



Development and Validation of Virtual Laboratory for Enhancing Quality Physics Education in Nigeria

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ABSTRACT

This study focuses on the development and validation of a Physics Virtual Laboratory Instructional Package (PVLIP) to improve the quality of physics education in Nigeria, addressing challenges such as inadequate laboratory equipment and abstract concepts. The research employed an instrumentation design, utilizing the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model for the PVLIP's creation. The PVLIP's effectiveness was validated by a diverse group of experts, including physics teachers, lecturers, computer programmers, and educational technology specialists, alongside 95 students. Validation was conducted in four stages: expert validation, one-on-one student validation, small group validation, and large group field trial validation. Data collected through various questionnaires (Content Validation, Computer Expert, Educational Technology Expert, and Students' Response) were analyzed using frequency counts and percentages. The results demonstrated positive feedback from both experts and students, with agreement rates consistently above 97% across all validation aspects, including content suitability, functionality, interactivity, navigation, feedback mechanisms, and screen design. These findings underscore the PVLIP's potential as a viable and effective alternative to traditional laboratories, enhancing learning engagement and promoting quality physics education in Nigeria.

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INTRODUCTION

The world has become a global village as a result of innovation due to science and technology. Therefore, science is a verified body of knowledge which is arranged in an orderly manner. Science is an integral part of everyone's life. It comprises the basic discipline such as Chemistry, Biology, Mathematics and Physics. Physics is a field of specialization concerning with two basic aims, which are the production of scientifically interactive society and technological manpower. Physics education in the area of academic and industrial activity is the backbone of industrialization and development of any nation (Ouahabi et al, 2021).

Physics education is a school subject that play an important role in life, it is important

because it is the basic subject for the development of many study fields such as mechanical engineering, electronics, nuclear sciences, medicine and surgery, medical laboratory sciences, pharmacy and digital information system. Physics education presents various problems, from the simplest to the complex ones, as well as from the macro to the micro-ones. It contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries. It plays a major role in the area of health, economic development, energy and environment. It generates fundamental knowledge needed for future technological advances that will continue to drive the economic engine of the world (Bunkure & Saifullahi, 2023).

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Carrying out the physics learning process requires teachers to take students in physical experiment and observation activities. This is because most of the instruments in the laboratory cannot function properly due to lack of availability of laboratory equipment, and there are some physics concepts that cannot be practiced directly because they are abstract (Gambari, et al, 2013). It appears that the inadequate tools in the laboratory affects the conduct of practical activities in Physics laboratory. To overcome this challenge, there is need for a paradigm shift to embrace virtual laboratories so that experimental activities can carried out virtually at anytime and anyplace.

Virtual laboratory in general is one of the developments in information and communication technology. Virtual laboratories are computer software systems that can be used to simulate effects or phenomena in learning that cannot be explained verbally. It can change the functions of a real laboratory which is then implemented with applications that are contained on a computer. It is a series of computer programs that can visualize abstract and visible phenomena which seem to be in a real laboratory (Ouahabi et al, 2021). Virtual laboratories can replace expensive and too hazardous experimental devices into safe and affordable activities in the learning process. The use of virtual laboratory media does not mean that it can replace the actual role of the laboratory, but as an alternative solution to the incompleteness of real laboratory facilities and equipment in schools.

Physics education contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries. In physics and engineering education, virtual laboratories have emerged as alternative or supplementary tools of the hands-on laboratory education, for instance, using them for preparing for the real laboratory task (Mahmoud & Zoltan, 2009). Virtual laboratory is an interactive environment without real laboratory tools meant for creating and conducting simulated experiments. It provides students with tools and materials set on computer in order to perform experiments saved on CDs or on website and it has been proven to improve students'

performance in science-based subjects globally (Babateen, 2021). For instance, Mahmoud and Zoltan (2009) found that virtual laboratory instruction improves students' academic achievements in physics.

Empirical studies revealed that development and validation of virtual laboratories in science and engineering subjects offer significant benefits including flexibility, cost-effectiveness, and enhanced student engagement, improving conceptual understanding and accessibility to experiments. For instance, Usman et al., (2024) successfully developed and validated a virtual laboratory package for Biology practicals using a Research and Development (R&D) design. Through content, functionality, and usability questionnaires, the VLP was confirmed to be functional, suitable, and user-friendly for effective teaching, providing a strong methodological example for similar physics developments. Furthermore, Ouahabi et al., (2021) developed and implemented a low-cost, internet-accessible virtual physics laboratory in Moroccan universities. Evaluation by teachers and students confirmed its positive impact on learning outcomes, demonstrating its viability as an alternative to physical labs.

In addition, Falode and Gambari (2017) evaluation of virtual laboratory package on Nigerian secondary school physics concepts. A researcher-developed virtual physics laboratory package was found to be accessible within schools having functional computers and significantly improved students' physics achievement. However, its flexibility for access on mobile devices and the internet was rated low, indicating a need for improved multi-platform compatibility in future designs. Despite initial development cost, it was considered profitable due to long-term educational benefits. Based on the above literature, the study aimed at development and validation of virtual laboratory for enhancing quality physics education in Nigeria.

