} = 1.27$ ,  $p > 0.05$ ).
17. There was no significant difference in pupils' knowledge of science concepts (KSC) when taught using virtual laboratory only (EX GI)

and those taught using virtual laboratory + physical laboratory only (EX GII) ( $F_{(1, 70)} = 3.26, p > 0.05$ ).

18. There was no significant difference in pupils' science process skills when taught using virtual laboratory only (EX GI) and those taught using virtual laboratory + physical laboratory only (EX GII) ( $F_{(1, 70)} = 0.62, p > 0.05$ ).

19. There was no interaction effect of the independent variables (treatment, gender and score level) on pupils' knowledge of science concept ( $F_{(2, 86)} = 1.36, p > 0.05$ ).

20. There was no interaction effect of the independent variables (treatment, gender and score level) on pupils' science process skills ( $F_{(1, 89)} = 0.44, p > 0.05$ ).

## **CHAPTER FIVE**

### **DISCUSSION, CONCLUSION AND RECOMMENDATIONS**

This concluding chapter deals with the discussions of the research findings and recommendations.

#### **Discussion on Research Findings**

The findings of this study are discussed under the following four headings:

1. Findings on the Effects of Treatments (virtual laboratory only and virtual laboratory + physical laboratory) on pupils' knowledge of science concepts (KSC) and science process skills (SPS).
2. Findings on the Effects of Treatments on Male and Female Pupils' (KSC) and (SPS).
3. Findings on the Effects of Treatments on Pupils' Score Levels
4. Findings on Pupils' Attitude Towards Physics Aspects of Basic Science and Technology

### **Findings on the Effects of Treatments (virtual laboratory only and virtual laboratory + physical laboratory) on Pupils' Knowledge of Science Concepts (KSC) and Science Process Skills (SPS).**

The findings of the result of analysis of covariance on the performance of students taught using virtual laboratory only against physical laboratory only, virtual laboratory + physical laboratory against physical laboratory only and virtual laboratory only against virtual laboratory + physical laboratory were examined using hypotheses one, two, eight, nine, fifteen, and sixteen. The result indicated a significant difference in favour of the pupils in the treatment groups. The findings agree with the earlier findings of Mohammed (2016) which confirmed a significant difference in the achievement of students taught physics using virtual laboratory only, virtual laboratory + physical laboratory and physical laboratory only in favour of those exposed to virtual laboratory + physical laboratory. The study was also supported by Hassan (2010) who reported a significant difference in the performance of students taught using web-based virtual laboratory than those in the control group both in conceptual understanding and science process skills.

The finding also agrees with the finding of Tatli and Ayas (2013) who concluded that the developed virtual chemistry laboratory software and physics virtual laboratory package was as effective as the real laboratory, both in terms of student achievement in the unit and students' ability to

recognize laboratory equipment. Similar to this finding was the study conducted by Gambari, Falode, Fagbemi and Idris (2013) which showed that the application of the virtual laboratory had positive effects on students' achievements, retention and attitudes when compared to physical laboratory method. Also, the study agreed with finding of Yang and Heh (2007) who examined the effect of internet virtual physics laboratory (IVPL) instruction on tenth grade students' academic achievement in physics. The findings indicated that computer-based learning facilitated students' achievement in physics. The finding of this study is in the same direction with finding of Efe and Efe (2011) who revealed that students taught with the help of computer simulations made statistically significant improvements in their test scores on all six levels (knowledge, comprehension, application, analysis, synthesis and evaluation) of Bloom's taxonomy. Also, it is in line with the findings of Tüysüz (2010) which showed that virtual laboratory applications made positive effects on students' achievements and attitudes when compared to traditional teaching methods after being exposed to 'Separation of Matter'.

Similarly, Omilani, Ochanya and Aminu (2016) reported that virtual laboratory combined with traditional laboratory had a significant effect on students' achievement in chemistry practical. It also agreed with the studies of Ozge and Serkar (2015); Zacharias, Marios, Giorgos and Vasoula (2014), Abdullah and Shariff (2008); Natasa, Milena and Dejan (2014); Bilek,

(2010); Carmichael et al., (2010); Georgiou et al., 2008; Lee, (2010); who reported that virtual laboratories provided handy and cheap way for supporting laboratory education; enhanced students' performance. On the same note, Murniza, Halimah and Azlina (2010) revealed that virtual laboratory for biology could support students to explore and visualize the abstract concepts in learning biology especially in "Describing the application of knowledge on mitosis in cloning".

However, the finding of this study contradicts with the findings of Azar and Şengüleç (2010) who found that students' achievements and attitudes towards physics using the computer-assisted teaching method can be more effective than the laboratory-assisted teaching method. Similarly, it did not support the finding of Başer and Durmuş (2010) that reported no significant effect among the pre-service teachers exposed to Direct Current Electricity (DCE) in virtual (VLE) and real laboratory environment (RLE). Similarly, Kaewprapan and Suksakulchai (2008) found that students exposed to virtual reality module within one course and traditional lecture within another did not significantly differ in their performance after the treatment. It also disagrees with the finding of Gorghiu, Gorghiu, Alexandrescu and Borcea (2009) who reported that traditional laboratories were more effective, despite the fact that virtual laboratories provided a variety of benefits.

## **Findings on the Effects of Treatments on Male and Female Pupils' (KSC) and (SPS).**

The fact that no significant difference existed in the performance of male and female pupils with the use of virtual laboratory agrees with the earlier findings of Mohammed (2016) who confirmed no gender difference between male and female pupils taught using virtual laboratory. It also agrees with the conclusion of Hassan (2010) who found no difference in the performance of male and female students taught using web-based virtual laboratory. Similarly, Aina and Akintunde (2013), Tabassum (2004), Fagbemi (2004), Bello and Abinbola (1997), Gambari and Mogbo (2006) and Orabi (2007) who investigated the effect of one treatment or the other on male and female students' performance reported no significant difference.

However it contradicts the findings of Anagbodu and Exeleliora (2007) who reported that female students performed better than their male counterparts. It also contradicts the findings of Ogunwale (2008) who found that male students perform better than female students. It can be deduced that the use of virtual laboratory and virtual laboratory + physical laboratory enhance the performance of both male and female alike. Therefore the findings of this study corroborate most of the earlier submission by various experts that gender difference did not have any influence on students' performance when taught using virtual laboratory.

### **Findings on the Effects of Treatments on Pupils' Score Levels**

The findings showed that the treatments had no influence on low, medium and high score level pupils. This agrees with the findings of Yusuf (2004) who revealed that scoring ability levels of students did not influence their performance when taught Social Studies using Cooperative Instruction Strategy. Similarly, Adesoji (2008) investigated students' ability levels and effectiveness of problem solving instructional strategy and reported that there was no significant difference in the performance of different ability level after the treatment.

However the finding disagrees with the findings of Gambari (2010) who revealed that students' academic achievement levels had significant difference on their performance in Jigsaw II, STAD and TAI cooperative learning strategy. These significant differences existed among the students in Jigsaw II, STAD, and TAI cooperative learning strategies in favour of high achievers, then medium achievers and low achievers. It also contradicts the findings of Mohammed (2016) who reported that low score level students benefited from virtual laboratory. The finding also disagrees with that of Aluko (2004) who found out that high score level students benefited than others. The difference might be due to difference in age.

### **Findings on Pupils' Attitude towards Physics Aspects of Basic Science and Technology**

The result of the analysis of t-Test Statistics showed no significant difference in the attitudes of pupils when exposed to virtual laboratory. However, the pupils' attitude towards basic science and technology was positive. The findings agree with the findings of Gülsüm and Didem (n.d.), Kelvin and Rod (2012); and Tuysuz (2010) who investigated the impact of the virtual laboratory experiences on attitudes towards physics laboratories. The findings of those studies revealed that the virtual laboratory experiences had positive effects on the students' attitudes.

Similarly, Zacharias (2003) investigated whether the use of computer simulations in a conceptual change learning environment will promote more positive attitude towards physics and the use of computer for instructional purposes. Findings indicated that the use of simulation in a college introductory physics course significantly influenced students' attitudes towards physics. Not only students' attitudes toward physics was positive, students' attitudes toward computer simulations were also positive.

This finding is in line with the findings of Oloruntegbe and Alam (2010) that carried out experimental study on the effect of 3D environments and virtual realities in science teaching and learning. The result showed that the treatment improves learning outcomes in the affective domains such as satisfaction, interest, fun and enjoyment. The result of this might be due to the fact that both the physical and virtual laboratories were exciting to the pupils since they have not been exposed to any of them before.

## **Implications of the findings**

Based on the findings of this study, the following implications could be drawn.

The findings have strong implications for teaching and learning of basic science and technology in primary schools in Nigeria. It is an indication that performance of pupils in basic science and technology would be greatly improved if students are exposed to virtual laboratory.

The application of virtual laboratory instructional package would serve as a motivator, which could encourage pupils to come to class and actively participate during the lesson especially as most physical laboratories are virtually empty.

Virtual laboratory instructional strategies when integrated into Nigerian classrooms would assist to produce better performance of pupils which means that more pupils will enroll for physics when they get to senior schools. The treatment used in this study is not gender biased. Also, all pupils could learn equally irrespective of their score levels. This study has contributed to existing knowledge in the area of strategy that can be used to improve pupils' performance in the physics aspect of science at the primary school level. This aspect of science is a no-go area for most students in the secondary school.

## **Conclusions**

It has been found from this study that knowledge of science concepts and science process skills of basic six pupils have been improved with the use of virtual laboratory irrespective of gender and score levels of the pupils.

