

Development of Web-Based Automated Learning Assessment Tool for Mathematics Education in Abia State College of Education (Technical), Arochukwu

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Abstract- *Mathematics is a critical subject that plays a vital role in enhancing human life. One of the Important components in the growth and evolution of mathematics teaching and learning is the emergence of web-based Technologies. Innovative web-based technology enhances students activities in mathematics learning especially in the assessment. Assessment and feedback are crucial aspects of teaching and learning of mathematics , and the process can be conducted efficiently by the introduction of technology. This study focused on the development and evaluation of a web-based learning assessment system for mathematics education at the Abia State College of Education (Technical). The increasing integration of technology in education has highlighted the need for more efficient, flexible, and effective assessment methods beyond the traditional paper-pencil approach. This research aimed to design, implement, and assess a web-based assessment tool capable of improving students' academic performance, enhancing feedback delivery, and reducing lecturers' workload. The study adopted a developmental research design, which involved the systematic design, development, and evaluation of the web-based assessment system. The system was developed using MySQL and incorporated multiple-choice questions with automated grading and instant feedback features. A quasi-experimental approach using a pre-test and post-test design was employed to evaluate the effectiveness of the system. The population of the study consisted of 20 students and 3 lecturers from the Department of Mathematics Education. Data were collected through tests, questionnaires, interviews, and observation. The paired t-test was used to analyze students' performance before and after the implementation of the web-based system, while descriptive statistics were used to analyze questionnaire responses. The findings revealed that the web-based learning assessment system significantly improved students' academic performance in mathematics. The results also showed that the system enhanced efficiency by reducing grading time, provided immediate feedback to students, and increased overall user satisfaction. Furthermore, the system proved to be more effective than the traditional paper-pencil method in terms of speed, accuracy, and student engagement. However, minor challenges such as internet connectivity issues and limited access to digital devices were identified. Despite these challenges, the study concluded that the web-based assessment system is a viable and effective tool for improving mathematics education. The study recommends the adoption of web-based assessment systems in educational institutions to enhance teaching, learning, and assessment practices.*

I. INTRODUCTION

In the current digital era, technology has become an indispensable component of mathematics education across all levels of learning. The integration of digital tools into instructional practices has significantly transformed the traditional classroom environment into a more interactive, engaging, and learner-centered space. The use of technology not only stimulates students' interest in learning but also provides rich and dynamic visual experiences that enhance the development of deep conceptual understanding in mathematics. Concepts that were once abstract and difficult to grasp can now be illustrated through simulations, animations, and interactive platforms, making learning more meaningful and accessible.

Research conducted by Spires et al. (2013) revealed that the integration of web-based technologies has a positive impact on students' knowledge acquisition as well as their perceptions of educational technology. These findings suggest that students who are exposed to technology-enhanced learning environments tend to develop more positive attitudes toward learning and demonstrate improved academic performance. In particular, web-based learning has emerged as a powerful tool for enhancing mathematics education by providing flexible, independent and resourceful learning opportunities.

Several studies have examined the effectiveness of web-based learning in improving students' understanding and performance in mathematics. These studies indicate that students who engage with online learning platforms often show better retention of knowledge, improved problem-solving skills, and increased motivation to learn. Furthermore, web-based learning environments allow the incorporation of diverse instructional strategies, such as multimedia presentations, interactive exercises, and collaborative learning activities, all of which contribute to a more holistic learning experience.

Researchers have explored the potential of web-based learning in developing students' mathematical problem-solving abilities. Problem-solving is a critical aspect of mathematics education, and web-based platforms provide opportunities for students to engage in exploratory learning, test hypotheses, and

receive immediate feedback on their performance. This process encourages active participation and helps students develop strategic thinking skills necessary for solving complex mathematical problems.

Web-based learning also plays a significant role in promoting active and participatory learning. Unlike traditional teaching methods that often emphasize passive learning, web-based environments encourage students to take ownership of their learning by engaging with content, participating in discussions, and collaborating with peers. This active engagement fosters the development of various problem-solving strategies and enhances students' ability to apply mathematical concepts in real-life situations.

