



Development of Virtual Workshop Package for Electronic Practical in Technical Colleges, Nigeria

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Abstract

The study developed a Virtual Workshop Package (VWP) for Electronics Practical in Technical Colleges in the Six Geo-Political Zones, Nigeria involving a population of 138 subjects. Two research questions were answered. The instruments for data collection were the Virtual Workshop Functionality Questionnaire, Virtual Workshop Assessment Questionnaire (VWAQ), Virtual Workshop Usability Questionnaire. Hypertext Mark-up Language (HTML) and Cascading Style Sheets (CSS) were used for the user interface design, while Python (Django framework) was used for the logic and database in the development of the VWP. Findings revealed that the appropriate contents of a four-model VWP which are Domain Model involving the contents for Electronics Practical as well as the Student, Tutoring and User Interface Models were developed into a complete package. The VWP was found to have high ratings on functionality, validity and usability among the respondents. It was recommended among others that Workshops and Seminars should be organized by the various State Science and Technical Education Boards in Nigeria to create awareness among electronic teachers and students on the importance of the VWP.

Keywords: Virtual Workshop, Four-Models, Technical Colleges, Electronics Practical, Electronics Students and Electronics Teachers.

Introduction

Technical Colleges in Nigeria play a crucial role in equipping students with the practical skills and knowledge necessary for careers in various technical and vocational fields. These institutions are designed to bridge the gap between theoretical knowledge and practical application, preparing students for the demands of the rapidly evolving industrial landscape. In addition to theoretical knowledge, Nigerian Technical Colleges focus on providing practical training in areas such as automobile, electronics, metalwork, building, and other technical disciplines.

Most of the technical colleges in Nigeria struggle with outdated workshop equipment and facilities as well as inadequate provision and investment in modern tools and technologies which hampers students' exposure to current industry practices (Adeyinka, 2018). This is more so as insufficient financial support for technical education institutions limits their ability to maintain and upgrade workshops (Okebukola, 2016). This lack of functional equipment and funds affects the overall quality of practical training. Technical colleges often face a shortage of

experienced instructors who can effectively guide students through practical activities (Ibrahim, 2017). This dearth of qualified personnel impedes the transfer of cognitive and psychomotor skills in technical workshops thereby limiting students' exposure to practical skills essential in today's workplace. This creates a wide gap between the skills acquired in the technical schools and the skills needs of the industries.

Practical skills allow students to apply theoretical knowledge acquired in the classroom to real-world situations. As pointed out by Fitzgerald et al. (2018), hands-on experience bridges the gap between theory and application, reinforcing concepts and enhancing understanding. Engaging in practical projects fosters problem-solving skills when electronic students encounter challenges and learn to troubleshoot complex electronic circuits. As noted by Lee and Kang (2019), incorporating hands-on experience ensures that students acquire the technical skills demanded by employers, making them more competitive in the job market. These aspects collectively contribute to a well-rounded education that empowers electronic students

for success in the electronics industry which may be achieved with the use of virtual workshop.

A virtual workshop, also referred to as remote labs, represents a technological solution that enables students and researchers to conduct practical simulations in a virtual environment, rather than in traditional physical workshop settings. In the context of this study, the virtual Workshop package (VWP) was developed to cater for electronic practical in technical colleges. The VWP consisted of the main menu and a series of practical lessons. The topics included in the VWP that technical teachers with more than ten years or working experience perceived during round table discussion as being more difficult included: (1) Transformer, (2) Indicating Instruments, (3) Radio Transmission and Reception, (4) Oscillators, (5) Power Supply and (6) Radio and TV troubleshooting.

The VWP in this study is the four-model type presenting lessons in user-paced segments as recommended by Bourdeau & Mizoguchi (2010) consisting of: (1) Student Model which stores and updates data about students' performances in the subject domain; (2) Tutoring Model which controls the method of presentation of the practical lessons; (3) Domain Model in which the contents of the electronic practical which are to be taught to the learner were integrated; and (4) User Interface Model which ensures that the practical lessons are presented in user-paced segments rather than as a continuous unit. This innovative approach leverages advancements in technology to replicate real-world workshop experiences through digital platforms. This is because; virtual workshops offer several advantages in education and research.