### **Recommendations**

Based on the findings of this study, the following recommendations are proffered:

1. Virtual laboratory is gender friendly because it enhances the performance by male and female pupils alike therefore, basic science and technology teachers should employ this strategy to improve their performance in the subject.
2. It is recommended that stakeholders in education should strive to equip physical laboratory for use by pupils especially in rural areas where electricity supply is not constant.
3. The use of virtual laboratory can be improved upon if the federal and state ministry of education and other educational agencies such as National Teachers' Institute (NTI), Nigerian Educational Research and Development Council (NERDC), Non-Governmental Organizations (NGOs) and other education stakeholders organize workshops in the use of virtual laboratory to enhance better performance by primary school pupils.

4. Primary school teachers should be encouraged to be computer literate. This will enable them to appreciate and use virtual laboratory instruction to promote effective teaching and learning.
5. Textbook writers should shift emphasis from teacher-centered to learners-centered such as computer technology one of which is virtual laboratory instructional strategy in the teacher's manual/guide.
6. Computer programmers and developers should develop relevant computer assisted instructional packages for use within the Nigerian school systems.
7. Curriculum developers should embrace and include virtual laboratory instructional strategy that will bring about improvement in learning and developing problem-solving, performance and science process skills in pupils into the curriculum.

### **Suggestions for Further Studies**

Based on the experience gathered during the course of this study, the following are suggested for future research on virtual laboratory.

- a. The scope of the study could be improved.
- b. Chemistry topics in basic science and technology could be worked on using the virtual laboratory.
- c. Primary six pupils were sampled in this research. Junior school students may be sampled in the future research.

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## APPENDIX I

### BASIC SIX CURRICULUM

#### THEME 4: YOU AND ENERGY

| TOPIC                         | PERFORMANCE OBJECTIVES                                                                                                                         | CONTENT                                                                                                                             | ACTIVITIES                                                          |                                                                                                                                                                              | TEACHING AND LEARNING MATERIALS                                                                                                 | EVALUATION GUIDE                                                                                                                                                                  |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                               |                                                                                                                                                |                                                                                                                                     | TEACHER                                                             | PUPILS                                                                                                                                                                       |                                                                                                                                 |                                                                                                                                                                                   |
| Simple machines<br><br>Levers | Pupils should be able to:<br><br>Collect and identify simple machines;<br><br>Identify the parts of a lever;<br><br>List common uses of lever; | Meaning/<br>definition of:<br><br>- Machine<br><br>- lever<br><br>- examples of lever.<br><br>Parts of lever.<br><br>Uses of lever. | Collects examples of levers for pupils to identify, name and group. | Take turns to play with lever, e.g. the see-saw and explain how it works.<br><br>Make and use simple lever.<br><br>Draw the different types of lever and identify the parts. | Bottle opener.<br><br>Can opener.<br><br>Scissors<br><br>Pliers<br><br>Chart/diagram of some common levers.<br><br>Nut cracker. | Pupils to:<br><br>Name five common lever machines in their homes;<br><br>Locate the pivot, load and effort arms in common lever machines;<br><br>State five common uses of levers |

|         |                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                |                                                                                                                                                                                                                                                                                    |                                                                                                                                                                       |                                                                                                                                                      |                                                                                                                                                                                                             |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pulleys | <p>Pupils should be able to:</p> <p>Recognize and identify simple pulley machines;</p> <p>Identify and describe the different uses of pulley machines in everyday life;</p> <p>Distinguish between fixed and movable pulleys;</p> <p>Make and use pulley machines to do work.</p> | <p>Types of pulleys</p> <ul style="list-style-type: none"> <li>- fixed</li> <li>- movable</li> </ul> <p>Examples of pulley machines</p> <p>Common applications of pulleys.</p> | <p>Guides and helps in the collection of simple pulley machines.</p> <p>Guides pupils to identify the application of pulleys.</p> <p>Guides pupils to construct and use pulleys.</p> <p>Takes the class on visits to places where they can observe the application of pulleys.</p> | <p>Collect simple pulley machines. Identify the application of pulleys. Examine and observe pulleys at work. Construct simple pulleys. Use pulleys to lift loads.</p> | <p>Strings.</p> <p>Metal/wooden/plastic rollers.</p> <p>Nails.</p> <p>Wood.</p> <p>Charts showing uses of simple pulleys.</p> <p>Simple pulleys.</p> | <p>Pupils to:</p> <p>Give three examples of simple pulleys;</p> <p>State two applications of pulley machines;</p> <p>Differentiate between fixed and movable pulleys;</p> <p>Construct and use pulleys.</p> |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                 |                                                                                                                                                                                    |                                                                          |                                                                                                                                                                                                             |                                                                                                                                                                                        |                                                                                                                                                     |                                                                                                                                                              |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Inclined planes | <p>Pupils should be able to:</p> <p>State examples of inclined planes;</p> <p>Construct and use inclined planes to lift loads;</p> <p>State the advantages of inclined planes.</p> | <p>Example of inclined planes.</p> <p>Advantages of inclined planes.</p> | <p>Gives examples of inclined planes</p> <p>Arranges for pupils to visit construction sites to observe the use of inclined planes.</p> <p>Leads class discussions on the advantages of inclined planes.</p> | <p>Use planks to make inclined planes.</p> <p>Observe the use of inclined planes at construction sites.</p> <p>Participate in the discussion of the advantages of inclined planes.</p> | <p>Wooden plank.</p> <p>Charts showing inclined planes and staircases.</p> <p>Cement/blocks</p> <p>Drums</p> <p>Nails</p> <p>Saw</p> <p>Hammer.</p> | <p>Pupils to:</p> <p>Identify inclined planes;</p> <p>Construct and use inclined planes to move objects;</p> <p>State two advantages of inclined planes.</p> |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                   |                                                                                                                                                                                               |                                                                                                               |                                                                                                     |                                                                                                                                                                                     |                                                                                                                                                                                             |                                                                                                                               |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Forces            | <p>Pupils should be able to:</p> <p>Explain forces as a push or pull;</p> <p>Give examples of forces-gravity, friction, magnetic, etc;</p> <p>Demonstrate the effect of force on objects.</p> | <p>Meaning of push and pull.</p> <p>Examples of force.</p> <p>Evidence of force.</p> <p>Effects of force.</p> | <p>Shows the effects of force for pupils to observe.</p> <p>Guides pupils to activity on forces</p> | <p>Play with springs, magnets, batteries, rubber bands, etc</p> <p>to demonstrate the existence of force.</p> <p>Describe the effect of force.</p> <p>Push things in the class.</p> | <p>Nails</p> <p>Stones</p> <p>Rough surfaces e.g. wood</p> <p>Smooth surfaces e.g. glass</p> <p>Magnets</p> <p>Batteries</p> <p>Pieces of foam</p> <p>Springs</p> <p>Rubber bands, etc.</p> | <p>Pupils to:</p> <p>Define force:</p> <p>Give three examples of force;</p> <p>Describe the effect of force on materials.</p> |
| 3. Friction Force | <p>Pupils should be able to:</p> <p>Explain friction as the resistance between two surfaces in contact;</p> <p>Mention instances of the application of friction in daily</p>                  | <p>Meaning of friction.</p> <p>Effects of friction.</p> <p>Advantages and disadvantages of friction.</p>      | <p>Guides pupils to demonstrate friction.</p> <p>Shows the effects of friction for pupil to</p>     | <p>Rub the following surfaces together and describe their experience s;</p>                                                                                                         | <p>Palms</p> <p>Stones</p> <p>Pebbles</p> <p>Balls bearings</p> <p>Matchet</p> <p>Knife</p> <p>Floor</p> <p>Water</p> <p>Vaseline</p>                                                       | <p>Pupils to:</p> <p>Define friction;</p> <p>State two instances of the application of friction in daily</p>                  |

|  |                                                                                                  |                    |                                                                                                                                                                          |                                                                                                                                                 |                                            |                                                                          |
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|  | activities;                                                                                      |                    | observe.                                                                                                                                                                 | <ul style="list-style-type: none"> <li>- their palms</li> <li>- a rough surface against a smooth one</li> <li>- two smooth surfaces.</li> </ul> | Sand paper<br>Glass<br>Oil<br>Soapy Water. | activities;<br><br>Mention two advantages and disadvantages of friction; |
|  | 3. State the advantages and disadvantages of friction;<br><br>Suggest ways of reducing friction. | Reducing friction. | Plans and takes the class on visits to places such as metal fabrication workshop etc for pupils to observe friction.<br><br>Guides pupils to put Vaseline on the surface | Describe what happens when:<br>- they rub their palms together<br>- strike two stones together<br>- they strike a sharp edge of a matchet or    |                                            | Suggest three ways of reducing friction.                                 |

|  |  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |  |
|--|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
|  |  |  | <p>of a rough and knife</p> <p>rub it against against a</p> <p>another rough stone.</p> <p>surface to note</p> <p>the effect of Use</p> <p>reducing different</p> <p>friction. lubricants,</p> <p>ball-</p> <p>bearing,</p> <p>rollers to</p> <p>reduce</p> <p>friction.</p> <p>Identify</p> <p>and</p> <p>discuss the</p> <p>effect of</p> <p>friction on</p> <p>the</p> <p>machines</p> <p>and tools</p> <p>found in</p> <p>the</p> <p>workplaces</p> <p>visited.</p> |  |  |
|--|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

|                 |                                                                                                                                                                                                            |                                                                              |                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                          |                                                                                                                                                                                            |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4.<br>Magnetism | <p>Pupils should be able to:</p> <p>State the properties of magnets;</p> <p>Group materials into magnetic and non-magnetic;</p> <p>Name common applications of magnetism;</p> <p>Make and use magnets.</p> | <p>Properties of magnets.</p> <p>Uses of magnets.</p> <p>Making magnets.</p> | <p>Collects different types of magnets.</p> <p>Plans and organizes simple activities to teach pupils about magnetism.</p> <p>Leads class discussions on the uses of magnets in some household appliances e.g. door bell, radio, etc.</p> <p>Guide pupils to make temporary magnets.</p> | <p>Play with magnets to discover their properties e.g. magnets will attract or repel another can act through non-magnetic materials, etc.</p> <p>Examine toys and household appliances for magnets.</p> <p>Group materials as magnetic and non-magnetic.</p> <p>Make temporary magnets.</p> | <p>Bar magnets</p> <p>Nails</p> <p>Pins</p> <p>Iron fillings</p> <p>Paper clips</p> <p>Drawing pins</p> <p>Coins</p> <p>Rubber bands</p> <p>Paper cork</p> <p>Thread</p> <p>Wires</p> <p>Wool</p> <p>Wooden blocks</p> <p>Soft iron.</p> | <p>Pupils to:</p> <p>Identify magnets and state two properties of magnets;</p> <p>Name three common appliances that use magnets;</p> <p>Group materials into magnetic and non-magnetic</p> |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |  |  |  |  |  |                                            |
|--|--|--|--|--|--|--------------------------------------------|
|  |  |  |  |  |  | ;<br><br>Make<br>temporar<br>y<br>magnets. |
|--|--|--|--|--|--|--------------------------------------------|

