

DESIGN AND DEVELOPMENT OF AN ONLINE CBT SOFTWARE FOR ASSESSMENT AND EXAMINATION IN THE DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION, UNIVERSITY OF JOS

¹Dung, Choji Joseph, ²Benard Augustine Adakole, ³Gwani, Enoch Musa and ⁴Yagwom, Manseh Bulus

^{1,2&3}Department of Science and Technology Education, Faculty of Education, University of Jos, ⁴Department of Industrial Technology Education Faculty of Vocational and Technical Education, University of Nigeria, Nsukka

Email:chojidung48@gmail.com, pheelzconnect@gmail.com, enochgm@unijos.edu.ng, yagwommanseh@yahoo.com

ABSTRACT

This study was on the Design and Development of an Online CBT Software for Assessment and Examination in the Department of Science and Technology Education, University of Jos. In other to achieve this objective, three specific objectives were raised. In line with these objectives, three research questions were formulated and three hypotheses were posited. This study adopted Research and Development (R&D) design based on the theoretical foundation of Iterative life cycle. The CBT Software was developed as a web application using HTML, CSS, Angular 12, Java 11, Spring boot with Rest API and MySQL. The software was developed and deployed to a Virtual Private Server (VPS) for testing. The estimated population of the study is 3460. The sample size is 110, comprising of 100 students, 6 lecturers, and 4 software developers taken for the study. The data collected were presented in tables and analyzed using mean and standard deviation. The hypotheses were tested using t-test statistic at $p < 0.05$ level of significance. The CBT software was validated and tested and used by students and staff for taking and computing student examination and assessment; the staff and students rated the CBT software as simple, flexible, user friendly, reliable, fast, accurate, consistent, secure, responsive and of good colour quality. Furthermore, the findings on hypotheses tested using t-test statistic at $p < 0.05$ level of significance. The hypotheses revealed that, there is no significant difference in the mean responses of software developer and lecturer on the software requirement specification used in developing the Computer Based Test (CBT); there is no significant difference in the mean responses of software developer and lecturer on the software design that guides the development of the Computer Based Test (CBT); there is no significant difference in the mean responses of male and female student ease of use of the Computer Based Software (CBT). It is recommended that the developed CBT software should be adopted by tertiary institutions and examination especially for courses having large number of students which makes marking and invigilation of exam difficult. This will go a long way to curb examination malpractices amidst student and also help in marking of examination scripts and issues related to missing student's examination scripts.

KEYWORDS: Computer Based Test (CBT), E-Examination, Assessment. Design and Development of CBT application

INTRODUCTION

All formal education; whether traditional type (involving face-to-face contact) or electronic-learning is subjected to a form of assessment at the end of the learning period. Evaluation, test, assessment, or examination is a term synonymously used as a measure of the level of knowledge acquisition by the trainees at the end of their learning period. According to Emaikwu (2012), examination as part of evaluation in education is aimed at determining a learner's level of skill acquisition or intellectual competence and understanding after a given period. Ogunlade et al. (2014) defined evaluation as a way of assessing a system in order to make a declaration on the outcome of that system. And when talking about evaluating, assessing and testing students' academic performance, there are several ways in which this can be done. We have the paper and

pencil method, the oral method and the Computer Based Test (CBT) which is our major concern in this work.

Examination or Assessment is one of the best methods of evaluating an individual knowledge and ability. Its purpose is to assess how much each student has learned compared to fellow students in the same course or learning situation. Various methods of assessing student knowledge are being used in the department of Science and Technology Education and even the university at large to assess academic progress, such as paper-pencil based assessment/test, examination, assignments, presentations, etc. These methods are referred to as traditional methods. Traditional assessment or examination refers to a formal examination administered through question papers to which students respond in the form of written answers to a limited choice of previously unseen examination questions, set in advance and answered in examination hall where invigilators (examination supervisors) prevent communication between students and prohibit the use of notes or other revision aids.

