TESTING THE EFFECTIVENESS OF DEVELOPED, CHEMISTRY ESSAY COMPUTER BASE EXAMINATION SOFTWARE FOR STUDENTS IN FEDERAL UNIVERSITY DUTSIN-MA

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Abstract

The study investigated the effectiveness of a developed chemistry essay Computer-Based Test (CBT) examination at Federal University Dutsin-Ma in Katsina state Nigeria. Two research questions were formulated in line with the study's objectives. The study employed the ADDIE model for research and development, to develop the software. While to test the effectiveness of the software the study adopted quasi-experimental research design: one-group posttest-only design. The population comprises of all 145 final-year, 400-level students in the Department of Science Education. A purposive sampling technique was used to select all 43 chemistry students for the study. One instrument was developed for data collection: the Chemistry Students' Essay CBT Assessment Questionnaire, designed on a four-point Likert scale. The instrument was validated appropriately. The reliability of the questionnaire was established using 20 students from the population who were not part of the sample, and Cronbach's alpha yielded a reliability coefficient of 0.87, confirming its dependability. In decision making, if the findings grand mean score was above 2.50 confirmed the software's effectiveness, while a score below 2.50 indicated ineffectiveness. The research questions were answered, using mean and standard deviation. The findings revealed that the web-based essay CBT was effective in terms of both functionality and graphical user interface. Based on the findings, it was recommended among others that students should be trained, on how to use the software, and seminars or workshops should be organized for lecturers to enhance their utilization of the web-based essay CBT software.

Keywords: Effectiveness, Essay Computer Base Test, Chemistry, Functionality and Graphic User Interface.

Introduction

Education has been a fundamental driving force behind the advancement and development of human civilization, which has been the main equipment in transforming the world into a center for scientific probe and development of modern technology. Through education, unprocessed, raw ideas and human intuitiveness are refined into technological innovations that enhance human existence, equipping people with higher intellectual capacities and a paramount comprehension of the universe. These breakthroughs result in the formulation of new ideas and technology, transforming several disciplines, including education into refurbished discipline. Dahlman, and Westphal, (2019) affirmed that the advancement and development of any nation fundamentally depend on its commitment to science and technological innovations. This continuous innovation not only improve economic and social growth but also enhances the overall quality of life for its citizens, ensuring sustainable national development (Hariram, Mekha, Suganthan & Sudhakar, 2023).

The work force of every country depends on the technical knowhow of its members, these characteristics can only be acquired through education, the skills and knowledge acquired by every member can only be certify through examination.

Examination is prominent in each institution of learning across the globe; it is commonly mentioned that without examination certification becomes challenging, but not entirely impossible (Okoye & Duru, 2019). It also serves a vital function in any country aspiring for financial and technical independence, necessitating the certification of its citizens to achieve academic autonomy and productivity. These aspiring countries can enhance teaching and learning by ensuring students undertake examinations or tests to evaluate their comprehension of the material taught. These assessments not only measure student understanding but also enable lecturers or teachers to assess their teaching effectiveness based on student performance (Usman & Olaleye, 2022). It is essential for assessing classroom progress, notably for teaching and learning, and is integrated as a means of piloting the educational system (Madaki, Kadiri & Esajobor, 2020). In the teaching and learning, of science it is important, for every person to be equipped with the knowledge and understanding of chemistry, hence every technologically incline nation needs to assessed the nation's citizens.

The assessment of these citizen in Chemistry is significant, since it serves as a vital tool for measuring students' comprehension in the application of chemical ideas in the progress and development of every nation. Moreover, standardized chemistry examinations, such as those used in national assessments or university admission exams, which ensure a uniform measure of competency across diverse educational settings, promoting fairness and comparability in educational outcomes a consistent measure of proficiency across varied educational perspective, encouraging educational equity and comparability (Yunita, Nurjayadi & Hariwibowo, 2021). A well-designed chemistry test, can highlight students' strengths and imperfections providing useful input for teaching tactics and curriculum modifications globally.