STATEMENT OF THE PROBLEM

Physics education is crucial for Nigeria's development, fostering critical thinking and innovation. However, its quality in Nigerian

secondary schools is severely hampered by underfunding. The traditional reliance on physical laboratories is ineffective due to the scarcity of essential equipment, leading to consistently low student performance in examinations (WAEC, 2021). Students often grasp theoretical concepts but lack practical application. This highlights a significant gap of continued dependence on an under-resourced traditional model despite available technological alternatives. This perpetuates a superficial understanding of physics and hinders students' ability to solve real-world problems. It also exacerbates inequality in education, as many students are deprived of vital practical learning experiences. This undermines Nigeria's progress towards SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities), and jeopardizes the aspirations of Africa Agenda 2063.

A paradigm shift in physics education is urgently needed. Educational technology, particularly virtual laboratories, offers a viable solution. These platforms provide immersive, interactive, and accessible practical learning experiences without the need for expensive physical equipment or extensive manpower. Therefore, this study aims to develop and validate a virtual laboratory specifically for Nigerian secondary schools. By providing a cost-effective and engaging instructional package, this research will improve students' academic performance in physics and contribute significantly to achieving quality education and reducing inequality in Nigeria, even with our current economic challenges.

Research Objectives

The study aimed at the Development and Validation of Virtual Laboratory for Enhancing Quality Physics Education in Nigeria. The objectives of the study were set to:

1. develop a virtual laboratory instructional package for enhancing quality Physics in Nigeria.
2. ensure experts' consensus on the validity of the developed virtual laboratory instructional package for effective teaching of Physics in Nigeria.

3. ensure students' consensus on the validity of the developed virtual laboratory instructional package for effective teaching of Physics in Nigeria.

Research Questions

1. What are the procedures for developing a physics virtual laboratory instructional package for enhancing quality Physics Education in Nigeria?
2. What are the experts' consensus on the validity of the developed virtual laboratory instructional package for effective teaching of Physics in Nigeria?
3. What are the students' consensus on the validity of the developed virtual laboratory instructional package for effective teaching of Physics in Nigeria?

METHODOLOGY

The methods adopted in carrying out this study is described under the following sub-headings: Research Design, Sample and Sampling Techniques, Research Instruments. The researchers employed instrumentation research design. Instrumentation is the study that involves design, development of instrument needed for implementation in science and technology (Lyons & Seow, 1992). The emphasis on the development and validation is the focus of this study.

The target population for validating the physics virtual laboratory instructional package (PVIL) include: physics teachers, physics education lecturers, computer programmers, educational technology experts from different secondary schools and universities in Nigeria. Simple random sampling technique were employed used to select teachers with a rank from senior lecturer and above. 10 secondary school teachers in physics, 10 lecturers in physics education, 10 computer programmers, and 10 educational technology experts participated in the validation of the Physics Virtual Laboratory Instructional Package. Ninety-five students were randomly selected to participate in field trial validation.



Fifteen students were selected for one-on-one validation of the package; 30 students were randomly selected for small group validation and 50 students were selected for large group field trial validation totalling 95 students. Government Day Secondary School, Tunga, Minna, Government Day Secondary School, Minna, and Collage of Arabic and Islamic Studies Minna were purposively selected for the study because they are well equipped with ICT facilities and had adequate manpower that facilitate the study.

Research instruments

Six instruments were used to validate the PVLIP, these include: (i) Content Validation Questionnaire (SCVQ); (ii) Computer Expert Validation Questionnaire (CEVQ); (iii) Educational Technology Expert Validation Questionnaire (ETEVQ), and (iv) Students' Response Questionnaire (SRQ)

Subject Content Validation Questionnaire (SCVQ):

This instrument was developed to ascertain the adequacy of the content of the Physics Virtual Laboratory Instructional Package (PVLIP) with regards to the officially prescribed content of the NERDC curriculum. This contains nine statements to which the respondent required to state whether the contents embedded in the package are: Very Appropriate (4 points), Appropriate (3-points), Fairly Appropriate (2-points), and Not Appropriate (1-point). Respondents respond to statements regarding the appropriate sequencing of the contents, appropriate language use among others.

Computer Expert Validation Questionnaire (CEVQ):

It was developed to seek for their opinions on the appropriateness of the science concepts, the audio output, graphics and animation effects among others and were documented and used to improve on the video package. Further observations and suggestions made by the experts about the package workability were taken into consideration.

Educational Technology Expert Validation Questionnaire (ETEVQ): This was designed to seek educational technology experts' responses

on whether the Physics Virtual Laboratory Instructional Package (PVLIP) conforms to acceptable standards in educational technology. The respondents were asked to express their opinions about the simplicity of the video embedded in the Physics Virtual Laboratory Instructional Package (PVLIP), its audibility, visibility, graphics animation, video effects among others.

Students' Response Questionnaire (SRQ): This instrument contains some statement items for respondents regarding the efficiency of the Physics Virtual Laboratory Instructional Package (PVLIP) in terms of gaining students attention, and allowing for easy students' comprehension. The instrument were scored using four choice modified likert scale of Strongly Agree (SA = 4 points); Agree (A = 3 points); Disagree (D = 2 points); Strongly Disagree (SA = 1 point). The statement items include those.

Validation and Reliability of the Research Instruments

The validation of the Physics Virtual Laboratory Instructional Package (PVLIP) was carried out in four stages: stage 1 (Experts validation); stage 2 (One-to-one validation with 15 students); stage 3 (Small group validation with 30 students); and stage 4 (Field trial validation with 50 students). All the four instruments used to validate the package were validated by 2 secondary school physics teachers and (six) 6 lecturers from Physics Departments, Computer Science and Educational Technology experts from the Federal University of Technology.