Examination malpractice is a serious problem being encountered by teachers using the traditional method of giving examinations. Since exams are all the same in format and content, students can easily create tactics or strategies on how to cheat. This problem can be greatly reduced by Computer Based assessment.

Over the years, there have been various automated examination or e-testing systems that have been developed with one or more limitations. Some of these limitations include lack of scalability, near-reliability, lack of robustness, lack of flexible timing functionality to automatically log-off student upon expiration of allotted time as a challenge (Ipaye as cited Adebayo 2014); malpractice due to questions not randomly generated (Ayo et al, 2007); not well secured application domain in terms of data security and integrity (Levy & Ramim in Carlton 2019); most existing computer based test (CBT) systems are deployed as stand-alone applications that run on distributed networks making access to such applications restricted to the networked geographical domain and are only suited for the application environment only (Hushti & Petho in Rathi, 2017). With the constant change around the world there is need for improve system. As such, no unified development model exists and this alone undermines the success of the e-assessment platform for real-time adoption in practice. These limitations for a better and more efficient Computer Based Test Software that will overcome these challenges and also provide the administrator or teacher so dynamically manage and determine how their student is been assessed without much stress and delay.

The world is in its industry revolutionaries stage (the 4.0 industrial revolution). The development of this generation of revolution has not come off the influence of education (Manurung, A., Fildzah, A., & Rajagukguk, J. 2019). One of the attempts to be done is to connect between education and the development of technology. The use of computers had become very popular in education sector in the last few decades. Computers are used in education from presenting the lesson to student examination. Computer-based testing (CBT) has emerged as one of the recent "innovative" approaches to assessments most pursued by states. CBT is lauded as the answer to having cheaper and speedier test delivery for state and district-wide assessments (Thurlow, et al., 2010). Virtually errorless high speed data processing feature has made computers accepted assessment tools in education (Akdemir, et al. in Albers 2015). Testing based paper and pencil had become obsolete and left behind and start to use computers as a tool for saving, accessing, and processing the test (Csapó, B., Ainley, J., Bennett, R. E., Latour, T., & Law, N. (2012). This assessment is known as a Computer Based Test (CBT).

The Department of Science and Technology Education under the faculty of Education University at present comprises of 17 units which include, Biology Education, Integrated Science Education, Computer Science Education etc. Testing based paper and pencil had become obsolete and left behind and start to use computers as a tool for saving, accessing, and processing the test (Martin, 2008). This assessment is known as a Computer Based Test (CBT). At present, the traditional assessment method used is mainly based on paper and pen (PPT). The shortcoming of

this method are overload of work for lecturers, delay of statistics and evaluation due to large crowd of students, error-prone, missing examination or test result etc. With the popularity of computers and the development of the network, we need a new test platform to solve these problems. Hence the need for a technology-based approach to solving these challenges with the use of Computer Based Test applications.

STATEMENT OF THE PROBLEM

The problems posed by traditional methods of taking assessments or examinations are enormous. The situation is the same in the University of Jos, and correspondingly, Science and Technology Education department. The use of Information and Communication Technology (ICT) has been effectively applied to almost all human endeavours such as banking, businesses, health and of course education or what is better known as e-assessment there remains a very big vacuum to be filled in many areas, especially in the area of University Education in Nigeria (Ayo, et.al 2007). Also, the challenges faced with Pencil-Paper Test (PPT) or Paper-based test is overwhelming, they include but are not limited to exam malpractice, inaccuracy in marking, delay in marking results.

These challenges do not help in the growth of the education sector in Nigeria. Hence there is a need to replace the traditional way of assessing students which were characterized by massive examination leakages, impersonations, demand for gratification by teachers, bribe-taking by supervisors and invigilators of examinations, missing scripts or paper etc. By the electronic method, we mean by developing a Computer Based Test (CBT) system that can overcome these challenges.