VWPs provide accessibility to a wider audience, overcoming problems of overcrowded workshops as well as physical and geographical constraints. Students can engage in experiments from anywhere with or without an internet connection, fostering inclusivity and flexibility in learning (Majumdar, 2019). Additionally, virtual labs allow for the repetition of experiments without resource limitations, facilitating deeper understanding and skill development (Khan, 2016). These platforms often incorporate interactive simulations, 3D models, and multimedia elements to enhance the learning experience. As demonstrated by research, VWPs contribute to improved learning outcomes, increased students' engagement, and enhanced critical thinking skills (Abdurrahman & Ozturk, 2020). This technological solution continues to evolve, offering a

valuable alternative or complement to traditional Workshop practices in various scientific and engineering disciplines.

Several empirical studies related to the present research have indicated significant effect of VWP in enhancing students' cognitive and psychomotor skills in learning of technical subjects within and outside Nigeria. For instance, Hassan and Raymond (2019) developed an intelligent tutor which was found to enhance Think-Pair-Share learning of LED TV troubleshooting skills than Traditional Workshop Practice. Similarly, Oloyede and Adekunle (2009) developed a computer Instructional package on electrochemistry (ECIP) for secondary schools in Nigeria and found that the design of the ECIP conformed to the acceptable standards of Educational Technologists in terms of legibility, simulation and navigation.

On the other hand, Chen et al. (2020) had a contrary opinion, reporting that virtual reality can effectively improve knowledge acquisition, but was unsuitable in terms of skills development, satisfaction and confidence. Similarly, Nassar et al. (2017), Middleton et al. (2017), as well as Udogu and Igwe (2021) whose results were in agreement with that of William et al. (2015) observed that students taught through real object experience learn insignificantly better than those taught through computer simulation teaching technique. These contradictory findings prompted further investigation into the possibility of the development of VWPs for electronic practical.

While there is existing literature on the use of VWPs in the teaching and learning of both cognitive and psychomotor aspects of basic electronics concepts such as Ohm's Law and circuit analysis, there is a gap in the exploration of VWPs for wider applications in more advanced electronics topics such as electronic measurement, transformer as well as radio and TV troubleshooting and other complex aspects in teaching and learning of electronics in Technical Colleges, Nigeria. Furthermore, most of the VWPs developed in Nigeria focused on narrow areas with much emphasis on theoretical knowledge in electronics. Therefore, the effectiveness and feasibility of implementing VWP in the context of Nigeria technical colleges, especially in covering a wider range of practical experience in electronics remains largely unexplored. This research aimed to fill this gap in knowledge.

Objectives of the Study

The study developed a Virtual Workshop Package for electronics practical in technical colleges, Nigeria. The specific objectives are to:

1. Develop the Models of the VWP in terms of Student, Tutoring, User-Interface and Domain for electronics practical in technical colleges, Nigeria.
2. Ascertain that the Student, Tutoring, User-Interface and Domain Models of the VWP met software development specifications of functionality, validity and usability for electronics practical in technical colleges, Nigeria.

Research Questions

1. What are the appropriate contents of the Four (4) Models for electronic practical in Technical Colleges, Nigeria?
2. What is the functionality, Content Validity and Usability of the 4 Model VWP?

Methodology

The study adopted Research and Development (R & D) design to produce the VWP. The R & D method according to Gall *et al.* (2007) is concerned with the development of educational products and consists of ten stages. The 1st to 6th stages of the R & D method guided the researchers in ascertaining the instructional goals, students' characteristics, entry-level skills and expectations, assessment instruments and instructional strategies in the VWP to perform the intended instruction on electronic practical. This involved Desk Review to extract the practical contents from National Board for Technical Education (NBTE) approved electronic work syllabus at National Technical Certificate level as well as Round Table Discussion and interview to sieve out six most difficult aspects of the practical for inclusion in the VWP.