## APPENDIX II

### BUDGET PROPOSAL

| S/N | DESCRIPTION OF ITEMS                      | EXPECTED FROM |         |        | TOTAL (₦)      |
|-----|-------------------------------------------|---------------|---------|--------|----------------|
|     |                                           | STUDENT       | SPONSOR | OTHERS |                |
| 1.0 | <b>Personnel Cost / Allowances</b>        | Students      |         |        |                |
|     | Research Assistance                       | Students      |         |        | 100,000        |
|     | Technical assistance                      | Students      |         |        | Nil            |
|     | Sub Total (not > 20% of budget)           |               |         |        | <b>100,000</b> |
| 2.0 | <b>Equipment (List and specification)</b> |               |         |        |                |
|     | Laptop                                    | Students      |         |        | 100,000        |
|     | Printers                                  | Students      |         |        | 90,000         |
|     | iPad                                      | Students      |         |        | 40,000         |
|     | Flash / Modem                             | Students      |         |        | 10,000         |
|     | Generator                                 | Students      |         |        | 50,000         |
|     | Sub Total (not > 20% of budget)           |               |         |        | <b>290,000</b> |
| 3.0 | <b>Consumables</b>                        |               |         |        |                |
|     | Papers and Toners                         | Students      |         |        | 120,000        |

|            |                                     |          |                |
|------------|-------------------------------------|----------|----------------|
|            | Fuel and petrol                     | Students | 90,000         |
|            | Data subscription (1500 X 30)       | Students | 45,000         |
|            | Sub Total                           |          | <b>255,000</b> |
| <b>4.0</b> | <b>Data Collection and Analysis</b> |          |                |
|            | Cost of package development         | Students | 100,000        |
|            | Cost of instrument administration   | Students | 80,000         |
|            | Cost of analysis                    | Students | 50,000         |
|            | Sub Total                           |          | <b>230,000</b> |
| <b>5.0</b> | <b>Transportation</b>               |          |                |
|            | Researcher's Trip                   | Students | 200,000        |
|            | Sub Total                           |          | <b>200,000</b> |
| <b>6.0</b> | <b>Presentation</b>                 |          |                |
|            | Seminal 1 (Proposal)                | Students | 50,000         |
|            | Seminal 2 (Small Panel)             | Students | 30,000         |
|            | Seminal 3 (Mock Defence)            | Students | 60,000         |
|            | Seminal 4 (Oral Defence)            |          | 50,000         |
|            | Sub Total                           |          | <b>190,000</b> |

7.0 **Others / Miscellaneous**

|                                |          |                  |
|--------------------------------|----------|------------------|
| Accommodation on research trip | Students | 100,000          |
| Miscellaneous                  | Students | 220,000          |
| Sub Total                      |          | <b>1,485,000</b> |
| Ground Total                   |          |                  |



### APPENDIX III

#### UNIVERSITY OF ILORIN, ILORIN, NIGERIA

#### FACULTY OF EDUCATION, DEPARTMENT OF SCIENCE EDUCATION

#### TEACHER'S INFORMED CONSENT FORM

Dear Teacher,

Please be informed that you are selected to participate in a research as research assistant. Your consent is hereby required to take part in the study. Detailed information about the research is provided below. Kindly endorse this consent form if you volunteer to participate in the study after reading about the research.

**The purpose of the research:** The purpose of the research is to examine the effects of virtual laboratory instructional strategy on basic six pupils' knowledge of science concepts and process skills.

**Procedure:** Pupils would be taught the selected physics concepts of the Basic Science and Technology Curriculum. More so, they would be required to fill the questionnaire and answer the multiple choice test items and the practical questions on their knowledge of science concepts and process skills after the completion of the exercise. The completed test would be returned to the researcher or the research assistant immediately after its completion.

**Confidentiality:** All the information you provide would be treated with utmost confidentiality and for the purpose of the research only.

**Risk:** The test and the questionnaire would be administered in the pupil's regular classroom; hence no risk is envisaged to the pupils during the research.

**Benefits:** The successful outcome of the study could promote the interest and the performance of the pupils in sciences especially physics.

**Right of volunteers** (Teacher participant). Your participation in this research is voluntary; hence your decision not to take part or to stop your participating in this research at any time would not make you lose anything. If you have any question about this research, you may contact the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08077943696.

**Teacher’s respondent agreement:** I hereby voluntarily consent to participate in the research. I know that I may refuse to participate or stop any participation in the research at any time.

Also, I understand that if I have any question about the research, I may contact the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08077943696.

.....

Teacher Participant

.....

Signature and Date

.....

Researcher

.....

Signature and Date



#### APPENDIX IV

### UNIVERSITY OF ILORIN, ILORIN, NIGERIA

### FACULTY OF EDUCATION, DEPARTMENT OF SCIENCE EDUCATION

### PARENTS' INFORMED CONSENT FORM

Dear Parents,

Please be informed that your child is selected to participate in a research study. Your consent is hereby required to allow him/her take part in the study. Detailed information about the research is provided below. Kindly endorse this consent form if you agree that your child should participate in the study after reading about the research.

**The purpose of the research:** The purpose of this research is to examine the effects of virtual laboratory instructional strategy on basic six pupils' knowledge of science concepts and process skills

**Procedure:** Pupils would be taught the selected physics concepts of the Basic Science and Technology curriculum. More so, they would be required to fill the questionnaire and answer the multiple choice test items and practical questions on their conceptual understanding and science process skills after the completion of the exercise. The completed test would be returned to the researcher or the research assistant immediately after its completion.

**Confidentiality:** All the information provided by you would be treated with utmost confidentiality and for the purpose of the research only.

**Risk:** The questionnaire would be administered in the pupil's regular classroom; hence no risk is envisaged to the students during the research.

**Benefits:** The likely benefit to your child is to promote his/her interest and performance in Sciences especially Physics.

**Right of volunteers (Pupils participant):** Your ward's participation in this research questionnaire is voluntary; hence if you decide to stop your child participating in the research at any time, you will not lose anything. If you have any question about this research, you may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08077943696.

**Parent's respondent agreement:** I hereby voluntarily consent to allow my child's participation in the research. I know that I may refuse to allow my child to participate or stop his/her participation in the research at any time.

Also, I understand that if I have any question about the research questionnaire or my right as a parent, I may contact the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08077943696.

.....

Student Participant

.....

Signature and Date

.....

Parent/ Guardian Participant

.....

Signature and Date

.....

Researcher

.....

Signature and Date



## APPENDIX V

### UNIVERSITY OF ILORIN, ILORIN, NIGERIA

#### FACULTY OF EDUCATION, DEPARTMENT OF SCIENCE EDUCATION

#### HEADMASTERS' INFORMED CONSENT FORM

Dear Sir/Ma,

Please be informed that your school is selected to participate in a research study. Your consent is hereby required to allow the school takes part in the study. Detailed information about the research is provided below. Kindly endorse this consent form if you agree that your school should participate in the study after reading about the research.

**The purpose of the research:** The purpose of this research is to examine the effects of virtual laboratory instructional strategy on basic six pupils' knowledge of science concepts and process skills.

**Procedure:** Pupils would be taught the selected physics concepts of the Basic Science and Technology curriculum. More so, they would be required to fill the questionnaire and answer the multiple choice test items and practical questions on their conceptual understanding and Science process skills after the completion of the exercise. The completed test would be returned to the researcher or the research assistant immediately after its completion.

**Confidentiality:** All the information provided by you would be treated with utmost confidentiality and for the purpose of the research only.

**Risk:** The questionnaire would be administered in the pupil's regular classroom; hence no risk is envisaged to the pupils during the period.

**Benefits:** The likely benefit to your child is to promote their interest and academic performance in Sciences especially Physics.

**Right of volunteers (Pupils participant):** Your pupils' participation in this research is voluntary; hence if you decide to stop your pupils' participation in the research at any time, you will not lose anything. If you have any question about this research, you may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08077943696.

**Headmaster Respondent Agreement:** I hereby voluntarily consent to allow my pupils' participation in the research. I know that I may refuse to participate or stop any participation in the research at any time.

Also, I understand that if I have any question about the research or my right as a headmaster, I may contact the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08077943696.

.....

Headmaster Participant

.....

Signature and Date

.....

Researcher

.....