To test the reliability of the Content Validation Questionnaire (CVQ); Computer Expert Validation Questionnaire (CEVQ); Educational Technology Expert Validation Questionnaire (ETEVQ), and Students' Response Questionnaire (SRQ) were administered on Physics students from five selected secondary schools in Minna, Computer Science specialist, Physics and Education Educational Technology lecturers from Ibrahim Badamasi Babangida University, Lapai, Niger state College of Education, Minna and Federal Government College, Minna, Niger State.



The samples were part of the research population but were not selected for the real study. The questionnaires were administered on the selected samples. Data obtained were analysed using Cronbach's Alpha used to measure internal consistency that yielded 0.898 for CVQ, 0.889 for CEVQ, 0.952 for ETEVQ and 0.923 for SRQ.

Data Collection and Analysis Procedure

First week of the data collection began with experts' validation which was carried out on the developed Physics Virtual Laboratory Instructional Package (VLIP) with 20 lecturers and secondary school physics teachers, 10 computer programmers, and 10 educational technology experts all. Their responses were analysed using frequency and simple percentage. For One-on-One Field Trial Validation Physics Virtual Laboratory Instructional Package (PVLIP) was administered on 15 selected students from Government Day Secondary School, Tunga, Minna using PVLIP for a week period. This validation provides the researcher with a first-hand glimpse of the feasibility of using the Physics Virtual Laboratory Instructional Package (PVLIP).

The researchers identified evaluation criteria such as: graphic design of the package, audibility, visibility, pronunciation of words, among others. Also, how easy or difficult students learn using the Physics Virtual Laboratory Instructional Package (PVLIP), how satisfied the students were at the end of learning Physics with Virtual Laboratory Instructional Package (PVLIP). A report on the outcome of the one-on-one Field Trial Validation of PVLIP was done through the Students Response Questionnaire. The data that obtained were analysed using Frequency counts and simple percentage. One week after one-on-one validation, Small Group Field Trial Validation

was conducted on 30 physics students from Government Secondary School, Minna using PVLIP for a week period. The students were guided on the use of Physics Virtual Laboratory Instructional Package (PVLIP) for learning practical concepts. After exposing the students to the package, Students Response Questionnaire was administered to the students. The data obtained were quantitatively analysed using frequency counts and simple percentage. The responses from the students were used to improve Physics Virtual Laboratory Instructional Package (PVLIP) for final stage validation.

In the last stage, Large Group Field Trial Validation was conducted with 50 selected physics students from College of Arabic and Islamic Studies (CAIS), Minna using PVLIP. The students were exposed to Physics practical concepts using the Physics Virtual Laboratory Instructional Package (PVLIP) over one week. At the end of this stage, students' response questionnaire was administered to find out their observations on the use of Physics Virtual Laboratory Instructional Package (PVLIP) as medium of instruction. The data will be obtained from administration of Students' Response Questionnaire was analysed using frequency counts and simple percentage.

METHODOLOGICAL FLOW CHAT OF THE STUDY

The researchers provided specific layout instructions (methodological flow chat) to the experts on how each item in the PPM was presented in the Physics Virtual Laboratory Instructional Package (PVLIP). Figure 2 shows the conceptual framework.

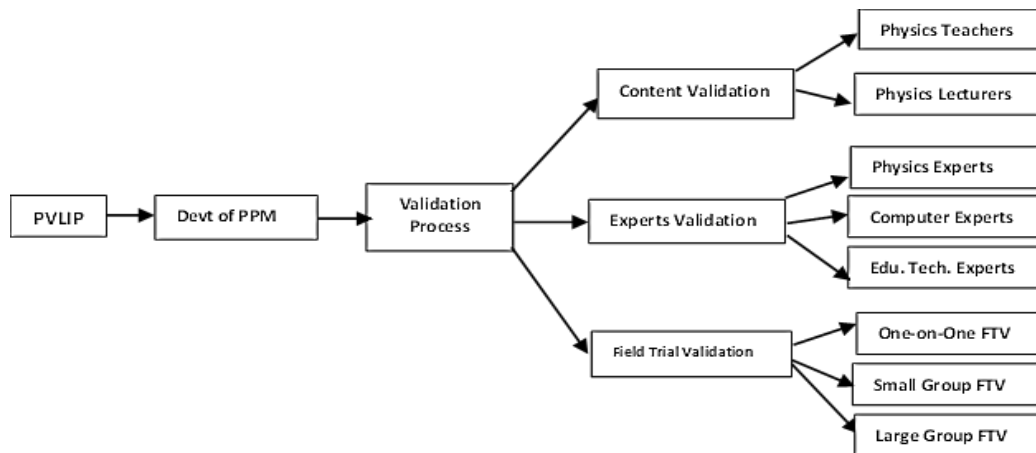


Figure 1: Methodological Flow Chat

RESULTS

Research Question One: What are the procedures for developing a physics virtual laboratory instructional package for enhancing quality Physics Education in Nigeria?

In answering research question one, the procedure for the development of physics virtual

laboratory instructional package using ADDIE model were discussed.

The study adopted Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model theoretical foundation of instructional design as provided by the Dick and Carey (2005) as presented in figure 2.



Figure 2: ADDIE Model

This is one of the most used instructional system design models among instructional designers and researchers. It is a general-purpose model and most useful for creating and developing instructional products which is also applicable for programme design. The model has five components namely: Analysis, Design, Development, Implementation, and Evaluation (Dick & Carey, 2005).