The framework of 21st-century skills highlights the importance of creativity, critical thinking, and problem-solving as essential competencies for learning and innovation. In today's rapidly evolving world, it is crucial for students to acquire these skills to remain competitive and adaptable. Technology serves as a vital tool in supporting the development of these competencies by providing platforms for exploration, experimentation, and innovation. Moreover, these skills can be effectively measured through well-designed assessment systems that capture not only students' knowledge but also their ability to think critically and solve problems.

In recent years, advancements in technology have led to the development of web-based assessment systems designed to enhance the evaluation process in education. These systems enable teachers to administer assessments more efficiently while providing learners with immediate and meaningful feedback. Unlike traditional assessment methods, web-based assessments offer flexibility, scalability, and the ability to track students' progress over time. This makes it easier for educators to identify learning gaps and tailor instruction to meet individual student needs.

Assessment plays a crucial role in teaching and learning activities, as it provides valuable insights into students' understanding and progress. Effective assessment practices can significantly improve learning outcomes by guiding both teaching strategies and student efforts. One of the key benefits of assessment is the feedback it provides. Feedback helps learners identify their strengths and weaknesses, reflect on their learning processes, and make necessary adjustments to improve their performance.

Meaningful feedback is particularly important in enhancing students' motivation and self-esteem. When learners receive constructive and timely feedback, they are more likely to engage in self-assessment and take responsibility for their learning. This, in turn, fosters a growth mindset and encourages

continuous improvement. Additionally, feedback enables students to recognize their errors, understand underlying concepts, and develop strategies for overcoming learning challenges.

Furthermore, feedback supports the transfer of learning by helping students apply acquired knowledge and skills to new contexts. It also encourages learners to value opportunities for revision and refinement, which are essential components of effective learning. Through continuous feedback and reflection, students can develop a deeper understanding of mathematical concepts and improve their overall academic performance.

However, despite the importance of feedback in the learning process, teachers often face challenges in providing timely and meaningful feedback due to large class sizes, heavy workloads, and time constraints. Managing assessments for many students simultaneously can be overwhelming, making it difficult for teachers to give individualized attention to each learner. As a result, students may not receive the support they need to fully benefit from the assessment process.

To address these challenges, the development of web-based learning assessment tools has become increasingly important. These tools enable teachers to efficiently administer assessments and provide instant feedback to learners. Automated systems can evaluate students' responses, generate performance reports, and offer personalized feedback, thereby reducing the burden on teachers. At the same time, students benefit from immediate insights into their performance, allowing them to make timely improvements.

In conclusion, the integration of web-based learning and assessment tools in mathematics education offers significant potential for improving teaching and learning outcomes. By leveraging technology, educators can create more engaging, interactive, and effective learning environments that support the development of essential 21st-century skills. As educational systems continue to evolve, the adoption of web-based approaches will play a critical role in shaping the future of mathematics education.

II. STATEMENT OF PROBLEM

Currently, The Department of Mathematics Education in Abia State College of Education (Technical) conduct assessment for mathematics Scholars using the traditional Paper-pencil practice which is not efficient due to the ratio of students to lecturers.

Mathematics education in Abia State College of Education (Technical), Arochukwu faces challenges such as: High Lecturer workload as manual grading

of assessment and exams consumes excessive time, Delayed feedback whereby students often wait for days or weeks for assessment result, therefore missing opportunities for timely remediation, Limited assessment frequency, Potential human error in manual grading and underutilization of technology because of the limited integration of technology specifically for efficient and effective mathematics assessment.

Due to the time and effort required for manual grading, lecturers may not be able to conduct assessments as frequently as needed. This reduces opportunities for continuous evaluation and limits the effectiveness of formative assessment practices. Additionally, manual grading is prone to human error, which may affect the accuracy and reliability of assessment results.

A web-based assessment tool provides lasting solution to some of these challenges. By automating grading processes, providing instant feedback, and enabling more frequent and diverse assessments, the system significantly improves the quality of mathematics education. Hence, this research develops a web-based learning assessment tool for mathematics education in Abia State College of Education (Technical), Arochukwu.