There has been a growing interest in recent years in developing and using Computer based tests in educational assessment especially in Nigeria. The Joint Admission Matriculation Board (JAMB), the body responsible for admission into Nigerian University went a step higher in 2013 with the use of Computer based tests (CBT) software in conducting her examination and also the Nigeria Universities for Post Unified Tertiary and Matriculation Examination (Post-UTME) otherwise called pre-admission screening, Olawale and Shafi'i (2010) cited in Angela (2021). It becomes necessary and timely innovation to keep with technological trend.

However, despite the fact that the department of Science and Technology Education, University of Jos has commenced its operation for a long time, there has not been any research work carried out to determine whether it is generally acceptable by the students across units and whether students field of specialization influences their perception of the CBT/e-assessment platform or better still check its efficiency on their academic performance. Hence this study seeks to design and develop an online Computer Based Test for the department of Science and Technology Education, University of Jos.

PURPOSE OF THE STUDY

The main purpose of this study was to design and develop a Computer Based Test software for online assessment and examination in the department of Science and Technology Education, University of Jos. Specifically, the study sought: -

1. To determine the software requirement specification (SRS) for developing a Computer Based Test software.
2. To develop the software according to the SRS and software design.
3. To determine the ease of use of the Computer Based Test among students in Science & Technology Department, University of Jos.

RESEARCH QUESTIONS

The following research questions were raised to guide the conduct of this study:

1. What are the software requirement specification for developing a Computer Based Test Software?

2. To what extent does the developed Computer Based Test conform to the software design that guides its development?
3. To what extent does the developed CBT system useful to the student of Science and Technology department, University of Jos?

HYPOTHESES

The following null hypotheses were formulated to guide the study:

1. There is no significant difference in the software requirement specification used in developing the Computer Based Test (CBT).
2. There is a significant difference mean response on the software design that guides the development of Computer Based Test.
3. There is no significant difference in the mean score of male and female student's response on the use of the Computer Based Test.

METHODOLOGY

This study adopted Research and Development (R&D) design of which purpose is to develop and validate the products (Gall, Gall & Borg, 2007). The R and D design was considered for this study in that it aimed at developing a new product for Science & Technology department, University of Jos. In order to get the expected product which meets the standard and needs of the institution, the researcher adopted the model of research and development suggested by Gall, Gall & Borg (2007) because this model is the most comprehensive of the other models since this model involves the process of planning, developing, validating and revising. The 10 steps are:

research and information collection, develop preliminary form of product, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, final product revision, dissemination and implementation.

University of Jos was adopted as the area of the study which is in Jos North Local Government Area of Plateau State, Nigeria. This study was conducted in University of Jos, Plateau State, Nigeria. Department of Science and Technology Education was used for the study.

The population of the study is 3460. The population comprises 156 lecturers of Science and Technology Education department, University of Jos and 3300 students of Science & Technology department, University of Jos.

The sample size for this study is 110. The sample comprises of 100 students in the department of Science & Technology Education, University of Jos and 6 lecturers in the department of Science & Technology Education, University of Jos and 4 software developers. Simple random sampling technique was used for the study.

The instrument for data collection is the structured questionnaire. The instrument is the Software Requirement Specification Questionnaire (SRSQ), Computer Expert Validation Questionnaire (CEVQ) and Student Ease of Use Questionnaire (SEUQ)

Firstly, Software Requirement Specification Questionnaire (SRSQ) was used for data collection. It sought to gather information on what should be the specifications that will guide the development of the CBT. The SRSQ that was administered involved gathering information on how best the structure of CBT system should be, appropriate computer language to be used in development of the CBT, and compatibility issues which was administered to software developers, and Science and Technology Education lecturers of University of Jos. The requirement specifications were collected and used in the development process.

The Computer Expert Validation Questionnaire (CEVQ) was administer to 4 staff in the department of Science and Technology Education, University of Jos and 2 software developers. The data was collected and their suggestions and opinions on ease of use were elicited.