The Module design phase in this study which is the 7th stage in the R & D method was considered as the phase of the VWP prototype development using V-Model of Software Development Life Cycle (SDLC). As such, Hypertext Mark-up Language (HTML) and Cascading Style Sheets (CSS) were used for the user interface design, while Python (Django framework) was used for the logic and database. The criteria for selecting Python were based on: multimedia capability, data handling capability, ease of use and level of configuration with little or no difficulty on installation that met the software requirements specifications. The integration of every part of the VWP prototype was then tested to ensure that it works properly according to the

SRS acceptable standard by Computer Experts and educational technology experts using VWP Functionality Questionnaire (VWFQ). The prototype was modified and refined at various stages to correct or include some functions which were not originally included in the design specifications. For instance, the students' help line was debugged and included due to initial malfunction as suggested by one of the validators during the validation process. The main menu of the VWP consisted of students' registration, and list of six practical lessons.

The 8th stage of the R & D method which is on formative evaluation involved the testing of the developed VWP prototype in Government Technical Colleges, two from each of the six Geo-political regions in Nigeria using 18 electronic students from each school. The students used the VWP and rated it using the VWP Usability Questionnaire.

The ninth and tenth stages involved the revising of the VWP package based on the results from the formative evaluation and expert validation at various stages of the VWP development into an operational product. The population of the study was 138 subjects. This consisted of 10 computer programming experts and 8 experts in educational technology from various universities in Nigeria as well as 12 electronic teachers with more than ten years of teaching experience (1 from each of the 12 technical colleges purposely chosen across the six geopolitical zones) and 108 electronic students (18 from each of the 12 technical colleges). Only schools that had functional computer lab were used for the study.

The instruments for data collection were Virtual Workshop Functionality Questionnaire (VWFQ), Virtual Workshop Assessment Questionnaire (VWAQ) and Virtual Workshop Usability Questionnaire (VWPSQ). These instruments were validated by experts in computer science, educational technology and technical education to ascertain the face and content validities. The reliability index of the VWFQ, VWAQ and VWPSQ were computed using Cronbach Alpha, yielding indices of 0.89, 0.87, and 0.79 respectively.

Data collected in this project were analysed both at the formative and summative level. At formative level, the qualitative data collected from the desk review, round table discussion and interview were analysed using thematic analysis and used to develop the VWP model. The quantitative data collected from the survey questionnaires were analysed using

Percentage, Counts, Charts, Mean, and Standard Deviation.

Results

Research Question One: What are the appropriate contents of the Four (4) Models for electronic practical in Technical Colleges, Nigeria?

The student, Tutoring, User-Interface and Domain which are the four (4) Models of the VWP were developed through desk review, round table discussion and interview and the data was analysed using thematic analysis to come up with the expectations of the VWP to perform the intended instruction. The expectations of the VWP for electronic practical were carefully sorted out into a Software Requirement Specification (SRS) document as follows:

The VWP was expected to:

- Provide the benefit of one-on-one instruction of six lessons including (1) Transformer, (2) Indicating Instruments, (3) Radio Transmission and Reception, (4) Oscillators, (5) Power Supply and (6) Radio and TV troubleshooting.
- Store students' information such as name, level, registration number and year;
- Track the user's learning history and behavior;
- Force the learner to follow a strict sequence of lessons in learning of electronic practical;

- Provide clear demonstration of the virtual workshop of effective learning of electronic practical;
- Give students exercises at the end of each learning session;
- Provide timely feedback on attempted exercises and store student's performance;
- Give clear instructions using demonstration videos and help-line on how to use the software;
- Provide help to students so that their energy is mainly devoted on electronic practical and not struggling to use the VWP;
- If a student quit the program before completing a learning session, it should be possible to re-enter at the point where he or she gave up.

Research Question Two: What is the functionality, Content Validity and Usability of the 4 Model VWP?

The validation of the VWP was done in stages to ensure effective system delivery of electronic practical: (1) Functionality Test was done by software experts to ensure that the VWP development is in line with the SRS. (2) The second aspect of the validation was to scrutinize the contents of the domain model (electronic practical) to ensure that the practical lessons are in line with the approved syllabus. (3) Lastly, the Usability of the VWP was tested by the end users who are technical students at technical college level in Nigeria.