In the analysis phase, the instructional problem is clarified, the instructional goals and objectives are established and the learning environment and learners existing knowledge and skills are identified. The design phase deals with learning objectives, assessment instruments, exercises, content, subject matter analysis, and lesson planning and media selection. The design

phase will be systematic and specific. The development phase is where instructional designers and developers create and assembles the content assets that were blueprinted in the design phase. In this phase, a procedure for training the facilitators and the learners is developed. The facilitators' training should cover the course curriculum, learning outcomes, method of delivery, and testing procedures. The evaluation phase consists of two parts: formative and summative. Formative evaluation is present in each stage of ADDIE process. Summative evaluation consists of tests designed for domain specific criterion-related referenced items and providing opportunities for feedback from the users which are identified.

The content of physics as specified by the national education, research and development council (NERDC, 2007) curriculum was extracted

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by the researchers. It was named 'Physics Practical Manual (PPM)'. The PPM was typed and copies were made available to 10 senior physics teachers and 10 lecturers in physics education for thorough scrutiny. This is to ensure that it adequately covered the topics, and that there is no misrepresentation of scientific facts. The input of the teachers and university lecturers were taken into consideration and the document were thoroughly revised to ensure its validity and to meet national standard. The Physics concepts were developed into Physics Virtual Laboratory Instructional Package (PVLIP) that covered a twelve-week lessons. Some practice exercises were included in the course materials. After this exercise, the PPM was recorded into a video package suitable for science classroom instruction, with the video producers, video

editors, script writers, audio narrators, video camera operator and computer programmer who is highly knowledgeable in graphics and simulation.

Research Question Two: What are the experts' consensus on the validity of the developed virtual laboratory instructional package for effective teaching of Physics in Nigeria?

In answering research question two, experts' validation was carried out on the developed Physics Virtual Laboratory Instructional Package (VLIP) with 20 lecturers and secondary school physics teachers, 10 computer programmers, and 10 educational technology experts all. Their responses were analysed using frequency and simple percentage and the result is presented in Table 1, 2, and 3.

Table 1: Frequency Counts and Percentage of Content Validation by Secondary School Teachers and University Lecturers (N=20)

| S/N | Items | VA | A | FA | NA |
|--------------------------------------|--|------------------------|---------------------|---------------------|-------------------|
| 1 | The level of suitability of the contents for teaching the chosen topics | 13 (65%) | 7 (35%) | 0 (0%) | 0 (0%) |
| 2 | The contents comprehensively cover all the learning objectives and content specified in the curriculum | 15 (75%) | 5 (25%) | 0 (0%) | 0 (0%) |
| 3 | The contents are clear, concise, and easy for teachers to understand and follow (Clarity and simplicity of the physics contents) | 11 (55%) | 9 (45%) | 0 (0%) | 0 (0%) |
| 4 | The activities and resources suggested in the contents are realistic and achievable within typical classroom constraints (time, resources, class size) | 14 (70%) | 6 (30%) | 0 (0%) | 0 (0%) |
| 5 | The contents allow for some flexibility and adaptation to diverse student needs and classroom contexts | 9 (45%) | 10 (50%) | 1 (5%) | 0 (0%) |
| 6 | No ambiguities, inconsistencies, or errors in the content or instructions of the contents were observed | 11 (55%) | 7 (35%) | 2 (10%) | 0 (0%) |
| 7 | The questions were appropriately structured from the contents | 17 (85%) | 3 (15%) | 0 (0%) | 0 (0%) |
| 8 | The contents provide sufficient detail and guidance for a teacher to effectively implement the lesson | 12 (60%) | 8 (40%) | 0 (0%) | 0 (0%) |
| 9 | The activities, examples, and assessment methods proposed in the contents directly support the attainment of the stated learning objectives | 15 (75%) | 4 (20%) | 1 (5%) | 0 (0%) |
| 10 | A clear process for gathering feedback from teachers who use the contents and for incorporating that feedback into revision | 8 (40%) | 11 (55%) | 1 (5%) | 0 (0%) |
| Grand Total | | 125 (62.5%) | 70 (35%) | 5 (2.5%) | 0 (0%) |
| Summary of Agree and Disagree | | 195 (97.5%) | | 5 (2.5%) | |

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Table 1, which involved 20 secondary school teachers and university lecturers, provides a content validation of physics contents for PVLIP. The overall findings indicate a strong positive reception, with 97.5% of responses falling into the "Very Appropriate" and "Appropriate" categories, and only 2.5% in the "Fairly Appropriate", while none is found in "Not Appropriate" category.

Therefore, it was concluded that expert consensus on the appropriateness of the content embedded in the package was attained. All the necessary corrections as recommended by the experts were taken into consideration in producing the final version of Physics Virtual Laboratory Instructional Package (PVLIP).