The Student Ease of Use Questionnaire (SEUQ) was administered to 100 students from the department of Science and Technology Education, University of Jos. The data collected on the ease of use of the software was collected, their suggestions and opinions on ease of use were elicited.

The research instruments were validated by 3 lecturers in the department of Science & Technology Education, University of Jos. The lecturers validated the instruments by face and by content.

The reliability of the instrument was tested using Cronbac Alpha reliability analysis. The reliability of the instruments was as follows: The Software Requirement Specification Questionnaire has a reliability coefficient of 0.6. The Computer Expert Validation has a reliability coefficient of 0.6. The Student Ease of Use Questionnaire has a reliability coefficient of 0.7

Statistical Package for Social Sciences (SPSS) version 25.0 for windows was used for the analysis of the research questions. Research questions 1, 2, and 3 was answered using Descriptive Mean Statistics of Mean score and Standard Deviation. The hypotheses 1,2, and 3 would be answered using independent sample T-test.

RESULTS

The results of data analysis are presented in the following tables in accordance with the research questions raised and hypothesis formulated for the study.

Research Question One: What are the software requirement specifications for developing Computer Based Test (CBT) software?

Table 1: Mean responses of the Software Requirement Specifications for the development of CBT.

S/No	Items	Mean	Std. Deviation	Remarks
1	CBT Software should be a web application	3.80	0.422	Highly Required
2	The software should allow students registration	3.60	0.699	Highly Required
3	The software should have navigation menus on dashboard	3.70	0.483	Highly Required
4	Students should be able to update their information	3.50	0.527	Highly Required
5	Time and duration of examination should be created and able to update	3.60	0.516	Highly Required
6	The CBT should allow multi choice examination questions	3.20	0.919	Highly Required
7	Students should be logged in to take the examination	3.20	0.919	Required
8	It should display the result of exam to student after the examination	3.20	1.135	Not Required
9	Previous and next button should be removed from test page	3.50	0.707	Highly Required
10	Timer should keep counting at the top right on the test page	3.20	0.919	Required
11	It should allow students to select multiple options	3.30	1.252	Highly Required
12	It should allow pdf and xls to download students results	3.00	1.155	Highly Required
13	It should allow students to start simultaneously	3.30	0.949	Highly Required
14	It require the use of internet	3.50	0.707	Highly Required
15	It should submit and Logout all students when time elapse	3.60	0.699	Highly Required
16	It should validates students information upon successful registration	3.60	0.516	Highly Required
17	Admin should be able to updated students record	3.10	0.738	Required
18	Only next button should be provided at the bottom right on the test page	3.50	0.972	Highly Required
19	It should be responsive on mobile and desktop	3.30	1.059	Highly Required
20	Matriculation number and password should be the access grant type	3.60	0.699	Highly Required

Table 2 showed the result of the software requirement specification analysis of the Computer Based Test. The items rated by respondents as Required and Highly Required were accepted as requirement specifications for the development of Computer Based Test

Research Question Two: To what extent does the developed Computer Based Test conform to the software design that guides its development?

The data for answering this research question were presented in the table below.

Table 2: Result of Computer Expert Validation

S/No.	Items	Mean	Std. Deviation	Remark
29	Clarity and ease of use procedure	4.17	0.408	Very Good
30	Colour quality	3.83	0.753	Very Good
31	Server Compatibility	3.50	0.837	Good
32	Ease of menus and navigation	3.83	0.408	Very Good
33	Clicks and responses	4.50	0.548	Excellent
34	Speed of navigation/ quick response time	4.33	0.816	Excellent
35	Font size and style	4.00	0.632	Very Good
36	Error Prevention/ detection	3.83	0.408	Very Good
37	Overall Reliability	3.83	0.753	Very Good
38	Level of Security	3.83	0.408	Very Good
39	Maintenance of the application software	3.67	0.516	Very Good
40	Software packaging	3.83	0.753	Very Good
41	Overall quality standard of CBT	4.33	0.516	Very Good
42	Hardware/Platform compatibility	4.33	0.516	Very Good
43	Consistency with user interface design	3.50	0.548	Excellent
44	Responsiveness	4.00	0.632	Very Good
45	Information retrieval	4.20	0.447	Very Good