Signature and Date



## **APPENDIX VI**

### **TEACHING MODULE USING CONVENTIONAL METHOD**

#### **THEME 4: YOU AND ENERGY**

##### **WEEK ONE**

Name: AKINTUNDE Zacchaeus Taiwo

Matric No: 08/68SC003

School:

Class: Basic Six

Subject: Basic Science and Technology

Topic: Simple Machines

Sub Topics: Levers, pulleys and inclined plane

Date:

Duration: 50 minutes

Period of Lesson:

Average Age of Pupils: 10years

Teaching and Learning Materials: Bottle Opener, scissors, pliers, chart/diagram of some common lever, charts showing inclined planes and staircases.

Objectives: At the end of the lesson, the pupils should be able to:

- (i) Collect and identify simple machines,
- (ii) Identify the parts of a lever,
- (iii) List common uses of lever
- (iv) Identify simple pulley machines and inclined planes
- (v) Distinguish between fixed and movable pulleys
- (vi) Use inclined planes to lift loads;

(vii) State the advantages of inclined planes

**Previous Knowledge:** The pupils are familiar with some of these simple machines in day-to-day activities but might not be able to identify and classify them as simple machines.

**Introduction (5minutes):** The teacher introduces the lesson by asking the pupils the following questions.

**What is machine?**

**Give examples of machine that you know**

**Presentation/Lesson Development (35minutes)**

**Step 1:** having known the status of the pupils, based on their responses to the questions asked the teacher directs the students thinking towards the correct conception of simple machines.

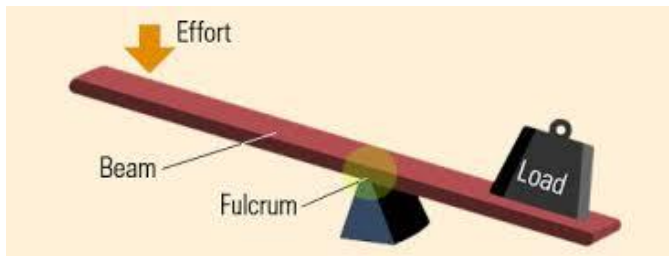
**A machine is a tool or device which makes our work easier to do.** Many objects in your classroom and in your home such as a pair of scissors, bottle opener and cutlass are examples of simple machines. In science, any means which helps us to use less energy to do much work or to overcome a large force is called a machine. Machine can be grouped into two:

**(i) Simple machine:** Examples are pair of scissors, bottle opener, cutlass, sea-saw, wheelbarrow etc.

**(ii) Complex machine:** Examples are motorcycle, bulldozer, washing machines, crane etc.

There are six types of simple machine which are: lever, pulleys, inclined plane, screw, wedge and wheel but we shall consider three types which are: (i) Lever (ii) Pulleys (iii) inclined plane

**(I) Lever:** A lever is a simple machine that makes work easier for use. It consists of a beam or rigid rod pivoted at a fixed hinge or fulcrum. Many of our basic tools use levers.



### There are three classes of lever

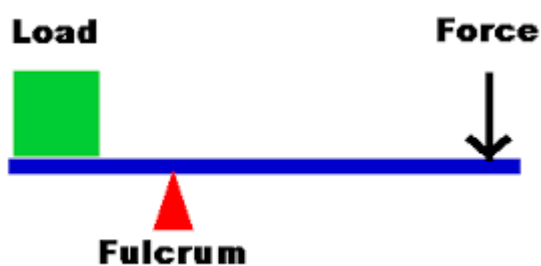
- (i) Class one
- (ii) Class two
- (iii) Class three

A lever has three important parts namely: load (L), Pivot or fulcrum (F) and effort (E)

The arrangement of these parts determines the class to which a lever belongs.

The work to be done is called LOAD (L). The energy used to carry out work on the load is called efforts (F) while the point about which motion occurs is called Pivot or FULCRUM (F)

- (a) **Class one lever** or **First class lever**. In this type of lever, the pivot is between the effort and load.

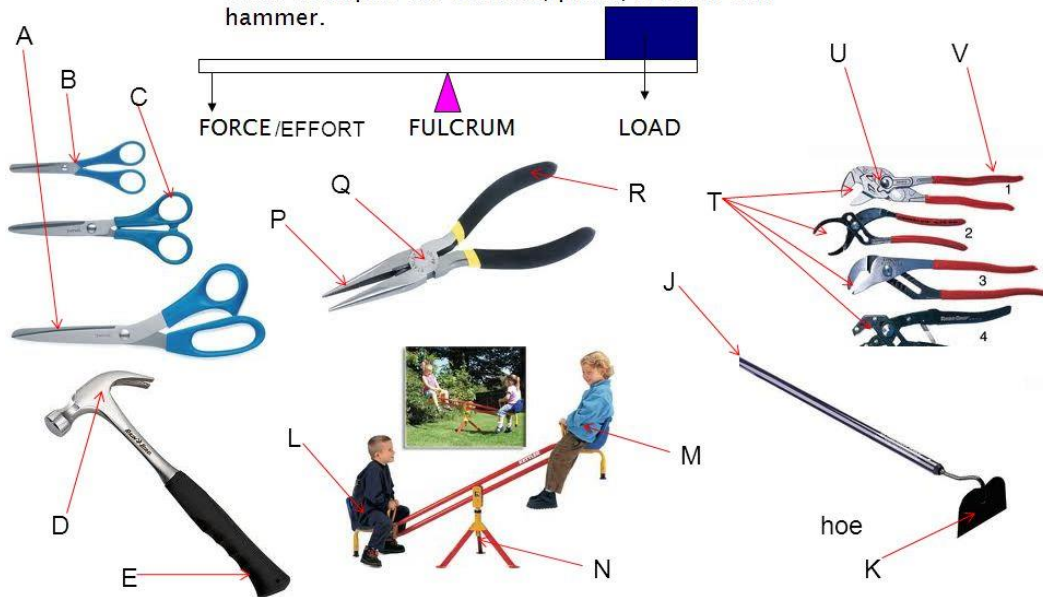


Examples are, pair of pliers, pair of scissor, sea-saw, crowbar and hammer as shown below..

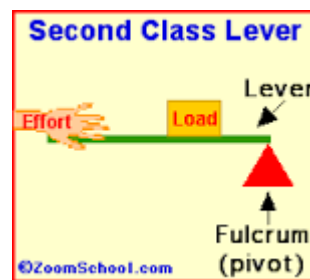
# First class lever

reason → The fulcrum is between the force (Effort) and the load

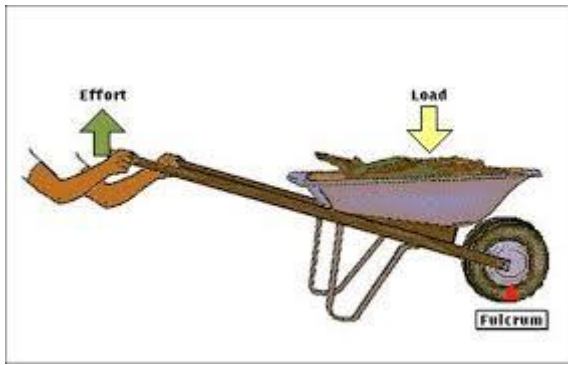
Some examples are scissors, pliers, crowbar and hammer.



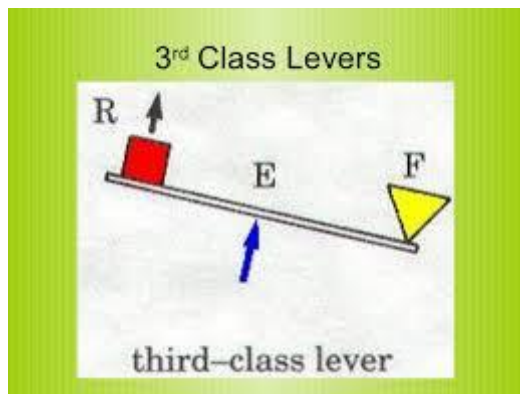
- (b) **Class two lever or second class lever.** In this type of lever, the load is between the pivot (fulcrum) and the effort



Examples are: stapler, bottle cap, opener, wheel barrow, cart, hammer, claw, nut cracker



(c) **Class three lever or third class lever.** In this type of lever, the effort is between the pivot (fulcrum) and the load



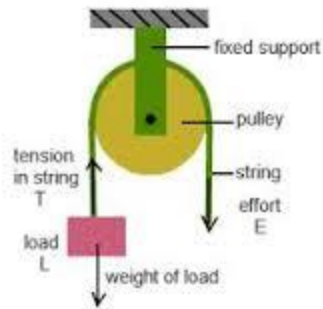
(d)

Examples are: fishing rod, sugar tong, human fore arm,



**Step 2:** The teacher explains pulley machines

A pulley is a wheel that has a smooth groove on its rim, with a rope passing through the groove.



### Types of pulleys

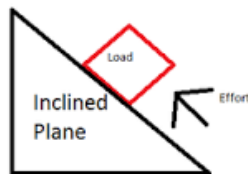
- (i) A single fixed pulley
- (ii) A movable pulley

### Applications of Pulley

- (i) Pulley are used to draw water from the well
- (ii) Towing van makes use of pulley to pull a vehicle
- (iii) Crane makes use of pulley to lift heavy loads.
- (iv) A grinder makes use of pulley

**Step 3:** The teacher explains the inclined plane

**Inclined plane:** An inclined plane is a sloping surface used to roll up or roll down load.



A heavy load is raised or moved more easily by pulling or rolling it along a sloping surface than by lifting it vertically. The longer the plank (inclined plane), the easier the work.



Applications of inclined plane

- (i) Loading barrels of oil or other heavy loads into a vehicle
- (ii) Offloading loads from a vehicle

**Step 5: Evaluation:** To determine whether or not, the performance objectives are achieved the teacher assesses the pupils by asking the following questions:

- (i) What is a machine?
- (ii) State three classes of a lever with one example each
- (iii) Mention two types of pulley
- (iv) What is an inclined plane used for?