Table 2: Frequency Count and Percentage of PVLIP Computer Experts Validation (N=10)

| S/N | Items | VA (4) | A(3) | FA(2) | NA(1) |
|--------------------------------------|---|---------------------|---------------------|-------------------|-------------------|
| 1 | The Physics Virtual Learning Instructional Package (PVLIP) is compatible with existing school/individual technology infrastructure (operating systems, devices, browsers) | 7 (70%) | 3 (30%) | 0 (0%) | 0 (0%) |
| 2 | The functionality of the package (it performs consistently and reliably) | 9 (90%) | 1 (10%) | 0 (0%) | 0 (0%) |
| 3 | The storage capacity and durability of the package complied with manageable file size | 6 (60%) | 4 (40%) | 0 (0%) | 0 (0%) |
| 4 | Availability and accessibility of the package by the user | 8 (80%) | 2 (20%) | 0 (0%) | 0 (0%) |
| 5 | Simplicity of the user operational guide and tutorial section in the package | 4 (40%) | 5 (50%) | 1 (10%) | 0 (0%) |
| 6 | The PVLIP intuitive and easy for both students and teachers to navigate (simplicity of navigation of the package) | 6 (60%) | 4 (40%) | 0 (0%) | 0 (0%) |
| 7 | The PVLIP interface is user friendly | 3 (30%) | 6 (60%) | 1 (10%) | 0 (0%) |
| 8 | The simulation in the package simplifies the abstract concept | 9 (90%) | 1 (10%) | 0 (0%) | 0 (0%) |
| 9 | The level at which software clearly defines its learning objective engaging and motivating students to learn with keen interest | 4 (40%) | 5 (50%) | 1 (10%) | 0 (0%) |
| 10 | The PVLIP includes built-in assessment tools to gauge student learning and provides immediate feedback | 8 (80%) | 2 (20%) | 0 (0%) | 0 (0%) |
| Grand Total | | 64 (64%) | 33 (33%) | 3 (3%) | 0 (0%) |
| Summary of Agree and Disagree | | 97 (97%) | | 3 (3%) | |

Table 2 presents the results of a validation exercise conducted by 10 computer experts on the Physics Virtual Learning Instructional Package (PVLIP). The table evaluates ten different items related to the technical aspects and usability of the PVLIP. Overall, the results indicate a very high level of agreement among the computer experts regarding the quality and functionality of the PVLIP. The "Summary of Agree and Disagree" shows that 97% of responses indicated agreement

(combining "Very Appropriate" and "Appropriate" categories), while only 3% indicated disagreement (combining "Fairly Appropriate" and "Not Appropriate" categories). Therefore, it was concluded that Computer expert consensus on the appropriateness of the package was attained. All the necessary corrections as recommended by the experts were taken into consideration in producing the final version of Physics Virtual Laboratory Instructional Package (PVLIP).

Table 3: Frequency Count and Percentage of PVLIP Educational Technology Specialist Validation (N=10)

| S/N | Items | VA | A | FA | NA |
|--------------------------------------|---|---------------------|---------------------|-------------------|-------------------|
| 1 | Attractiveness of the Homepage, slide layout and suitability of the background colours of the package | 6 (60%) | 4 (40%) | 0 (0%) | 0 (0%) |
| 2 | Simplicity and sequencing of the information in the package | 7 (70%) | 3 (30%) | 0 (0%) | 0 (0%) |
| 3 | Clarity and legibility of the text in terms of choice of font types, sizes, upper, lower cases among others | 9 (90%) | 1 (10%) | 0 (0%) | 0 (0%) |
| 4 | Appropriateness of the illustrations and images in the package | 5 (50%) | 4 (40%) | 1 (10%) | 0 (0%) |
| 5 | The level of audibility of the video in the package | 8 (80%) | 2 (20%) | 0 (0%) | 0 (0%) |
| 6 | The mode of simulation of the physics practical concepts | 10 (100%) | 0 (0%) | 0 (0%) | 0 (0%) |
| 7 | The images and captions in the video consistently depict the actual information | 7 (70%) | 3 (30%) | 0 (0%) | 0 (0%) |
| 8 | The Physics Virtual Laboratory Instructional Package level of engaging, relevant, and easy to use by students and teachers | 9 (90%) | 1 (10%) | 0 (0%) | 0 (0%) |
| 9 | The level of accuracy of the estimated completion time, feedback and rewards in the quiz section | 6 (60%) | 4 (40%) | 0 (0%) | 0 (0%) |
| 10 | The level at which the virtual laboratory package caters for different learning styles and needs (e.g., visual, auditory, kinesthetic learners) | 8 (80%) | 1 (10%) | 1 (10%) | 0 (0%) |
| Grand Total | | 75 (75%) | 23 (23%) | 2 (2%) | 0 (0%) |
| Summary of Agree and Disagree | | 98 (98%) | | 2 (2%) | |

Table 3 presents the results of a validation exercise conducted by 10 educational technology specialists on the Physics Virtual Learning Instructional Package (PVLIP). The table evaluates ten different items related to the instructional design, aesthetics, and user engagement aspects of the PVLIP. The results indicate an exceptionally high level of agreement among the educational technology specialists regarding the quality and effectiveness of the PVLIP. The "Summary of Agree and Disagree" shows that 98% of responses indicated agreement (combining "Very Appropriate" and "Appropriate" categories), while only 2% indicated disagreement (combining "Fairly Appropriate" and "Not Appropriate" categories). Therefore, it was concluded that Educational Technology Specialist consensus on the appropriateness of the package was attained. All the necessary corrections as

recommended by the experts were taken into consideration in producing the final version of Physics Virtual Laboratory Instructional Package (PVLIP).

Research Question Three: What are the students' consensus on the validity of the developed virtual laboratory instructional package for effective teaching of Physics in Nigeria?

In answering research question three, students' validation was carried out on the developed Physics Virtual Laboratory Instructional Package (VLIP) with 15 secondary school physics students for One-on-One Field Trial Validation, 30 physics students for Small Group Validation and 50 students for Large Group Validation. Their responses were analysed using frequency and simple percentage and the result is presented in Table 4, 5, 6, 7, 8 and 9.