Table 2 above showed the result of the computer expert validation the Computer Based Test. Table 2 revealed that all the items had mean scores between 3.50 to 4.50, which means the items were rated to range between very good to excellent. However, item 3 (Server compatibility) was rated good but will need to be improved upon. The overall rating of CBT in computer expert validation is very good with an overall mean score of 4.50.

Research Question Three: To what extent does the developed CBT system useful to the student of Science and Technology department, University of Jos?

The data collected for this research question was presented in the table below based on the usefulness of the of the CBT to the students of Science and Technology Department.

Table 3: Result of Student's ease of use of the CBT

S/No.	Items	Mean	Std. Deviation	Remark
61	The CBT software is flexible	3.29	0.701	Agree
62	The CBT software is user friendly	3.49	0.502	Strongly Agree
63	The button and links are well positioned	3.37	0.580	Agree
64	The CBT software have good color quality	3.49	0.541	Strongly Agree
65	The menus are easy to locate	3.44	0.556	Agree
66	There is adequate response time	3.29	0.574	Agree
67	Accessing the CBT software is easy	3.39	0.567	Agree
68	The CBT software timing and duration is tallies with local time	3.41	0.605	Strongly Agree
69	This software is responsive on mobile and web	3.31	0.734	Agree
70	Creating of account is easy	3.34	0.623	Agree
71	It is easy in taking examination/test compared to paper-based test	3.33	0.652	Agree

72	It support network connectivity via mobile network, router and hotspot	3.37	0.597	Agree
73	Loading of questions is fast	3.16	0.581	Agree
74	It has the appropriate feedback on completion of assessment	3.20	0.620	Agree
75	It provides appropriate response feedback to action	3.37	0.509	Agree

The table showed the result of the response from the student ease of use of the CBT software. The table revealed that the fifteen (15) items considered for the validation ranged from Agree to Strongly Agree. The mean scores of the items ranged between 3.16 to 3.49. The overall rating of CBT software on student ease of use is Agree with a mean score of 3.35.

HYPOTHESES

Hypothesis One: There is no significant difference in the software requirement specification used in developing the Computer Based Test (CBT).

Table 4: Summary of T-test result software requirement specification between software developers and lecturers

Group	N	Mean	S.D	Df	α	T	t-Critical	Sig. (2-tailed)
Software Developer	4	3.31	0.36	8	0.05	1.083	2.306	0.310
Lecturer	6	3.54	0.29					

From the statistics presented in table 4, it reveals that the software developer response mean score is 3.31 with standard deviation of 0.36 while the lecturer response mean score is 3.54 with standard deviation of 0.29. The observed t-value is found to be 1.083 while the t-critical value was found to be at 2.306 at 0.05 significant level.

Since the value of t is less than t-critical, the null hypothesis is upheld. The finding presented in table 4 implies that there is no significant difference in the mean responses of software developer and lecturer on the software requirement specification used in developing the Computer Based Test (CBT).

Hypothesis Two: There is a significant difference mean response on the software design that guides the development of Computer Based Test

The data generated from the hypothesis testing is shown in Table 5.

Table 5: Summary of T-test result of software design that guides the development of CBT between software developers and lecturers

Group	N	Mean	S.D	Df	α	t	t-Critical	Sig. (2-tailed)
Software Developer	4	3.97	0.21	4	0.05	0.049	2.776	0.963
Lecturer	6	3.99	0.37					

From the statistics presented in table 10, it reveals that the software developer response mean score is 3.97 with standard deviation of 0.21 while the lecturer response mean score is 3.99 with standard deviation of 0.37. The observed t-value is found to be 0.049 while the t-critical value was found to be at 2.776 at 0.05 significant level.