1. Functionality Test

The software experts and educational technology personnel checked all the functions of the VWP and ascertained that it was able to perform the expected tasks as follows:

Table 1: Functionality Analysis of the VWP by Software Experts

SN	Expectation/Requirement	Score (%)	Remark
1.	Provides the benefit of one-on-one instruction of six electronic practical including: Transformer, Indicating Instruments, Radio Transmission and Reception, Oscillators, Power Supply and Radio and TV troubleshooting.	98	Satisfactory
2.	Store students' information such as name, level, registration number and year	99	Satisfactory
3.	Track the user's learning history and behavior	97	Satisfactory
4.	Force the learner to follow a strict sequence of lessons in learning of electronic practical	98	Satisfactory
5.	Provide clear demonstration of the virtual workshop for effective learning of electronic practical	99	Satisfactory
6.	Give students exercises at the end of each learning session	96	Satisfactory
7.	Provide timely feedback on attempted exercises and store student's performance	97	Satisfactory



8.	Give clear instructions using demonstration videos and help-line on how to use the software	95	Satisfactory
9.	Students' energy should mainly be dedicated to the contents of the subject matter and not how to use the system	97	Satisfactory
10.	If a student quit the program before completing an instructional unit, it should be possible to re-enter at the point where he or she gave up	99	Satisfactory

The data presented and analyzed in Table 1 shows that the VWP software had very high system functionality output of 96-99%. This means that the package performed all the expected functions based on the requirement engineering that was conceived in the SRS document.

2. Content Validation

A designed validation guide instrument was administered to the participants and the data collected was analysed using count, percentage, mean and standard deviation. A mean of 2 and above indicates positive response while a lesser mean indicates negative response. The percentages were used in determining the degree of the respondents' responses. The results of the analysis were presented in Table 2 and Figure 5.

**Table 2: Validation Results of Electronics VWP**

S/N	Statement	1	2	3	Total	\bar{X}	SD	Remark
1.	Adequacy of the practical in relation to the National Educational Research and Development Council/National Business and Technical Examinations Board (NABTEB) curriculum.	2(16.7%)	6(50%)	4(33.3%)	12(100%)	2.17	0.75	Moderately Adequate
2.	Adequacy of the practical in relation to the scheme of work.	0(0%)	4(33.3%)	8(66.7%)	12(100%)	2.67	0.52	Very Adequate
3.	How the practical in the VWP reflect the actual practical conducted in senior secondary school?	0(0%)	10(83.3%)	2(16.7%)	12(100%)	2.17	0.41	Moderately Reflected
4.	Is there any practical in the software that is not conducted in your school?	12(100%)	0(0%)		12(100%)	1.00	0.00	No
5.	Appropriateness of the arrangement of the practical in order of simplicity and relevance.	0(0%)	4(33.3%)	8(66.7%)	12(100%)	2.67	0.52	Very Appropriate
6.	Relevance of the practical in achieving the learning outcomes.	0(0%)	2(16.7%)	10(83.3%)	12(100%)	2.83	0.41	Very Relevant
7.	Adequacy of the practical in achieving the learning outcomes.	0(0%)	8(66.7%)	4(33.3%)	12(100%)	2.33	0.52	Moderately Adequate
8.	Suitability of the items required for conducting the practical.	0(0%)	6(50%)	6(50%)	12(100%)	2.50	0.55	Suitable
9.	Adequacy of the items required for conducting the practical.	0(0%)	6(50%)	6(50%)	12(100%)	2.50	0.55	Adequate
10.	Suitability of the apparatus for conducting the practical.	0(0%)	8(66.7%)	4(33.3%)	12(100%)	2.33	0.52	Moderately Suitable
11.	Adequacy of the apparatus for conducting the practical.	2(16.7%)	8(66.7%)	2(16.7%)	12(100%)	2.00	0.63	Moderately Adequate
12.	Accuracy of the steps involves in conducting the practical.	2(16.7%)	2(16.7%)	8(66.7%)	12(100%)	2.50	0.84	Very Accurate
13.	Appropriateness of the stated procedure in conducting the practical in relation to the students' ability level.	2(16.7%)	4(33.3%)	6(50%)	12(100%)	2.33	0.82	Very Appropriate
14.	Accuracy of the result(s)/outcome(s) of the practical.	0(0%)	2(16.7%)	10(83.3%)	12(100%)	2.83	0.41	Very Accurate
15.	Appropriateness of the evaluation questions in assessing the learning outcomes.	0(0%)	6(50%)	6(50%)	12(100%)	2.50	0.55	Appropriate
16.	Adequacy of the evaluation questions in covering the learning outcomes.	2(16.7%)	2(16.7%)	8(66.7%)	12(100%)	2.50	0.84	Very Adequate
17.	Clarity of the evaluation questions in line with the students' ability level.	0(0%)	6(50%)	6(50%)	12(100%)	2.50	0.55	Very Clear
Overall Responses		5(5.21%)	42(43.75%)	49(51.04)	96(100)	2.46	0.60	Highly Valid