The number of students enrolling in schools has been on the rise globally, not exempting Nigeria. Many of these enrolled, students have shown an intense curiosity to learn science, related discipline, which has led to several constrain on school, and human resources. The population of school age citizen in most places like Nigeria has grown tremendously to the extent that the examination of students using paper and pencil is highly burdensome and tasking. Moreover, Oladimeji and Mwuese, (2018) have revealed associated flaws with the traditional Paper Pencil Test (PPT) mode of assessment such as examination malpractices which often influences examination scores. These obnoxious mistakes led to the investigation of digital alternatives and the development of a faster, technology-integrated assessment method (Agustian, Mubarok, Zen, Wiwin & Malik, 2023). The integration of Information and Communication Technology (ICT) into educational institutions has transformed basic student assessments from traditional pen-and-paper procedures to computer-based evaluations, representing a recent innovation in student assessment techniques. Computer Based Test (CBT) can be described as the use of computer hardware and software to test student's achievement. It consists of multiple-choice questions in objective formats. Students read through a displayed question on screen and are expected to

select the correct option (answer) from a list of displayed options. Although CBT has already been embraced by many institutions of learning in Nigeria, with some degree of skepticism as to whether it can be used in totality as a mode for examining student.

Computer-based testing (CBT) systems provide alternatives for implementing tests more often on different educational settings. (Kamoru & Solomon, 2022). Although the advantages of CBTs are extensive, a primary concern must be whether CBT and Paper Pencil Test (PPT) examinations are similar in evaluating knowledge and comprehension. It must be assured that they reflect a student's content proficiency, not computer proficiency (Clear, Clear, Vichare, Charles, Frezza, Gutica & Szynkiewicz, 2020). The Computer-Based Testing (CBT) has been available in various forms for more than four decades and has grown from its initial focus on certification testing for Information Technology (IT) industry, to a widely accepted delivery model (Yu & Iwashita, 2021)

However, an increase in work responsibilities for academic staff, and the advancement of internet technology, the use of computer assisted assessment has been an attractive proposition for many secondary and higher education institutions (Alek, 2020). Its' examinees select their answers, which are automatically graded by the software upon submission, providing students with immediate feedback on their performance. This instant feedback enhances the learning experience (Suleiman & Nachandiya, 2018). However, most computer-based assessments primarily rely on multiple-choice or objective-type questions, which may not adequately measure students' analytical and explanatory skills in chemistry.

Nevertheless, when compared to the standard pen-and-paper test (examination), CBT provides numerous advantages, Burns (2018) stated fifteen benefits of CBT to teachers and students which are: multiple test administrations, dynamic and individualized assessments, immediate grading, helps with open ended assessments, immediate feedback, vertically and horizontally aligned assessments, value added growth measures, uncover student thinking, engaging, analytics for the instructor and student, greater amount of test items, help students with disabilities, incorporate other types of technology, improves writing and can secure testing.

Despite the potential benefits of a computer-based test there is limited research on essay (short answers) CBT examination system, and on its effectiveness in chemistry, particularly in the Nigeria. However, since CBT examinations are typically multiple-choice questions, where the examinee pick and click (select) the right answers with various distractors, multiple choice question are usually detrimental to certain group of students, Lee, (2019) affirmed that multiple choice questions may be readily guessed and answered correctly, and is usually strenuous to set, identifying suitable option is time-consuming, and an in-depth understanding of student's qualities cannot be assessed. Rudolph, Daugherty, Ray, Shuford, Lebovitz & DiVall, (2019) also proclaimed that this type of examinations does not consistently provide an appropriate assessment of students' comprehension of the content. Furthermore, such type of examination often emphasizes the retention of factual knowledge rather than the application of ideas and critical thinking abilities important in chemistry (Haycocks, Hernandez-Moreno, Bester, Hernandez, Kalili, Samrao & Vida, 2024). This format may insufficiently assess a student's capacity for complicated problem-solving or comprehension of the nuances of chemical processes and systems. Consequently, students

may excel in rote memorization without truly understanding the underlying principles, which can be disadvantageous to their long-term learning and practical application of chemistry knowledge (Liu, Du, Zhao, Liu & Cai, 2019).

For this reason, the researcher aims to incorporate close-ended short essay questions into CBT examinations for science (Chemistry). This method is similar to traditional essay PPT examinations, except that, it is conducted on a computer. In this format, examinees can type their responses in designated areas provided by the software. In summary, the research seeks to develop an alternative CBT examination environment that offers independence and flexibility, allowing students to type in their short answers, which will then be automatically marked.

Objectives of the Study

The following objectives were raised, which is to:

1. find out Chemistry students' assessment of the functionality of developed web-based application designed for essay-format CBT with short-answer responses.
2. determine Chemistry students' assessment of the graphical user interface (GUI) of developed web-based application designed for essay-format (CBT) with short-answer responses.