Objective of study:

The Main Objectives of this study are:

- 1). To design and develop a Web-based Learning Assessment tool to enhance the efficiency and effectiveness of mathematics assessment at Abia State College of Education, (Technical), Arochukwu.
- 2) To Implement and evaluate the web-based learning Assessment Tool for mathematics Education in Abia state college of Education (Technical), Arochukwu.
- 3). To determine user's Satisfaction with the performance of the web-based learning assessment tool.
- 4) To compare the effect and contribution of the web-based assessment with the traditional Paper-Pencil method to students and lecturer of the Institution.

III. LITERATURE REVIEW

Concept of web-based Learning Assessment:

The emerging of web related educational technologies in recent times have enhance the use of instructional educational course wares. Various educational web pages have been developed in the last few years. Students can now use available web browsers for educational purposes. This does not only offer enhanced information delivery mechanism but also provides students' progress tracking, students' self-evaluation, auto-marked tutorial questions, time on-line quizzes and test, through web-based learning assessment tools.

Web based Learning Assessment refers to the use of internet-connected technologies to create, deliver, administer and grade evaluations, tests and quizzes. The effectiveness of assessment for students and lecturers alike can be improved greatly by using online computerized assessment techniques. Flexibility of Assessment timing means that students can take test anytime, anywhere while automation of assessment marking means that lecturers have their marking load reduced. However, web-based learning assessment tool enhances flexibility of assessment timing and automation of assessment marking.

Dien and Gerald (2005) described the special features and accessibility of an innovative web-based practice tool (Webma) designed with randomized short-answers, matching and multiple choice items with automatically adopted feedback for middle school students. They also compared the effects and contributions of web-based practice on student learning processes with that of traditional Paper-pencil practice. With multiple practices and immediate adopted feedback, the web-based group performed significantly better than paper and pencil group.

Mitsuru K. and kentaro Y. (2017) developed the Website "MATH ON WEB" which consist of two System; Web-based Mathematics Learning System (WMLS) for assisting students' self learning and Web-based Assessment System of Mathematics (WSAM) for online assessment. They concluded that the system enhanced the result of teaching practice for first-year engineering students using the System.

Daniel S.j Costa et al (2010) reported on the development and evaluation of an online formative assessment tool. The web-based formative assessment tool was evaluated by a sample of undergraduate students, post graduate students and academic staff within Psychology department in order to determine the suitability and sensitivity of the tool. The result of the pilot test suggested that the development of assessment tool was appropriate and feasible for masters students studying Psychology.

Mehmet (2017) conducted a research and developed a web- based peer- assessment system(WesPASS), which allows students access their own or their peers' performance and project assignment and also report the results of the assessments so they can correct their assignments. The findings were analyzed through quantitative data analysis and it revealed that the system was simple and user friendly, it also accelerated the assessment process.

Sanusi Hasibuan (2021) Carried out a research on the development of a web-based assessment tool using R \$ D with the ASSURE Model. The research categorized web-based assessment as valid and

efficient for assessment.

Sylvia and Sharil (2006) designed and implemented a multiple-choice test as a part of computer-aided learning system in teaching mathematics in the undergraduate level, using free open-source software component. They focused on web-based assessment management software that was designed to diagnose students' progress and relate assessment with classroom instructions. The research indicates that the assessment system is a very good tool for predicting overall student performance as well as for assisting the lecturer in analyzing students' level of Knowledge and understanding.

Tzu-Hua Wang et al.(2004) in their study, developed a web- based assessment system, and a web-based assessment and test analysis (WATA) system, and examined its impact on teacher education. They concluded that findings from studies might provides some guidance to help those who are interested in the development of Web-based assessment and intend to infuse information technology into teacher education.They emphasized on the importance for web-based assessment system for teacher education.

Benefits of web-based learning Assessment system:

1). Efficiency and speed: Web-based Learning Assessment System automates grading and provides Instant result. Lecturers and Instructors can create questions banks, randomize questions and answers to prevent cheating and set automatic grading for multiple choice questions. This saves tremendous amount of time and resources.