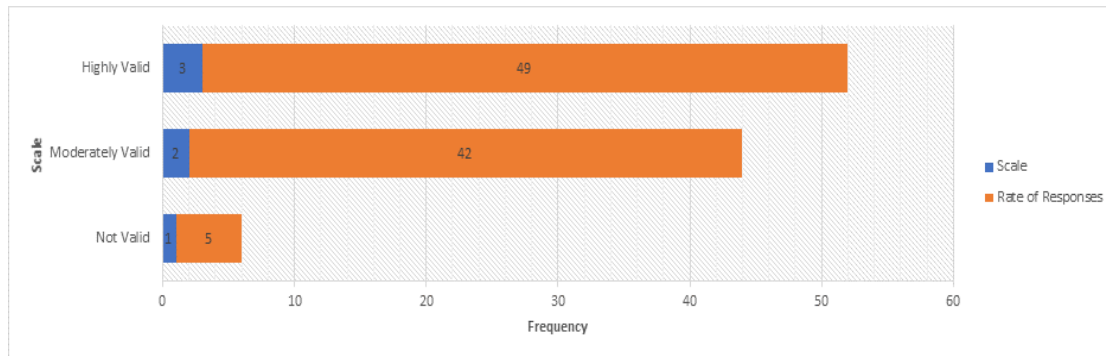


Figure 5: Overall Validity Assessment of Electronics Virtual Workshop Package

Results in Table 2 shows that the content and face validity of the Electronics Virtual Workshop Package received moderate to high rating from the respondents and the overall assessment shows that 49(51.04%) of the participants' responses revealed that the software is highly valid (Figure 5).

Usability Validation

The usability testing was conducted on three major constructs: "Effectiveness", "User-friendliness" and "Ease of Use". After performing the task, the users completed a questionnaire based on their experience of the test.

a. Effectiveness Evaluation

This evaluation was done by students and the data were analysed using mean (average rating) as presented in the Table 3, 4, and 4. A pictorial presentation is also shown in Figure 6, 7 and 8 as follows:

Table 3: Mean Rating of Electronic Students on the Effectiveness of the VWP

SN	Question	\bar{X}
1	How good is the virtual lab at helping students to identify the available practical?	4.47
2	How effective is the virtual lab in helping the students to conduct practical?	4.32
3	How good is the virtual lab at helping students to identify the available apparatus?	4.39
4	How good is the virtual lab at helping students to identify the procedure of conducting an experiment?	4.40

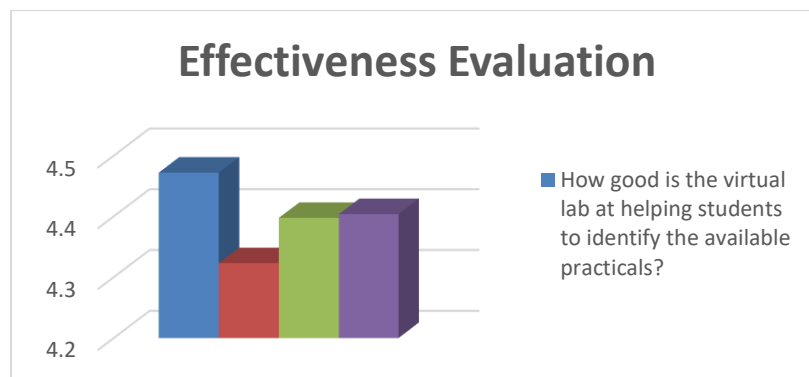


Figure 6: Pictorial presentation of effectiveness evaluation

Data presented and analyzed in Table 3 and Figure 6 in relation to **Effectiveness Evaluation**, shows that the average rating for the four questions is in the range of 4.4 – 4.47 on a scale of 1 – 5, with 5 being the highest preferred rating. This shows the virtual lab application is effective.