Research Questions

The following research questions guided the study

1. What is the assessment of Chemistry students regarding the functionality of the developed web-based application designed for essay-format CBT with short-answer responses?
2. What is the Chemistry students' assessment of the graphical user interface (GUI) of the developed web-based application designed for essay-format CBT with short-answer responses?

Method and procedure

This study adopts the Waterfall development model and the ADDIE model for its clear instructional design framework. It begins with a needs analysis using observations and interviews to identify issues in current CBT practices. Findings revealed a need to upgrade from multiple-choice to essay-based CBT for assessing complex learning. The development phase involves building the database, interface (admin and user views), and system architecture using PHP and MySQL. In the implementation phase, the system is tested through unit, integration, and system testing to ensure functionality and readiness.

In testing the effectiveness, of the developed software, this study adopted quasi-experimental research design: One-Group Posttest-Only Design, was utilized. As illustrated in figure 1.

Group A → Treatment (Web Base CBT Software) → Posttest (Chemistry student's essay CBT Assessment Questionnaire).

Figure 1: One-Group Posttest-Only Design.

Students first used the developed software to answer 20 chemistry questions, requiring them, to type in their responses, afterward, they were required to complete a set questionnaire. The study population comprised all 400-level students 145 in total, in the Department of Science Education, Faculty of Education, enrolled in various BSc (Ed) programs. A purposive sampling technique was employed to select all 43 chemistry students

for the study. The research instruments for this study, was: Chemistry students essay CBT Assessment Questionnaire. The instrument was organized into three sections: Section A: This section gathered demographic information about the respondents, including their gender, age, and department. Section B: This section focused on various criteria for assessing the functionality of the developed web-based essay CBT software. Section C: This section included statements assessing the graphical user interface (GUI) of the software, structured in a Likert scale format with response options: Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1).

The instrument was validated by three experts, and all suggested corrections were effected. The reliability of the questionnaire was then established using 20 students from the population who were not part of the sample. Cronbach's alpha was used to determine reliability, yielding a coefficient of 0.87. Which is sufficient to prove dependability. The students were required to answer 20 chemistry questions using the developed web-based essay CBT software. Upon successfully completing the test, they were asked to respond to the Student's CBT Assessment Questionnaire to gather data based on their view during the utilization of the web-based essay CBT software that would be used for the analysis.

Results and Discussion

The acquired data was analyzed with descriptive statistics. The study topic was addressed using mean and standard deviation, facilitated by the Statistical Package for the Social Sciences (SPSS). Since each item on the instrument had a total of 10 response points and used a 4-point Likert scale, the decision mean was calculated as 2.5. Therefore, any mean score above 2.5 indicated agreement, while scores below 2.5 indicated disagreement.

Research Question One: What is the assessment of Chemistry students regarding the functionality of the developed web-based application designed for essay-format CBT with short-answer responses?

Table 1

Mean Responses and Standard Deviation (SD) of the Assessment of Chemistry Students Regarding the Functionality of the Developed Web-Based Application Designed for Essay-format CBT

S/N	**Items Descriptions**	**Mean**	**SD**	**Decision**
1	The web essay CBT software is easy to navigate and use for assessment purposes.	3.30	0.801	Agreed
2	The interface design of the web base essay CBT software is visually appealing and user-friendly.	3.35	0.745	Agreed
3	I was able to complete my assessment without experiencing technical difficulties.	3.40	0.753	Agreed
4	The essay-format CBT software provided clear instructions for each step of the assessment.	3.25	1.019	Agreed
5	The response time of the essay-format CBT software was fast and efficient during my interaction.	3.30	1.031	Agreed
6	I felt comfortable using the web base CBT software for my chemistry essay assessment.	3.05	0.998	Agreed

7	The essay-format CBT software allowed me to adequately express my thoughts and ideas in the assessment.	3.10	0.967	Agreed
8	I found the feedback from the software useful and informative.	3.30	0.978	Agreed
9	I would prefer to use this software for future assessments over multiple choice CBT exams.	3.10	0.967	Agreed
10	I am satisfied with my experience using the essay-format CBT software for my chemistry assessment.	3.00	0.648	Agreed
	Grand Mean	**3.22**		

From Table 2, a grand mean of 3.22 for the assessment of Chemistry students regarding the functionality of the developed web-based application designed for essay-format CBT with short-answer responses, which is higher than the 2.5 indicating positive feedback that all the responded agreed that the developed web-based software designed for essay-format CBT with short-answer responses has good functionality and can be used for examination, and all the item's standard deviations was below 1.00, which shows that, while there was some variation, most users shared a similar perception of the software's functionality and design.