Simin \$ Heidari (2020) indicated in their study that automatic grading feature is the most valued aspect for educators, freeing them from mundane tasks and allowing them to focus on more complex student feedback and Instructional design.

2). Accessibility and flexibility: With the Web-based assessment system, Assessment can be taken anytime, anywhere with Internet connection. This supports remote learning, flexible work schedules. A report by EDUCAUSE(2020) highlighted that the flexibility of online learning tools including assessment was critical for institutional resilience and continuity during disruptive events like the covid-19 pandemic.

3) Cost-Effectiveness: Web-based assessment system reduces paper and printing cost.

It eliminates the need for physical materials, which is cheaper and more environmental friendly. It also saves cost related to physical test centers, proctoring and manual grading labour.

Web-based assessment generally offer a powerful efficient and effective approach to evaluation. It transforms assessment from a static, administrative task into a dynamic process that drives learning,

Improves decision-making and provides better experience for both Students and Lecturers.

IV. METHODOLOGY

This study adopts a developmental Research Design. Developmental Research is the systematic procedure of designing, developing and evaluating educational interventions such as (Programmes, Teaching-Learning Strategies and materials, Systems) as solutions for complex problems in educational practice, which also aim at advancing knowledge.

This study develops a web-based learning Assessment System for mathematics education at Abia State college of Education (Technical), Arochukwu. The system was designed using web technologies featuring multiple choice questions incorporated with automatically adapted feedback. Paired t-test was conducted using SPSS to determine the effect and contribution of the web-based Assessment compared to that of the traditional Paper-pencil assessment on students of the Institution. Data was obtained through observation, questionnaires, and tests. The population of study consist of 20 students and 3 lecturers of the department of mathematics education.

V. RESEARCH DESIGN

The Mathematics Assessment Platform was developed as a web-based application designed to improve the administration, delivery, and evaluation of mathematics assessments. The system provides a digital environment where students can register, take mathematics examinations, receive instant grading, and track their academic performance over time. At the same time, administrators can create assessments, manage users, monitor student performance, and control access to learning materials.

The platform was developed using modern web technologies to ensure reliability, scalability, security, and ease of use. The implementation followed a structured development process in which the system was built incrementally, beginning with the foundational architecture and gradually extending to include authentication, assessment management, analytics, role-based access control, and deployment.

VI. SYSTEM DESIGN AND IMPLEMENTATION

The system consists of three major layers:

- Frontend Layer
- Backend Layer
- Database Layer

Each layer performs a specific function within the platform.

React Frontend

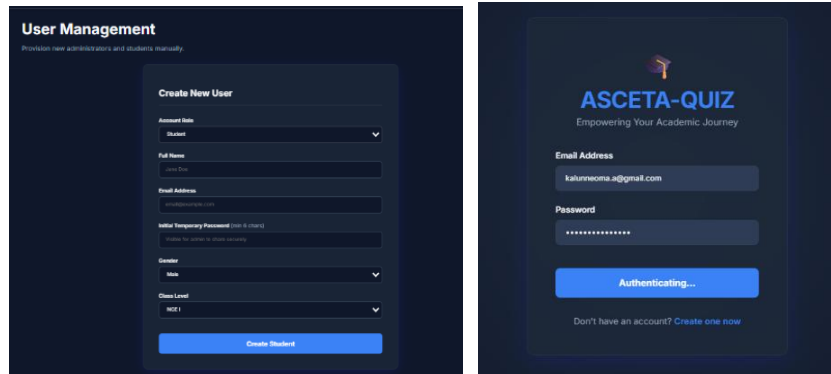
The frontend of the system was developed using React.

React is a JavaScript library used for building user interfaces. It was selected because it allows the development of highly interactive web applications with fast response times and reusable components. It provides a responsive user experience, allows component reuse, reducing development time, supports dynamic page updates without reloading the browser and easily integrates with backend APIs.