b. User Friendliness Evaluation

Table 4: Mean Rating of Electronics Students on the User Friendliness of the VWP

SN	Question	\bar{X}
1	How helpful is the design of the home page in finding the desired practical?	4.27

2	How helpful is the practical page in helping students to identify all the apparatus?	4.39
3	How helpful is the practical page in helping students to identify the procedure?	4.40
4	How clear are the texts or images on items in explaining the functions of the items?	4.34
5	Is the size of the texts and images big enough so that it is easy to be seen and read by user?	4.45
6	Is the system running smoothly and responsive to user action (e.g. page changes after user click on a button)?	4.10

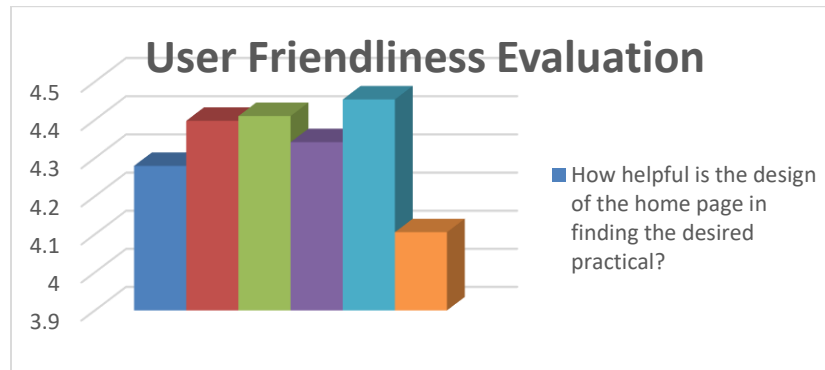


Figure 7: Pictorial Presentation of User Friendliness Evaluation

Data presented and analyzed in Table 4 and Figure 7 in relation to **User Friendliness Evaluation**, the average rating for the four questions is in the range of 4.11 – 4.45 on a scale of 1 – 5, with 5 being the highest preferred rating. This shows the virtual lab application is user-friendly.

c. Ease of Use Evaluation

Table 5: Mean Rating of Electronics Students on the Ease of Use of the VWP

SN	Question	\bar{X}
1	I think that I would like to use this system frequently	4.57
2	I found the system unnecessarily complex	2.72
3	I thought the system was easy to use	4.03
4	I think that I would need the support of a technical person to be able to use this system	3.59
5	I found the various functions in this system were well integrated	4.37
6	I thought there was too much inconsistency in this system	2.46
7	I would imagine that most people would learn to use this system very quickly	4.44
8	I found the system very cumbersome to use	2.93
9	I felt very confident using the system	4.40
10	I needed to learn a lot of things before I could get going with this system	3.61