Since the value of t is less than t-critical, the null hypothesis is upheld. The finding presented in table 5 implies that there is no significant difference in the mean responses of software developer and lecturer on the software design that guides the development of the Computer Based Test (CBT).

Hypothesis Three: There is no significant difference in the mean score of male and female student's response on the use of the Computer Based Test.

The data generated from the hypothesis testing is shown in Table 6.

Table 6: Summary of T-test result of student's ease of use of the CBT between male and female students

Gender	N	Mean	S.D	Df	α	t	t-Critical	Sig. (2-tailed)
Male	48	3.25	0.79	98	0.05	0.547	1.987	0.586
Female	52	3.33	0.62					

From the statistics presented in table 6, it reveals that the male student's response mean score is 3.25 with standard deviation of 0.79 while the female response mean score is 3.22 with standard deviation of 0.62. The observed t-value is found to be 0.547 while the t-critical value was found to be at 1.987 at 0.05 significant level. Since the value of t-calculated is less than t-critical, the null hypothesis is upheld. The finding presented in table 12 implies that there is no significant difference in the mean responses of male and female student ease of use of the Computer Based Software (CBT).

DISCUSSION

The data presented in table 1 shows the result of the software requirement specifications used for developing the Computer Based Test (CBT) software which provides answers to research questions 1. The data presented in Table 2 shows the result of the assessment on CBT software by software developers and computer experts which provides answers to research question 2 which addresses the extent to which the developed CBT conforms to the architectural design that guided the development. All the items such as server and platform compatibility, flexibility and extensibility to architectural flow diagram, conformity to the user interface, conformity to the use-case view of the CBT and extensive use of the specified software design tools for the CBT were rated very good to excellent. This is in line with the opinion of Oberscheven (2013) that software assessment is done to assess functional and structural quality which provides functions that meets the stated and implied needs when used under specified conditions for performance, efficiency and usability with which a product or system can be modified by the intended maintainers.

The data presented in table 3 shows the result of the ease of usefulness of the CBT software by students of Science and Technology Education department which provides answers to research questions 3 which address the ease of use of the developed CBT software to students.

In table 4,5, and 6, the data collected were analyzed using the T-test statistics at $p < 0.05$ level of significance, to test the hypothesis formulated.

CONCLUSION

From this study, it can be concluded that the design and development of CBT in Science and Technology Education, Faculty of Education, University of Jos is suitable and appropriate as this will bring into line the same standard with other Universities in the technological world in the use of CBT for online assessment and examination. Proffering alternative solutions to contemporary issues of using the paper based test. Hence,

- The developed software served as an alternative tool for students in taking examinations in their respective level.
- The developed software was a useful tool for the staff of Science and technology Education in the preparation and checking of examinations as well as the maintenance of student results.
- The developed software was a tool equipped with security features useful in minimizing cheating during examinations among students.
- The developed software also provided a useful tool in administering online exams rather than the traditional paper-based exams.

RECOMMENDATION

In view of the result emanating from this study and conclusion reached, the following recommendation were made:

- The developed Computer Based Test should be adopted by tertiary institution for taking examination especially for courses having large number of students which makes marking and invigilation of exam difficult. This will go a long way to curb examination malpractices amidst student and also help in marking or examination scripts and issues related to missing student examination scripts.
- The developed Computer Based Test should be adopted by professional examination bodies like the National Business and Technical Examination Board (NABTEB), West Africa Examination Council (WAEC), Institute of Chartered Accountants of Nigeria (ICAN), National Examination Council (NECO) etc. to explore the vast opportunities provided by ICT in the educational system especially as it concerns student assessment.
- Software companies should adopt the developed Computer Based Test in this study for their employee entrance assessment.

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