• React was used to develop:

- Landing page
- Login page
- Registration page
- Student dashboard
- Administrator dashboard
- Assessment interface
- Result pages
- Profile management pages

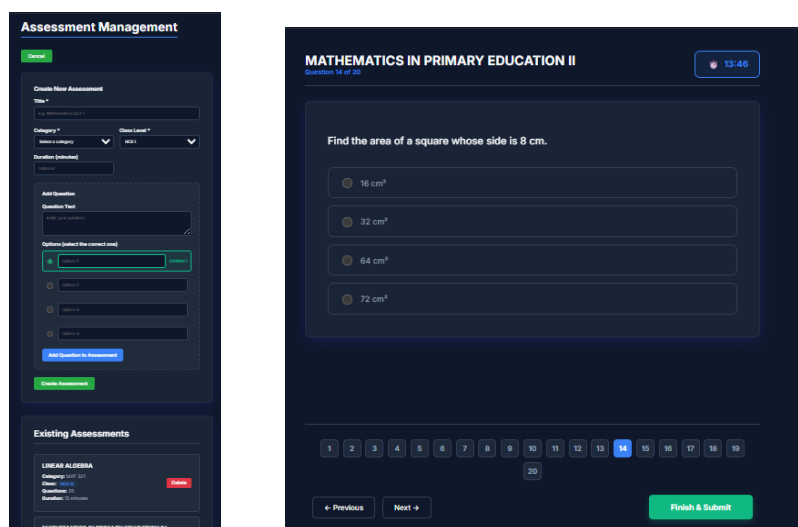
Each section was implemented as a separate reusable component, making maintenance easier and improving scalability.



The backend was developed using Node.js and NestJS.

NestJS is a progressive Node.js framework that provides a structured architecture for building scalable server-side applications. It supports the modular development, Provides built-in security features, Simplifies API development, Supports authentication and authorization mechanisms.

- The backend handles:
- User registration
- User login
- Authentication
- Authorization
- Assessment creation
- Question management
- Result computation
- Student performance tracking

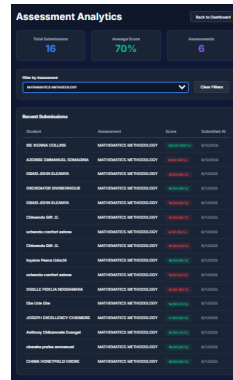


The backend serves as the brain of the platform, processing requests from users and communicating with the database.

MongoDB is a NoSQL database that stores data in flexible document structures. It enables fast data retrieval and flexible document structure.

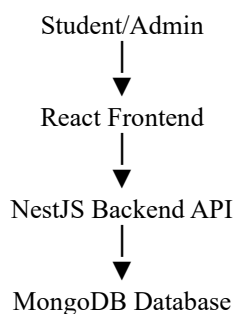
MongoDB Database

- MongoDB stores:
- User information
- Assessment details
- Questions
- Categories
- Student submissions
- Scores and results



All records are stored as documents and retrieved whenever needed.

The platform follows a three-tier architecture.



Mongoose

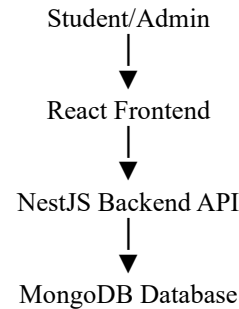
Mongoose was used as the Object Data Modeling (ODM) library. Mongoose acts as a bridge between NestJS and MongoDB. It was used to define data schemas, validate data, perform database operations and maintain data consistency.

JSON Web Token allows users to remain authenticated after login without repeatedly entering their credentials. It enables User enters login

details, server verifies credentials. A secure token is generated. The token is attached to future requests. The server validates the token before granting access. This mechanism improves security and user experience.

System Architecture

The platform follows a three-tier architecture.



System workflow:

- User interacts with the web interface.
- Frontend sends requests to backend APIs.
- Backend processes requests.
- Backend retrieves or stores data in MongoDB.
- Response is returned to frontend.
- User receives feedback instantly.