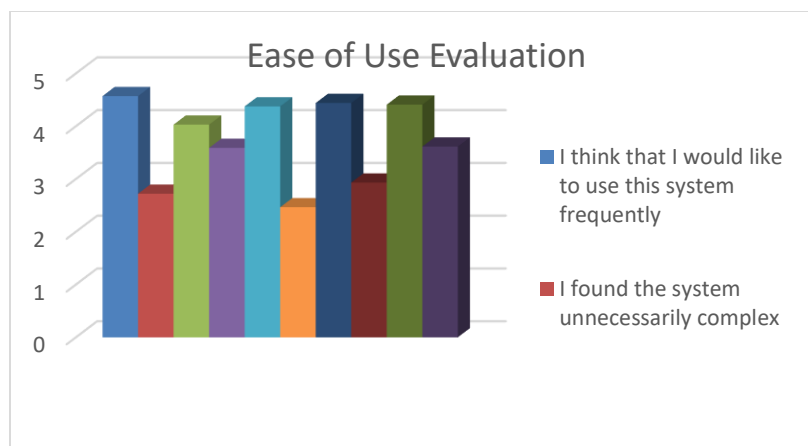


Figure 8: Pictorial Presentation of Ease of Use Evaluation

Data presented and analyzed in Table 5 and Figure 8 in relation to the **Ease of Use Evaluation**, there are six positively worded questions and has an average rating in the range of 4.41 – 4.57 on a scale of 1 – 5, with 5 being the preferred rating. This shows the virtual lab application has a good ease of use evaluation score. On the other hand, the negatively worded questions have an average rating in the range of 2.72 – 3.59 on a scale of 1 – 5 with 1 being the preferred score.

Discussion of Findings

The finding on objective one revealed that the following include the appropriate contents of the Student, Tutoring, User Interface and Domain Models of the VWP for electronic practical: **Student Model:** (a) Recognition of individual student by the VWP; and (b) Provision of user ‘log-in and out’ interface in the VWP. **Tutoring Model:** (a) Controlling the presentation of the instructional knowledge; (b) Adaptive presentation of lessons on electronic practical; and (c) Consistency of the format of presentation of lessons. **User Interface Model:** (a) Time taken in providing feedback to options selected by students; (b) Clarity and ease of operation and selection of menus in the VWP; (c) Ease of interaction between students and other aspects of the VWP. **Domain Model:** Practical lessons on (1) Transformer, (2) Indicating Instruments, (3) Radio Transmission and Reception, (4) Oscillators, (5) Power Supply and (6) Radio and TV troubleshooting. This finding is concurrent with that of Oloyede and Adekunle (2009) who developed a computer Instructional package on electrochemistry (ECIP) for secondary schools in Nigeria and found that the design of the ECIP conformed to the acceptable standards of Educational Technologists in terms of legibility, simulation and navigation.

Findings with regard to the validity of the Electronics Virtual Workshop Package received high rating from the participants and the overall assessment of the participants’ responses indicates that the subject matter contents of the software is highly valid. More so, it was

found that the VWP has met the software development for teaching and learning of electronics work in technical colleges, Nigeria. This validation result is similar to that of Yuniarti, Yeni and Yokhebed (2017) who conducted a study on Development of Virtual Workshop Based on Interactive Multimedia on Planting and Painting Bacteria. Similarly, the finding is congruent with that of Serevina, and Kirana (2019) in a study on Development of virtual Workshop assisted by Flash and PhET to support distance learning. Moreover, Sasmito and Sekarsari (2022) finding on enhancing students’ understanding and motivation during Covid-19 pandemic via development of virtual Workshop is also in agreement with this finding.

The success of the VWP in enhancing students cognitive and psychomotor skills achievement can be linked to the components of the software which provide virtual representation of the properties of traditional workshop practice interactively. Besides, the software provide virtually effortless environment through which students can acquire and learn a lot. This is unlike the traditional workshop practice that requires use of energy which can cause exhaustion and reduction in interest and motivation.

Conclusion

The research sought to develop virtual Workshop software for electronic practical at technical college level in Nigeria. The appropriate contents of the Student, Tutoring and User Interface Models of the



VWP for effective teaching and learning of the subjects were fully developed and found have high rate of functionality and received high rating from technical teachers indicating that the software is highly valid. Electronics students rated the VWP suitable in terms of “Effectiveness”, “User-friendliness” and “Ease of Use.

Recommendations

Based on the findings it was recommended that:

1. Workshops and Seminars should be organized by the various State Science and Technical Education Boards in Nigeria to create awareness among electronic teachers and students on the importance of the VWP as it has been found to high functionality and usability rating among the end users.
2. An intervention in form of teacher training/development programme should be initiated by the States Science and Technical Education Boards in Nigeria to train existing electronic teachers on the use of the VWP for teaching and learning of electronics practical at technical college level.
3. State and Federal Ministries of Education should provide the needed support in terms of facilities and equipment for the planning, inclusion and implementation in the use of the VWP for electronics practical in Technical Collages in Nigeria.

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