Table 4: Frequent Count and Percentage of the Content of the Package (N=95)

| S/N | STATEMENT | RESPONSE | | | |
|--------------------------------------|---|------------------------|------------------------|---------------------|-------------------|
| | | SA | A | D | SD |
| 1 | The messages in the package are easy to understand | 76 (80.0%) | 17 (17.9%) | 2 (2.1%) | 0 (0%) |
| 2 | The content in the package has been well organized (arranged in order) | 65 (68.4%) | 29 (30.5%) | 1 (1.1%) | 0 (0%) |
| 3 | The pictures/illustrations in the package are very clear to me. | 34 (35.8%) | 61 (64.2%) | 0 (0%) | 0 (0%) |
| 4 | The examples used in the various sections of the lessons in the package are relevant. | 23 (24.2%) | 71 (74.7%) | 1 (1.1%) | 0 (0%) |
| 5 | It was easy to understand the lesson because information was presented from simple to more difficult one. | 83 (87.4%) | 12 (12.6%) | 0 (0%) | 0 (0%) |
| Total | | 281 (59.2%) | 190 (40.0%) | 4 (0.8%) | 0 (0%) |
| Summary of Agree and Disagree | | 471 (99.2%) | | 4 (0.8%) | |

Table 4, detailing the frequent count and percentage of package content involving 95 students in one-on-one group, small group and large group. The result reveals overwhelmingly positive feedback from respondents. Across all statements, a remarkable 99.2% of responses indicated agreement, with only 0.8% expressing disagreement. It was therefore concluded that students' consensus on the appropriateness of the content embedded in the package was attained. This high consensus suggests that the package effectively delivers its messages, is well-organized, and utilizes clear and relevant supporting materials.

Specifically, respondents found the messages easy to understand (80.0% strongly agree, 17.9% agree), the content well-organized (68.4% strongly agree, 30.5% agree), pictures and illustrations clear (35.8% strongly agree, 64.2% agree), and examples relevant (24.2% strongly agree, 74.7% agree). The most resounding agreement was for the progressive presentation of information from simple to difficult, which greatly aided understanding (87.4% strongly agree, 12.6% agree). These findings underscore the overall effectiveness and user-friendliness of the package's content.

Table 5: Frequent Count and Percentage of the Content of Interactivity of the Package (N=95)

| S/N | STATEMENT | RESPONSE | | | |
|-----|--|---------------|---------------|-------------|-----------|
| | | SA | A | D | SD |
| 1 | It is easy to operate the package with computer keys and icons. | 51 (53.6%) | 43 (45.2%) | 1 (1.1%) | 0 (0%) |
| 2 | This package permits me to repeat the section, enlarge animation, and exit the lesson at any time. | 78 (82.1%) | 17 (17.8%) | 0 (0%) | 0 (0%) |
| 3 | The frequent display of questions to the learners does not interrupt the learning process. | 39 (41.1%) | 55 (57.8%) | 1 (1.1%) | 0 (0%) |
| 4 | This package enables me to apply what I have learnt rather than memorize it. | 38 (40.0%) | 57 (60.0%) | 0 (0%) | 0 (0%) |
| 5 | This package allows me to discover information through active learning. | 64 (67.3%) | 29 (30.5%) | 2 (2.1%) | 0 (0%) |

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| S/N | STATEMENT | RESPONSE | | | |
|-------------------------------|-----------|-----------------|-----------------|-------------|-----------|
| | | SA | A | D | SD |
| Total | 475 | 270 (56.84%) | 201 (42.32%) | 4 (0.8%) | 0 (0%) |
| Summary of Agree and Disagree | | 471(99.2%) | | 4 (0.8%) | |

Table 5 presents the frequent count and percentage of the content of interactivity of the package from a total of 95 respondents, provides insights into user perception of the package's interactive elements. The summary of "Agree" and "Disagree" responses indicates an overwhelmingly positive overall result. Out of a total of 475 responses across all statements, 471 responses (99.2%) indicated agreement, while only 4 responses (0.8%) indicated disagreement. It was therefore concluded that students'

consensus on the appropriateness of the content Interactivity of the package was attained. This suggests a very high level of satisfaction and perceived effectiveness regarding the package's interactive features among the respondents. It also reveals that the package is user-friendly, and contribute positively to the learning process by offering flexibility, non-disruptive assessments, and promoting application and active discovery.

Table 6: Frequent Count and Percentage of the Content of Navigation of the Package (N=95)

| S/N | STATEMENT | RESPONSE | | | |
|-------------------------------|---|----------------|----------------|-----------|-----------|
| | | SA | A | D | SD |
| 1 | From the main menu, students are allowed to register his/her name. | 33 (34.7%) | 62 (65.3%) | 0 (0%) | 0 (0%) |
| 2 | The EXIT key enables me to exit from the lesson/programme. | 59 (62.1%) | 36 (37.9%) | 0 (0%) | 0 (0%) |
| 3 | The PREVIOUS key enables me to revisit the previous section(s) of the lesson. | 41 (43.2%) | 54 (56.8%) | 0 (0%) | 0 (0%) |
| 4 | The NEXT key directs me to go to the next section of the lesson. | 64 (67.4%) | 31 (32.6%) | 0 (0%) | 0 (0%) |
| 5 | The OPTION keys allow me to select the correct option. | 88 (92.6%) | 7 (7.4%) | 0 (0%) | 0 (0%) |
| Total | | 285 (60.0%) | 190 (40.0%) | 0 (0%) | 0 (0%) |
| Summary of Agree and Disagree | | 475 (100.0%) | | 0 (0%) | |

The Table 6 represents the frequent count and percentage of the content of navigation of the package from a total of 95 respondents, provides insights into user perception of the package's navigation features. The summary of "Agree" and "Disagree" responses indicates a perfectly positive overall result. Out of a total of 475 responses across all statements, all 475 responses (100.0%) indicated agreement, while 0

responses (0%) indicated disagreement. It was therefore concluded that students' consensus on the appropriateness of the content navigation embedded in the package was absolutely attained. This suggests an exceptionally high level of satisfaction and perceived effectiveness regarding the package's navigation among the respondents.