**Assignment:** The teacher gives the following assignment to the pupils:

- (i) Construct and use inclined planes to move objects
- (ii) State two advantages of inclined plane
- (iii) Differentiate between fixed and movable pulleys
- (iv) Name five common lever machines in your home

**References:**

- Olumuyiwa, A.; & Okunola, O. O. (1998). *Comprehensive Certificate Physics for secondary schools*.
- Ogunniyi, M. B., Uzo, O., Okebukola, P. A. O. & Isa, M. (2009). *Macmillan Primary Science*.  
*Macmillan Nigeria Publisher Limited*.
- Olagunju, P. A., & Obi, B. N. (2010). *Extension Modern Basic Science and Technology*. Extension  
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- Ugo, C. U. (2009). *National Vocational Aptitude Tests for Primary Schools*. Ugo C.Ugo Publishing  
Company Limited.

Tunde, B., & Anthony, Y. (2013). *Basic Science and Technology for Nigerian Schools*. FGN/UBE, HEBN Publishers Plc.

## APPENDIX VII

### TEACHING MODULE USING CONVENTIONAL METHOD

#### THEME 4: YOU AND ENERGY

##### WEEK TWO Lesson Note

Name: Akintunde Zacchaeus Taiwo

Matric No: 08/68SC003

School:

Class: Basic Six

Subject: Basic Science and Technology

Topic: Forces/ Frictional Force

Date:

Duration: 50 minutes

Period of Lesson:

Average Age of Pupils: 10years

**Teaching and Learning Materials:** : Stones, springs, magnets, batteries, rubber band, palms, balls bearings, knife, floor, water, Vaseline, sand paper

- (i) **Objectives:** At the end of the lesson pupils should be able to:
- (ii) explain forces as a push or pull,
- (iii) give examples of forces – gravity, friction, magnetic etc.,
- (iv) demonstrate the effect of force on objects,
- (v) explain friction,
- (vi) mention two advantages and disadvantages of friction,
- (vii) state two ways of reducing friction

**Previous Knowledge:** The pupils are familiar with energy which produces force

**Introduction:** (5minutes): The teacher introduces the lesson by asking the pupils to pull their desk. The pull on the desk that produces motion is called force.

**Presentation:** Lesson development (35 minutes)

**Step 1:** The teacher explains what a force is and types of forces

A force is a pull or push exerted on an object which causes it to move.

### **Types of forces**

There are many types of forces but we shall discuss four of them.

(i) Muscular force: is that force which is produced by our muscles. When you lift an object, the muscles of your hands exert a force on the object and it moves up.

(ii) Gravitational force: if you release an object held some meters above ground level, it falls back to the ground. The force which pulls the object to the earth surface (ground) is called gravitational force.

(iii) Magnetic force: is a force that magnet uses to pull (attract) magnetic materials.

(iv) Electric force: this is the force experienced when two charged bodies are brought close to each other.

**Step 2:** The teacher explains the effects and classification of forces

### **Effects of forces**

(i) Carrying a bucket of water with your hand produces muscular force.

(ii) A mango fruit that drops from the tree reaches the ground by force of gravity

(iii) Two small batteries in a touch light glows the bulb by electric force

(iv) A nail put near a bar magnet is attracted to the magnet by magnetic force

## **Classification of forces**

Forces can be classified into two:

(i) Contact force

(ii) Field force or non contact force

(i) Contact force; This is the force produced when two bodies are in contact with each other e.g frictional force, spring force, pulling, pushing, a cart being pulled by the horse etc.

(ii) Field force: this is the force produced between objects that are not in contact e.g gravitational force, electrical force and magnetic force.

**Step 3:** The teacher asks the pupils to rub their palms together. What do you observe? Using the pupil's activities of rubbing their palms together, the teacher explains frictional force and its effects

**Frictional force** Friction is a force which tends to slow down or stop the motion of any two surfaces in contact.

## **Effects of friction**

(i) rubbing palms friction

(ii) scratching of matches

(iii) rubbing tin against a stone

(iv) riding a bicycle

(v) walking with a pair of shoe

(vi) rubbing a file against the edge of a matchet or knife

**Step 4:** The teacher explains the advantages and disadvantages of friction and how to reduce friction

## **Advantages of friction**

(i) Friction helps us to walk properly

- (ii) Friction helps us to stop a moving vehicle or engine at will
- (iii) It can be used to generate heat and light
- (iv) Friction helps us to climb a tree or hill

### **Disadvantages of friction**

- (i) Friction wears off rubbing surfaces e.g shoes, tyre etc.
- (ii) It causes waste of energy
- (iii) It can generate heat and cause fire outbreak

### **How to reduce friction**

**Activity 1:** Attach a spring balance to a small plank and pull across the following surfaces as shown in fig F, fig K and Fig L

- (i) Rough table
- (ii) Smooth table
- (iii) Oily table



Fig. F: Rough table



Fig. K: Smooth table

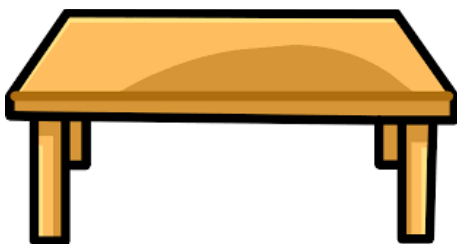


Fig. L: Oily table

Measure the force of friction on the spring balance and record

| Surface      | Reading |
|--------------|---------|
| Rough table  |         |
| Smooth table |         |
| Oily table   |         |

Which of the surfaces has the largest and the least frictional force?

**Conclusion:** Friction can be reduced through:

- (i) the use of oil or grease (lubricant)
- (ii) rollers,
- (iii) wheel and ball bearing

**Step 5: Evaluation:** To determine whether or not the performance objectives are achieved, the teacher assesses the pupils by asking the following questions.

- (i) What is friction?
- (ii) Mention two effects of frictional force
- (iii) Mention three uses of friction

**Assignment:** The teacher gives the following assignments to the pupils.

- (i) Mention three ways of reducing friction in a machine
- (i) State two advantages and two disadvantages of friction Describe the effect of force on materials
- (ii) Mention the two classifications of force and give three examples each

## References:

- Olumuyiwa, A.; & Okunola, O. O. (1998). *Comprehensive Certificate Physics for secondary schools*.
- Ogunniyi, M. B., Uzo, O., Okebukola, P. A. O. & Isa, M. (2009). *Macmillan Primary Science*.  
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- Olagunju, P. A., & Obi, B. N. (2010). *Extension Modern Basic Science and Technology*. Extension  
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- Ugo, C. U. (2009). *National Vocational Aptitude Tests for Primary Schools*. Ugo C.Ugo Publishing  
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- Tunde, B., & Anthony, Y. (2013). *Basic Science and Technology for Nigerian Schools*. FGN/UBE,  
HEBN Publishers Plc.

## APPENDIX VIII

### TEACHING MODULE USING CONVENTIONAL METHOD

#### THEME 4: YOU AND ENERGY

WEEK THREE      Lesson Note

Name:              AKINTUNDE Zacchaeus Taiwo

Matric No:        08/68SC003

School:

Class:              Basic Six

Subject:           Basic Science and Technology

Topic:              Magnetism

Date:

Duration:          50 minutes

Period of Lesson:

Average Age of Pupils: 10years

**Teaching and Learning Materials;** bar magnets, nails, pins, iron filling, drawing pins, rubber band coins, paper, cork, thread, wires, wools, wooden blocks, soft iron.

**Objectives:** At the end of the lesson pupils should be able to:

- (i)      state the properties of magnets
- (ii)    group materials into magnetic and non magnetic
- (iii)   make and use magnets

**Previous Knowledge:** The pupils are familiar with magnetic force

**Introduction: (5 minutes):** the teacher presents two similar objects a magnet and a metal rod to pupils while he asks them to move each near a pin. Which one is a magnet? and why? He further asks.

**Presentation/ Lesson Development (35 minutes)**

**Step 1:** The teacher explains what a magnet is and its properties

A magnet is a substance which can attract iron or steel materials to itself.

Magnets have a force which attracts objects to them. This force is called magnetic force. Where a magnet will be used determines its shape. A magnet may have the shape of:

(i) a ring

(ii) a horse shoe

(iii) a bar

(iv) a cylindrical rod

### **Uses of magnets**

1. Magnets can be used in industries for lifting heavy metallic loads
2. Magnets are used in the construction of different household electrical appliances. e.g. radio, electric bell, T.V set, electric generator, telephone receiver etc.
3. Magnets are used for making microphones and loudspeakers
4. Magnets is used for making compass (pocket and ship compass)

**Step 5:** Evaluation: to determine whether or not the performance objectives are achieved, the teacher assesses the pupils by asking the following questions

- (i) What is a magnet?
- (ii) Differentiate between magnetic and non magnetic materials with two examples each.
- (iii) Give four applications of magnets

**Assignment:** The teacher gives the following assignments to the pupils

- (i) Describe three ways of making magnets
- (ii) List five magnetic materials and five non-magnetic materials

**References:**

Olumuyiwa, A.; & Okunola, O. O. (1998). *Comprehensive Certificate Physics for secondary schools*.

Ogunniyi, M. B., Uzo, O., O Kebukola, P. A. O. & Isa, M. (2009). *Macmillan Primary Science*.  
*Macmillan Nigeria Publisher Limited*.

Olagunju, P. A., & Obi, B. N. (2010). *Extension Modern Basic Science and Technology*. Extension  
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Tunde, B., & Anthony, Y. (2013). *Basic Science and Technology for Nigerian Schools*. FGN/UBE,  
HEBN Publishers Plc.