Research Question Two: What is the Chemistry students' assessment of the graphical user interface (GUI) of the developed web-based application designed for essay-format CBT with short-answer responses?

Table 2

Mean Responses and Standard Deviation (SD) of the Assessment of Chemistry Graphical User Interface (GUI) of the Developed Web-Based Application Designed for Essay-format CBT with Short-answer Responses

S/N	**Items Descriptions**	**Mean**	**SD**	**Decision**
1	The layout of the web-based CBT software is well-organized and easy to navigate.	3.50	0.606	Agreed
2	The colors, fonts, and icons used in the interface enhance readability and usability.	3.45	0.759	Agreed
3	The graphical elements (buttons, menus, and icons) are intuitive and visually appealing.	3.55	0.686	Agreed
4	The CBT software design is consistent across different pages and functions.	3.35	0.988	Agreed
5	The placement of buttons and navigation tools allows for a smooth user experience.	3.60	0.753	Agreed
6	The text and labels in the web based CBT software are clear, concise, and easy to understand.	3.40	0.820	Agreed
7	The responsiveness of the interface ensures a seamless interaction across different devices.	3.50	0.512	Agreed

8	The application provides visual feedback that improves usability.	3.50	0.606	Agreed
9	I was able to complete my tasks within the application efficiently without confusion.	3.40	0.820	Agreed
10	I am satisfied with the graphical user interface of the web-based application.	3.30	0.732	Agreed
	Grand Mean	**3.45**		

From Table 2, A grand mean of 3.55 for the Chemistry students' assessment of the graphical user interface (GUI) of the developed web-based software designed for essay-format CBT with short-answer responses, which is higher than the 2.5 indicating that all the responded agreed that the developed web-based software designed for essay-format CBT with short-answer responses has good graphic user interface and can be used for examination and all the items had standard deviations below 1.00, except for Item 4, which had an SD of 0.988. This indicates a moderate variation in responses, suggesting that some users had differing opinions about its ease of use. However, for other items, despite some variation, most users shared a similar perception of the software's GUI and design

Discussion of Findings

The assessment of chemistry students regarding the functionality of a developed web-based application for essay-format computer-based testing (CBT) with short-answer responses provides valuable insights into its effectiveness. All the respondents agreed that the functionality of the application is efficient, the functionality were in agreement with Hall (2023), in a study, where he emphasizes the importance of aligning the application with students' needs and expectations to enhance usability. Moreover, the functionality, allow students, to receive immediate feedback, which is in agreement with Schuessler, Striewe, Pueschner, Luetzen, Goedicke, Giese and Walpuski, (2024) where they indicated that well-designed online platforms can enhance learning by providing immediate feedback.

The assessment of chemistry students regarding the graphical user interface (GUI) of the developed web-based software designed for essay-format computer-based testing (CBT) with short-answer responses provides valuable insights into its effectiveness. A well-designed GUI is important for facilitating interaction, enhancing user satisfaction, and ensuring efficient assessment processes. All the student agreed that the GUI layout, fonts placement button, and visual navigation, have satisfied, their interaction with the software, which is in agreement with Peng, (2024) emphasizes that the design of a GUI significantly impacts user engagement and satisfaction, noting that intuitive and aesthetically pleasing interfaces can enhance the overall user experience.

Conclusion

The results of this study demonstrate that the developed web-based essay CBT examination software is highly effective and functionally robust for academic assessments, particularly in chemistry. The graphical user interface (GUI) meets essential usability standards, enabling efficient and accurate assessment processes. Positive student feedback stresses its practical applicability, confirming the software's potential to enhance assessment

by offering a standardized, fair, and technologically advanced platform for essay examinations.

Recommendations

In view of the findings of this study, the following recommendations were made:

1. Workshops and seminars should be organized for lectures on how to utilize the web-based essay CBT software.
2. Students should be proficient in typing, as it will help them in effective input of their answers.
3. More researches should be conducted on for the essay CBT examination for further understanding.

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