Table 7: Frequent Count and Percentage of the Content of Feedback from the Package (N=95)

| S/N | STATEMENT | RESPONSE | | | |
|-----|-----------|----------|---|---|----|
| | | SA | A | D | SD |

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| | | | | | |
|--------------------------------------|---|------------------------|-----------------------|---------------------|-------------------|
| 1 | This package provides immediate feedback after selecting the option. | 90 (94.7%) | 4 (4.2%) | 1 (1.1%) | 0 (0%) |
| 2 | This package displays the correct or wrong answer chosen with some sound. | 86 (90.5%) | 9 (9.5%) | 0 (0%) | 0 (0%) |
| 3 | This package allows me to proceed to the next lesson only if the chosen answer is correct. | 81 (85.3%) | 14 (14.7%) | 0 (0%) | 0 (0%) |
| 4 | This package terminates my activities if after three attempts I got the answer wrong. | 34 (35.7%) | 60 (63.2%) | 1 (1.1%) | 0 (0%) |
| 5 | This package appreciates my efforts by congratulating me after completing the lesson correctly. | 87 (91.6%) | 8 (8.4%) | 0 (0%) | 0 (0%) |
| Total | | 378 (79.6%) | 95 (20.0%) | 2 (0.4%) | 0 (0%) |
| Summary of Agree and Disagree | | 473 (99.6%) | | 2 (0.4%) | |

Table 7 presents the frequent count and percentage of the content of feedback from the package from a total of 95 respondents, provides insights into user perception of the package's feedback mechanisms. The summary of "Agree" and "Disagree" responses indicates an overwhelmingly positive overall result. Out of a total of 475 responses. The 'Summary of Agree and Disagree' shows that 473 responses (99.6%) indicated agreement, while only 2 responses (0.4%) indicated disagreement. It was therefore

concluded that students' consensus on the appropriateness of the content feedback from the package was attained. This suggests a very high level of satisfaction and perceived effectiveness regarding the package's feedback features among the respondents. The features such as immediate feedback, clear audio-visual cues for correctness, progression based on mastery, and positive reinforcement are highly effective and well-received by the respondents.

Table 8: Frequent Count and Percentage of the Content of Screen Design of the Package (N=95)

| S/N | STATEMENT | RESPONSE | | | |
|--------------------------------------|--|-------------------------|-------------------------|----------------------|-------------------|
| | | SA | A | D | SD |
| 1 | The presentations of the information in the package attract my attention. | 72 (75.7%) | 23 (24.2%) | 0 (0%) | 0 (0%) |
| 2 | The use of proper lettering (fonts) in terms of style and size make the information legible. | 67 (70.5%) | 26 (27.4%) | 2 (2.1%) | 0 (0%) |
| 3 | The colors used for the various presentations are quite appealing. | 59 (62.1%) | 35 (36.8%) | 1 (1.1%) | 0 (0%) |
| 4 | The quality of the text, images, graphics and video are interesting. | 68 (71.6%) | 27 (28.4%) | 0 (0%) | 0 (0%) |
| 5 | The animations (moving picture) in the package assist in understanding the lessons better. | 89 (93.7%) | 6 (6.3%) | 0 (0%) | 0 (0%) |
| Total | | 355 (74.73%) | 117 (24.63%) | 3 (0.63%) | 0 (0%) |
| Summary of Agree and Disagree | | 472 (99.37%) | | 3 (0.63%) | |

Table 8 presents the frequent count and percentage of the content of screen design of the package from a total of 95 respondents, provides insights into user perception of the package's screen design features. The summary of "Agree"

and "Disagree" responses indicates an overwhelmingly positive overall result. Out of a total of 475 responses across all statements, 472 responses (99.37%) indicated agreement, while only 3 responses (0.63%) indicated disagreement.

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It was therefore concluded that students' consensus on the appropriateness of the content of screen design of the package was attained. This suggests a very high level of satisfaction and perceived effectiveness regarding the package's screen design among the respondents. The

elements of presentation, typography, colour scheme, multimedia quality, and animations are highly effective and well-received by the respondents, making the package engaging, legible, and conducive to learning.