## APPENDIX IX

### BASIC SCIENCE ACHEIVEMENT TEST (BSAT) ITEMS ON SIMPLE MACHINES, FORCES AND MAGNETISM

#### PRE- TEST AND POST –TEST

##### PRE-TEST

##### SECTION A

Demographic data of pupils

Name of school:.....

Class:.....

Gender:..... Age: .....

Private: ( ) Public: ( ) Duration: 1hr 30 minutes

Duration: 1hr 30 minutes

##### SECTION B

This section is divided into two parts: part 1 consists of twenty (20) multiple-choice questions and part II consists of 44 short-answer questions.

Part 1: Multiple-choice questions

**Instruction:** Read carefully and choose the answer you consider most appropriate in the options lettered A-D.

1. A machine is defined as anything that can be used to -----

(A) Sow clothes easier and faster

(B) Cut trees easier and faster

(C) Make work easier and faster

(D) Travel with

2. We cannot see machine in which of the following places?

(A) Homes

(B) Schools

(C) Offices

(D) Road

3. Which of the following items is not a simple machine?

(A) Sea saw

(B) Book

(C) Broom

(D) Knife

4. The part of the human body that serves as a lever is the -----

(A) Head

(B) Teeth

(C) Arm

(D) Nose

5. There are ----- classes of lever

(A) 1

(B) 2

(C) 3

(D) 4

6. A simple machine has ----- basic parts

(A) 4

(B) 3

(C) 2

(D) 1

7. In which of the classes of lever does the fulcrum lie between the load and the effort?

(A) 1<sup>st</sup>

(B) 2<sup>nd</sup>

(C) 3<sup>rd</sup>

(D) 4<sup>th</sup>

8. An inclined plane can be described as a ----- surface

(A) Flat

(B) Rigid

(C) Stopping

(D) Slopping

9. If you roll a ball on the ground it starts to move after sometime it stops. What makes it to stop?

(A) Lever

(B) Machine

(C) Gravity

(D) Friction

10. When two objects are in contact and they do not allow movement against each other, it can be prevented by -----

(A) Separating the objects

(B) Heating the object

(C) Using force on them

(D) Applying oil between them

11. Which of the following surfaces reduces friction?

(A) Smooth

(B) Rough

(C) Flat

(D) Plane

12. The major disadvantage of friction is that it-----

- (A) Increases efficiency
- (B) Reduces efficiency
- (C) Reduces force
- (D) Makes work to be done easily

13. A substance that can attract magnetic material is called -----

- (A) Magnetic
- (B) Plastic
- (C) Magnet
- (D) Iron

14. Which of the items listed below is magnetic?

- (A) Nail
- (B) Knife
- (C) Aluminum
- (D) Copper wire

15. Temporary magnets are made from

- (A) Iron
- (B) Plastic

(C) Bar

(D) Stone

16. A type of simple machine having groove on its edge to allow the movement of rope within the edge is referred to as -----

(A) Pulley

(B) Lever

(C) Wheel

(D) Inclined plane

17. A tool or device which makes work easier, faster and convenient is known as

(A) Pivot

(B) Task

(C) Lever

(D) Machine

18. What determines the class to which a lever belongs?

(A) The strength of the effort

(B) The arrangement of the lever part

(C) The arrangement of the load

(D) The strength of the pivot

19. A force of magnet is called .....

- (A) Field force
- (B) Gravitational force
- (C) Magnetic force
- (D) Frictional force

20. Which of the following items is not a magnetic material?

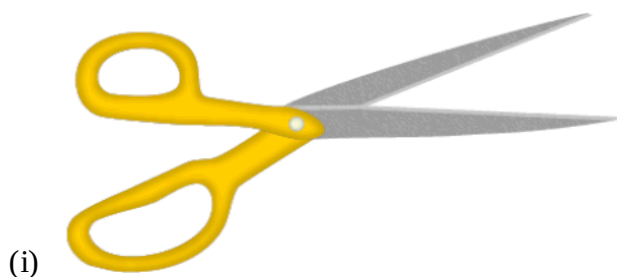
- (A) Nail
- (B) Plastic
- (C) Iron fillings
- (D) Metal

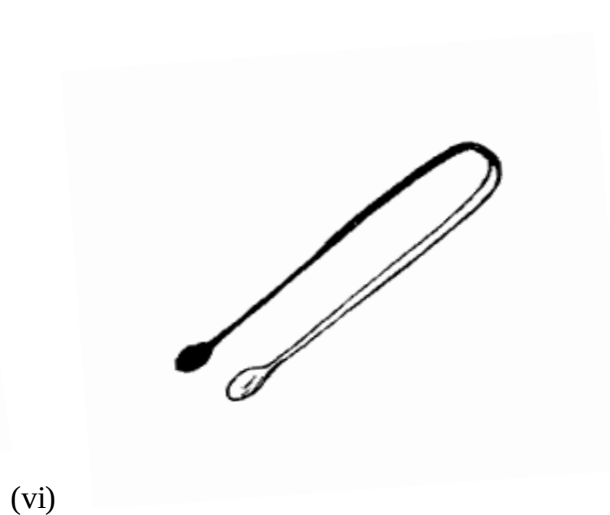
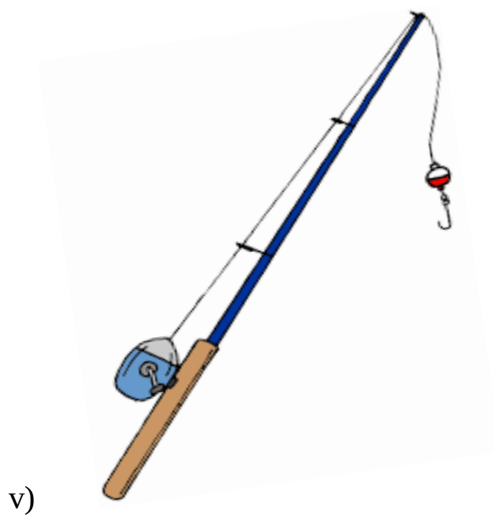
## PART II: PRACTICAL QUESTIONS

**Instruction:** Answer all questions

(1) **Aim:** Identification and classification of levers

**Procedure:** The teacher provides pupils with different types of lever.





Answer the following questions

- (1) Name the type of levers (i—vi) provided
- (2) Identify the parts of each of the levers and fill in the table below

|             | Fulcrum | Effort | Load |
|-------------|---------|--------|------|
| Lever (i)   |         |        |      |
| Lever (ii)  |         |        |      |
| Lever (iii) |         |        |      |
| Lever (iv)  |         |        |      |
| Lever (v)   |         |        |      |
| Lever (vi)  |         |        |      |

(3) Group the levers into their various classes

| Class1 lever | Class 2 lever | Class 3 lever |
|--------------|---------------|---------------|
|              |               |               |

2. **Aim:** To discover ways of reducing friction

The teacher provides three types of surfaces labeled A, B and C as rough, smooth and oily surfaces respectively.

Procedure: Attach a spring balance to the plank and pull it across different surfaces:

(i) Identify the types of surfaces provided, such as:

Rough surface, smooth surface, and oily surface

(ii) Read the value of frictional force in each case on the spring balance

(iii) Record the value of frictional force in each case as in the table below

| Surface        | Reading |
|----------------|---------|
| Rough surface  |         |
| Smooth surface |         |
| Oily surface   |         |

(iv) Which of the surfaces has the highest value of frictional force?

(v) What can you suggest as reason for the highest value of friction on this surface?

(vi) Which of the surfaces has the least value of frictional force?

(vii) What can you suggest as reason for the least value of friction on this surface?

(3) **Aim:** to discover the properties of magnets

Activity: You are provided with objects (Specimens) A, B, C, D and E, the teacher labels the objects as follows (without the prior knowledge of the pupils)

A is magnet

B is nail

C piece of paper

D is copper wire

E is iron fillings

Take object A and move it near objects B, C, D and E,

Answer the following questions

- (i) What do you observe as you move object A near object B?
- (ii) What types of material do you suggest object B to be?
- (iii) What do you observe as you move object A near object C
- (iv) What types of material do you suggest object C to be?
- (v) What do you observe as you move object A near
- (vi) What types of material do you suggest object D to be?
- (vii) What do you observe as you move object A near object E
- (viii) What type of material do you suggest object E to be?

(ix) What do you suggest object A to be?

Record your observation in each case as shown below:

Group each observation as attracted and not attracted as in the table below

| Object | Attracted | Not attracted |
|--------|-----------|---------------|
| B      |           |               |
| C      |           |               |
| D      |           |               |
| E      |           |               |

**BASIC SCIENCE ACHEIVEMENT TEST (BSAT) ITEMS ON SIMPLE MACHINES,  
FORCES AND MAGNETISM**

**PRE- TEST AND POST –TEST**

**POST-TEST:** To reduce the retest effect, the questions were reshuffled and administered in a different random order in the post-test.

**SECTION A**

Demographic data of pupils

Name of school:.....

Class:.....

Gender:..... Age: .....

Private: ( ) Public: ( )      Duration:      1hr 30 minutes

Duration:      1hr 30 minutes

**SECTION B**

This section is divided into two parts: part 1 consists of twenty (20) multiple-choice questions and part II consists of 44 short-answer questions.

Part 1: Multiple-choice questions

**Instruction:** Read carefully and choose the answer you consider most appropriate in the options lettered A-D.

1. A force of magnet is called .....

(A) Field force

(B) Gravitational force

(C) Magnetic force

(D) Frictional force

2. Which of the following items is not a simple machine?

(A) Sea saw

(B) Book

(C) Broom

(D) Knife

3. Temporary magnets are made from

(A) Iron

(B) Plastic

(C) Bar

(D) Stone

4. In which of the classes of lever does the fulcrum lie between the load and the effort?

(A) 1<sup>st</sup>

(B) 2<sup>nd</sup>

(C) 3<sup>rd</sup>

(D) 4<sup>th</sup>

5. Which of the following surfaces reduces friction?

(A) Smooth

(B) Rough

6. A machine is defined as anything that can be used to -----

(A) Sow clothes easier and faster

(B) Cut trees easier and faster

(C) Make work easier and faster

(D) Travel with

7. A tool or device which makes work easier, faster and convenient is known as

(A) Pivot

(B) Task

(C) Lever

(D) Machine

8. There are ----- classes of lever

(A) 1

(B) 2

(C) 3

(D) 4

9. A substance that can attract magnetic material is called -----

(A) Magnetic

(B) Plastic

(C) Magnet

(D) Iron

10. If you roll a ball on the ground it starts to move after sometime it stops. What makes it to stop?

(A) Lever

(B) Machine

(C) Gravity

(D) Friction

11. We cannot see machine in which of the following places?

(A) Homes

(B) Schools

(C) Offices

(D) Road

12. What determines the class to which a lever belongs?

(A) The strength of the effort

(B) The arrangement of the lever part

(C) The arrangement of the load

(D) The strength of the pivot

13. A simple machine has ----- basic parts

(A) 4

(B) 3

(C) 2

(D) 1

14. When two objects are in contact and they do not allow movement against each other, it can be prevented by -----

(A) Separating the objects

(B) Heating the object

(C) Using force on them

14. Which of the items listed below is magnetic?

(A) Nail

(B) Knife

(C) Aluminum

(D) Copper wire

16. Which of the following items is not a magnetic material?

(A) Nail

(B) Plastic

(C) Iron fillings

(D) Metal

17. The part of the human body that serves as a lever is the -----

(A) Head

(B) Teeth

(C) Arm

(D) Nose

18. A type of simple machine having groove on its edge to allow the movement of rope within the edge is referred to as -----

(A) Pulley

(B) Lever

(C) Wheel

(D) Inclined plane

19. An inclined plane can be described as a ----- surface

(A) Flat

(B) Rigid

(C) Stopping

(D) Slopping

20. The major disadvantage of friction is that it-----

- (A) Increases efficiency
- (B) Reduces efficiency
- (C) Reduces force
- (D) Makes work to be done easily

## **PART II: PRACTICAL QUESTIONS**

**Instruction:** Answer all questions

(1) **Aim:** to discover the properties of magnets

Activity: You are provided with objects (Specimens) A, B, C, D and E, the teacher labels the objects as follows (without the prior knowledge of the pupils)

A is magnet

B is nail

C piece of paper

D is copper wire

E is iron fillings

Take object A and move it near objects B, C, D and E,

Answer the following questions

- (x) What do you observe as you move object A near object B?
- (xi) What types of material do you suggest object B to be?

- (xii) What do you observe as you move object A near object C
- (xiii) What types of material do you suggest object C to be?
- (xiv) What do you observe as you move object A near
- (xv) What types of material do you suggest object D to be?
- (xvi) What do you observe as you move object A near object E
- (xvii) What type of material do you suggest object E to be?
- (xviii) What do you suggest object A to be?

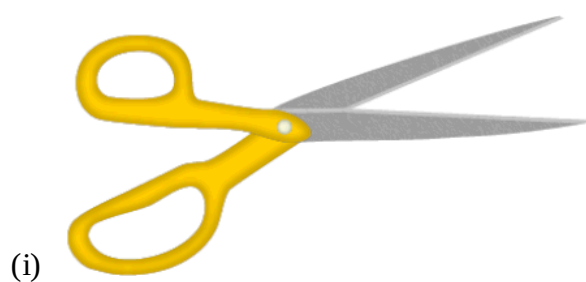
Record your observation in each case as shown below:

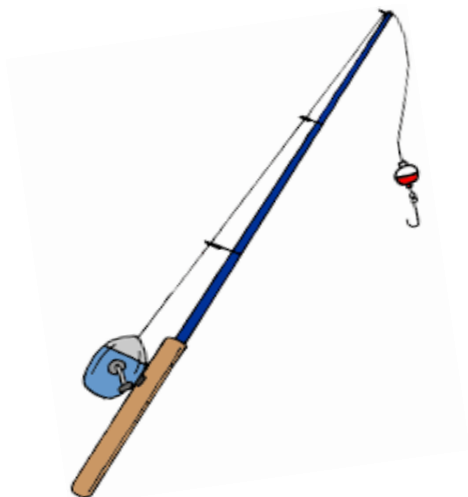
Group each observation as attracted and not attracted as in the table below

| Object | Attracted | Not attracted |
|--------|-----------|---------------|
| B      |           |               |
| C      |           |               |
| D      |           |               |
| E      |           |               |

(2) **Aim:** Identification and classification of levers

Procedure: The teacher provides pupils with different types of lever.





Answer the following questions

- (4) Name the type of levers (i—vi) provided
- (5) Identify the parts of each of the levers and fill in the table below

|             | Fulcrum | Effort | Load |
|-------------|---------|--------|------|
| Lever (i)   |         |        |      |
| Lever (ii)  |         |        |      |
| Lever (iii) |         |        |      |
| Lever (iv)  |         |        |      |
| Lever (v)   |         |        |      |
| Lever (vi)  |         |        |      |

- (6) Group the levers into their various classes

| Class1 lever | Class 2 lever | Class 3 lever |
|--------------|---------------|---------------|
|              |               |               |

3. **Aim:** To discover ways of reducing friction

The teacher provides three types of surfaces labeled A, B and C as rough, smooth and oily surfaces respectively.

Procedure: Attach a spring balance to the plank and pull it across different surfaces:

- (i) Identify the types of surfaces provided, such as:

Rough surface, smooth surface, and oily surface

- (ii) Read the value of frictional force in each case on the spring balance

- (iii) Record the value of frictional force in each case as in the table below

| Surface        | Reading |
|----------------|---------|
| Rough surface  |         |
| Smooth surface |         |
| Oily surface   |         |

- (iv) Which of the surfaces has the highest value of frictional force?

(v) What can you suggest as reason for the highest value of friction on this surface?

(vi) Which of the surfaces has the least value of frictional force?

(vii) What can you suggest as reason for the least value of friction on this surface?

## APPENDIX X

### DEPARTMENT OF SCIENCE EDUCATION

### FACULTY OF EDUCATION

### UNIVERSITY OF ILORIN, NIGERIA

Questionnaire on the effects of virtual laboratory package on pupils' attitude towards Basic Science and Technology. (BSVLAQ)

Dear pupils,

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

#### SECTION A: BIO DATA

Name of School .....

Gender: Male ( )      Female ( )      Age: .....

#### SECTION B

Instruction: Read carefully and indicate with a tick(✓) the most appropriate to you from the responses.

| S/N | Statement                                                                                                             | YES | NOT SURE | NO |
|-----|-----------------------------------------------------------------------------------------------------------------------|-----|----------|----|
|     | I enjoy learning basic science and technology through virtual laboratory.                                             |     |          |    |
|     | I will suggest to my friends to use virtual laboratory in learning basic science and technology instead of textbooks. |     |          |    |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |  |  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|  | <p>I understand the lesson better with virtual laboratory.</p> <p>The virtual laboratory is not boring to me.</p> <p>I can see the pictures in the virtual laboratory well.</p> <p>Instructions in the virtual laboratory package are simple to understand</p> <p>I pay more attention to the lessons through virtual laboratory than normal teaching in the class room.</p> <p>The virtual laboratory is so interesting to me.</p> <p>I easily remember the lessons taught through virtual laboratory.</p> <p>I want my teacher to be using virtual laboratory to teach us.</p> |  |  |  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|

## APPENDIX XI

### EXAMPLES OF KNOWLEDGE OF SCIENCE CONCEPTS AND SCIENCE PROCESS SKILLS TEST ITEMS IN THE AREA OF SIMPLE MACHINES, FORCES AND MAGNETISM

#### PART I: MULTIPLE CHOICE QUESTION (MCQ) ON KNOWLEDGE OF SCIENCE CONCEPTS

| Examples of question                                                                                         | Pupils ability to: | level         |
|--------------------------------------------------------------------------------------------------------------|--------------------|---------------|
| 1.A machine is defined as anything used to-----                                                              | Define             | knowledge     |
| 2. Which of the following places can we see machine?                                                         | Apply              | application   |
| 3. Which is not a simple machine?                                                                            | Identify           | knowledge     |
| 4. The part of human body that serves as lever is the .....                                                  | Apply              | application   |
| 5.There are ----- classes of lever                                                                           | Mention            | knowledge     |
| 6.A simple machine has ----- basic parts                                                                     | Mention            | knowledge     |
| 7. In which of the classes of lever does the fulcrum lie between the load and the effort?                    | differentiate      | Analysis      |
| 8.An inclined plane can be described as a ----- surface                                                      | Describe           | Comprehension |
| 9. If you roll a ball on the ground it starts to move after sometime it stops. What makes it to stop?        | Apply              | application   |
| 10.When two objects are in contact and they do not allow movement against each other, it can be prevented by |                    | application   |
| 11.Which of the following surfaces reduces friction                                                          | distinguish        | Analysis      |
| 12.The major disadvantages of friction is that it----                                                        | Explain            | Comprehension |
| 13.A substance that can attract magnetic substance is called                                                 | recall             | knowledge     |
| 14. Which of the item(s) listed below is/are magnetic?                                                       | distinguish        | Analysis      |
| 15.Temporary magnets are made from                                                                           | recall             | knowledge     |

|                                                                                                                             |               |           |
|-----------------------------------------------------------------------------------------------------------------------------|---------------|-----------|
| 16. A type of simple machine having groove on its edge to allow the movement of rope within the edge is referred to as..... | Recall        | knowledge |
| 17.A tool or device which make work easier, faster and convenient is known as                                               | Define        | knowledge |
| 18. What determines the class to which a lever belongs?                                                                     | differentiate | Analysis  |
| 19. A force of magnet is called .....                                                                                       | Define        | knowledge |
| 20.Which of the following items is not a magnetic material                                                                  | differentiate | Analysis  |