Table 9: Frequent Count and Percentage of the Content of Learners' Preferences toward the Use of the PVLIP Compared to Physical Laboratory

| S/N | STATEMENT | RESPONSE | | | |
|--------------------------------------|---|------------------------------|-------------------------------|---------------------------|-------------------------|
| | | SA | A | D | SD |
| 1 | I prefer to learn physics practical with PVLIP than using the physics lab. | 66 (69.5%) | 27 (28.4%) | 2 (2.1%) | 0 (0%) |
| 2 | Learning Physics with an interactive package is more preferable to me than using text books. | 42 (44.2%) | 52 (54.7%) | 1 (1.1%) | 0 (0%) |
| 3 | The activities provided in the PVLIP are more effective compared to normal physics practical instruction. | 45 (47.4%) | 48 (50.5%) | 2 (2.1%) | 0 (0%) |
| 4 | I will suggest to my friends to use PVLIP in learning physics instead of textbooks. | 76 (80.0%) | 19 (20.0%) | 0 (0%) | 0 (0%) |
| 5 | I prefer the use of this PVLIP method to normal classroom instruction. | 71 (74.7%) | 24 (25.3%) | 0 (0%) | 0 (0%) |
| Total | | 300 (63.2%) | 170 (35.78%) | 5 (1.1%) | 0 (0%) |
| Summary of Agree and Disagree | | 470 (98.9%) | | 5 (1.1%) | |

Table 9 presents the frequent count and percentage of learners' preferences toward the use of the PVLIP (Physics Virtual Laboratory Interactive Package) compared to a physical laboratory from a total of 95 respondents, provides insights into learner preferences. The summary of "Agree" and "Disagree" responses indicates an overwhelmingly positive overall result. Out of a total of 475 responses across all statements, 470 responses (98.9%) indicated agreement, while only 5 responses (1.1%) indicated disagreement. It was therefore concluded that students' consensus on the appropriateness of the content of learners' preferences toward the use of the PVLIP compared to physical laboratory was attained. This suggests a very high level of preference for and satisfaction with the PVLIP among the respondents. The package's interactive nature and perceived effectiveness of its activities appear to be key drivers of this high level of acceptance and recommendation by the respondents.

CONCLUSION

This study successfully developed and validated a Physics Virtual Laboratory Instructional Package (PVLIP) as a viable solution to enhance the quality of physics education in Nigeria. The comprehensive validation process, involving both experts and students, consistently demonstrated overwhelmingly positive feedback across all aspects of the PVLIP, including its content, functionality, interactivity, navigation, feedback mechanisms, and screen design. The high agreement rates (consistently above 97%) underscore the PVLIP's potential to effectively address challenges such as inadequate laboratory equipment and abstract concepts in physics education. The PVLIP emerged as a highly effective, user-friendly, and engaging alternative to traditional physical laboratories, promoting active learning and improved comprehension of physics concepts among students.



RECOMMENDATIONS

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

1. The Ministry of Education and relevant educational bodies in Nigeria should consider integrating the PVLIP into the national physics curriculum as a supplementary or alternative learning tool, especially in schools with limited laboratory resources.
2. Comprehensive training programs should be developed for physics teachers to equip them with the necessary skills to effectively utilize the PVLIP in their instruction. This will ensure seamless adoption and maximize the benefits of the virtual laboratory.
3. Schools should be adequately equipped with functional computers and internet access to enable widespread access and utilization of the PVLIP. This addresses the current limitations of inadequate facilities in many Nigerian schools.
4. Future research and development efforts should focus on expanding the PVLIP to cover more physics concepts and explore its adaptability for mobile devices and online platforms, enhancing its accessibility and flexibility.
5. Continuous monitoring and evaluation of the PVLIP's implementation should be conducted to gather further feedback from users and ensure its sustained effectiveness and relevance in the evolving educational landscape.
6. Policymakers should champion policies that promote the development and adoption of virtual laboratories and other educational technologies as a strategic approach to improving the quality of science education in Nigeria.

REFERENCES

- Babateen, H. M. (2021). *The role of virtual laboratories in science education*. Singapore:
- Bunkure Y. I., & Saifullahi M. (2023). Effects of scaffolding technique on secondary school Physics students' academic achievement in Malumfashi Local Government, Katsina State, Nigeria. *Bayero journal of science, technology and mathematics (BAJOSTME)*
- Dick, W., Carey, L., & Carey, J. O. (2005). *Systematic design of instruction* (6th ed.). Glenview, IL: Harper Collins.
- Falode, O. C., & Gambari, A. I. (2017). Evaluation of virtual laboratory package on Nigerian secondary school physics concepts. *The Turkish Online Journal of Educational Technology*, 16(2), 168-177.
- Gambari, A. I., Falode, O. C., Fagbemi, P. O., & Idris, B. (2013). Efficacy of virtual laboratory on the achievement and attitude of secondary school students in physics practical. *Journal of Research in Curriculum*, 9(1), 9-20.
- Lyons, K. A., & Seow, L. (1992). *Design and technology*. Singapore: Addison Wesley Longman Singapore Pte Ltd
- Mahmoud, A., & Zoltan, K. (2009). The impact of the virtual laboratory on the hands - on laboratory learning outcomes, a two years empirical study. *20th Australasian Association for Engineering Education Conference*. University of Adelaide, 6-9.
- Ouahabi, S., Lahraoua, B., El Asri, B., & Talbi, M. (2021). Design and Implementation of a Virtual Laboratory for Physics Subjects in Moroccan Universities. *Sustainability*, 13(7), 3711. DOI: 10.3390/su13073711
- Usman, H., Alabi, T. O., Falode, O. C., & Muhammed, B. Y. (2024). Development and Validation of Virtual Laboratory Package for Effective Teaching and Learning of Biology Practicals in Secondary Schools in Nigeria. *ATBU Journal of Science, Technology & Education*, 12(1), 22-31.
- WAEC (2021). *Chief examiners' report*. Yaba, Lagos