## PART II: PRACTICAL QUESTIONS ON SCIENCE PROCESS SKILLS

| Examples of question                                                        | Pupils ability to: | Skills         |
|-----------------------------------------------------------------------------|--------------------|----------------|
| 1.Name the type of levers provided                                          | Communicate        | Communication  |
| 2.Identify the parts of levers provided                                     | Observe            | Observation    |
| 3.Group the levers into their various classes                               | Group              | Classification |
| 4.Identify the types of surfaces provided                                   | Observe            | Observation    |
| 5.Read the value of frictional force in each case                           | Measure            | Measurement    |
| 6.Record the value of frictional force in each case                         | Record             | Communication  |
| 7. Which of the surfaces has the highest value of frictional force?         | Sort object        | Classification |
| 8. What can you suggest as reason for the highest friction on this surface? |                    | Inference      |
| 9. Which of the surfaces has the least value of frictional force?           | Sort object        | Classification |
| 10. What can you suggest as reason for the least friction on this surface?  |                    | Inference      |
| 11. What do you observe as you move object A near object B?                 | Observe            | Observation    |
| 12. What types of material do you suggest object B to be?                   | Infer              | Inference      |
| 13. What do you observe as you move object A near object C?                 | Observe            | Observation    |
| 14. What types of material do you suggest object C to be?                   | Infer              | Inference      |

|                                                             |          |                |
|-------------------------------------------------------------|----------|----------------|
| 15. What do you observe as you move object A near object D? | Observe  | Observation    |
| 16. What types of material do you suggest object D to be?   | Infer    | Inference      |
| 17. What do you observe as you move object A near object E? | Observe  | Observation    |
| 18. What types of material do you suggest object E to be?   | Infer    | Inference      |
| 19. What do you guess object A to be                        | Infer    | Inference      |
| 20. Grouping each observation                               | Classify | Classification |

## APPENDIX XII

### ANSWERS TO MULTIPLE-CHOICE QUESTIONS

#### SECTION B: PART 1

|      |       |       |       |
|------|-------|-------|-------|
| 1. C | 6. B  | 11. A | 16. A |
| 2. D | 7. A  | 12. B | 17. D |
| 3. B | 8. D  | 13. C | 18. B |
| 4. C | 9. D  | 14. A | 19. C |
| 5. C | 10. D | 15. A | 20. B |

#### ANSWERS TO PRACTICAL QUESTIONS

#### SECTION B: PART II

1. Naming the six types of levers provided correctly (3 mrks)
2. identifying the parts of each lever (3mrks)
3. Grouping the levers into their various classes (3 mrks)
4. Identifying the THREE types of surfaces provided (1.5 mrks)
5. Reading the values of the frictional forces (1.5 mrks)
6. Recording the values of the frictional forces (1.5 mrks)
7. The surface with highest value of frictional force (1/2mrk)
8. Suggesting reason (1mrk)

9. The surface with the least value of frictional force (1/2mrk)
  10. Suggesting reason (1mrk)
  11. Observing attraction as A was moved near B (1/2mrk)
  12. Knowledge of the type of material i.e magnetic (1/2mrk)
  13. Observing non attraction as A was moved near C (1/2mrk)
  14. Knowledge of the type of material i.e non-magnetic (1/2mrk)
  15. Observing non attraction as A was moved near D (1/2mrk)
  16. Knowledge of the type of material i.e non-magnetic (1/2mrk)
  17. Observing attraction as A was moved near E (1/2 mrk)
  18. Knowledge of the type of material i.e non-magnetic (1/2 mrk)
  19. Identifying what object A is -- a magnet (1/2 mrk)
  1. Grouping observations (2 mrks)
    - i.e B attracted (1/2 mrk)
      - C not attracted (1/2 mrk)
      - D not attracted (1/2 mrk)
      - E attracted (1/2 mrk)
- Total mark = 25

## APPENDIX XIII

### DISSEMINATION OF MAJOR FINDINGS

The findings of this research work would be disseminated as discussed below:

1. **Research Article Publication in Reputable Journals:** - The results of this study would be published in reputable journals. Preference will be given, first to journal of Physics Education and Science – based journals such as International Journal of science education and STAN.
2. **Workshops:** - The researcher plans to organize workshop for science teachers to communicate the major findings of the research work to them on how to improve the teaching and learning of science using virtual laboratory package especially on abstract and practical-based concepts.
3. **Organization of Seminars:** - Periodic seminar would be organized by the researcher with the view to covering large number of science teachers. This is to equip the teachers with the importance of virtual laboratory as it facilitates learning, develops scientific and process skills of the pupils and develops their interest to study science in higher education of learning.
4. **Print Media Engagement:** - The researcher will also employ print and electronic media through weekly or monthly write-up to educate and bring to the awareness of the general public, the benefits of virtual laboratory instructional strategy in enhancing teaching and learning process in Nigeria.
5. **Memo Writing:** - The researcher wishes to communicate the findings of the result to the federal and state Ministry of Education to push through the idea of national acceptability of the findings of the result. National examination bodies and Agencies will also be involved with the hope to improve the quality of teaching and learning of science.

## APPENDIX XIV

### EXPERT VALIDATION REPORTS

#### COMPUTER PROGRAMMERS VALIDATION REPORTS

Dear Sir/Ma,

I, Akintunde Zacchaeus Taiwo, a doctoral candidate in the Department of Science Education University of Ilorin, do hereby humbly request your assistance in validating this research instrument. I have designed a virtual laboratory package for teaching physics topics of Basic Science and Technology at the primary school level. The validation of this package is requested to ascertain its suitability for classroom instructional standard. Your constructive criticism will be appreciated. Thank you.

Please comment on the following:

1. Appropriateness of programme language use ..... *Very Appropriate*
2. Typography errors in the package: ..... *None*
3. Legibility of the package: ..... *Very legible*
4. The navigation: ..... *Easy*
5. The interface ..... *Well set*
6. The animations in the package: ..... *Well animated to suit purpose*
7. Functionality of the package: ..... *Well package, functionally works to suit objectives*
8. The storage capacity and durability: ..... *Good*

Suggestions for improving on the package:

1. *The author can further test the*
2. *package with students outside the study area.*

Name of the Specialist: *Theodoris, Adedayo Olayinka*

Area of Specialization: *Knowledge Management System*

Rank: *Lecturer III, M.Sc (Computer Science) Ibadan, 2016.*

Institution/Establishment: *Oyo State College of Agriculture and Technology*

Signature: *[Signature]* Date: *15/05/17*

Thank you for validating these instruments.

## PHYSICS EXPERTS VALIDATION REPORTS

Dear Sir/Ma,

I Akintunde Zacchaeus Taiwo, a doctoral candidate in the Department of Science Education University of Ilorin, do hereby humbly request your assistance in validating this research instrument. I have designed a virtual laboratory package for teaching physics topics of Basic Science and Technology at the primary school level. The validation of this package is requested to ascertain its suitability for classroom instructional standard. Your constructive criticism will be appreciated. Thank you.

Please comment on the following:

1. Appropriateness of package for teaching the chosen topics ..... *Very Appropriate*
2. Clarity and simplicity of the package: ..... *The package is very simple and clear*
3. Suitability for the level of the pupils: ..... *it is very suitable for primary school*
4. The extent to which the contents cover the topics they are meant to cover ..... *it covers most topics meant to cover*
5. The structure of the package: ..... *it is well structured for effective learning*
6. Others (some sentence errors, spelling mistakes and misrepresentation of some symbols in the package): ..... *not seen or detected*

Suggestions for improving on the package:

1. ..... *More physical animation may be useful to each topic*
2. ..... *The package may be linked to physics curriculum*

Name of the Specialist: *OLAWOORE TAIWO OLULADE*

Area of Specialization: *PHYSICS EDUCATION*

Rank: *LECTURER III*

Institution/Establishment: *OYO STATE COLLEGE OF AGRICULTURE & TECHNOLOGY, IGBOMOSHI*

Signature: ..... *CHH* ..... Date: *10/5/17*

Thank you for validating these instruments.

## EDUCATIONAL TECHNOLOGY SPECIALIST VALIDATION REPORTS

Dear Sir/Ma,

I Akintunde Zacchaeus Taiwo, a doctoral candidate in the Department of Science Education University of Ilorin, do hereby humbly request your assistance in validating this research instrument. I have designed a virtual laboratory package for teaching physics topics of Basic Science and Technology at the primary school level. The validation of this package is requested to ascertain its suitability for classroom instructional standard. Your constructive criticism will be appreciated. Thank you.

Please comment on the following:

1. Suitability of the package for instructions: *Very suitable for instructions used*
2. Clarity and simplicity of the package: *Appropriate*
3. Unity among illustrations: *Good*
4. Emphasis on key concepts: *Well simulated to fit instructions as students*
5. The use of colours (background colour): *Good*
6. The legibility of the texts: *Legibly clear enough*
7. Other errors: *Nil*

Suggestions for improving on the package:

1. *The Author should further test the package with schools*
2. *outside the study area in order to test compactability and uniqueness*

Name of the Specialist: *Theodore, Adebayo Olayinka*

Area of Specialization: *Educational Technology*

Rank: *Lecturer III, B.Sc (Ed) Computer Science, M.Ed (Education), Educational Technology (2012)*

Institution/Establishment: *Oyo State College of Agriculture and Technology, Egbeda*

Signature: *[Signature]* Date: *02/05/17*

Thank you for validating these instruments.