VII. DATA PRESENTATION, ANALYSYS AND INTEPRETATION

Data was obtained using a well-structured questionnaire. The questionnaire was analyzed using descriptive statistics. The paired t-test was used to analyze students' performance before and after the implementation of the web-based system. Results are presented in the tables below:

TABLE 1: DESCRIPTIVE STATISTICS ON USER'S PROFICIENCY OF WEB-BASED PLATFORM AND INTERNET BASED TECHNOLOGY:(N =23)

QUESTIONNAIRE ITEM	Mean	Std. Deviation
Access to internet-enabled devices for learning	3.48	.511
familiarity with using web-based learning platforms	3.52	.511
institution encouragement for the use of technology in teaching and learning	3.57	.507
Easy access to online educational resources	3.22	.671
Internet facilities available in the institution	3.22	.736
GRAND MEAN	3.40	

DECISION: Grand Mean (3.40) > 2.50, ACCEPTED

INTERPRETATION: users have proficiency to web-based assessment tool and access to internet facilities in the institution.

TABLE 2: DESCRIPTIVE STATISTICS ON EFFECTIVENESS OF WEB-BASED ASSESSMENT TOOL:

QUESTIONNAIRE ITEM	Mean	Std. Deviation
Tool is easy to use	3.39	.583
Provides immediate feedback after assessment	3.61	.499
Improves students' understanding of mathematics	3.39	.583
Automated grading reduces assessment errors	3.35	.647
Saves time during assessment	3.48	.511
Increases students' interest in mathematics	3.39	.656
Platform is reliable and efficient	3.39	.583
Supports independent learning	3.43	.590
GRAND MEAN	3.43	

DECISION: GRAND MEAN (3.47) > 2.50, ACCEPTED

INTERPRETATION: users agree that the web-based assessment tool is effective and efficient for mathematics assessment.

TABLE 3: DESCRIPTIVE STATISTICS ON USER'S SATISFACTION OF WEB-BASED ASSESSMENT TOOL:(N = 23)

QUESTIONNAIRE ITEM	Mean	Std. Deviation
Satisfied with performance of assessment tool	3.48	.511
Assessment results generated are accurate	3.48	.511
System interface is user friendly	3.52	.511
Prefer web-based over paper-pencil assessment	3.13	.694
Makes assessment more engaging	3.39	.499
Would recommend system for other courses	3.43	.507
GRAND MEAN	3.41	

DECISION: GRAND MEAN(3.41) > 2.50, ACCEPTED

INTERPRETATION: Users are highly satisfied with the web-based assessment tool.

TABLE 4: DESCRIPTIVE STATISTICS ON CHALLENGES OF USING THE WEB-BASED ASSESSMENT TOOL:(N =23)

QUESTIONNAIRE ITEM	Mean	Std. Deviation
Poor internet connection affects system use	3.26	.619
Lack of digital devices limits effective use	3.30	.559
Some users need training to effectively use platform	3.35	.714
Power supply issues affect system effectiveness	3.04	.767
Technical issues interrupt online assessments	3.30	.470
GRAND MEAN	3.25	

DECISION: GRAND MEAN (3.25) > 2.50, ACCEPTED

INTERPRETATION: Users agreed that internet connectivity, power supply and limited digital resources are challenges to the use of the web-based assessment platform.

T-Test

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Web-based assessment	71.20	20	3.888	.869
	Paper-pencil assessment	50.25	20	3.492	.781

Paired Samples Test

Paired Differences

				Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower
Pair 1	Web-based assessment	-	Paper-pencil assessment	20.950	4.071	.910	19.045

				Paired Samples Test		
				Paired Differences	95% Confidence Interval of the Difference	
				Upper	t	df
						Sig. (2-tailed)
Pair 1	Web-based assessment	-	Paper-pencil assessment	22.855	23.012	19
						.000

INTERPRETATION: The paired t-test shows significant improvement in the performance of students after using the web-based assessment tool.

VIII. CONCLUSION

This study focused on the development and evaluation of a web-based automated learning assessment tool for Mathematics Education at Abia State College of Education (Technical), Arochukwu. The study was motivated by the limitations associated with the traditional paper-and-pencil assessment approach, particularly the time required for manual grading, delayed feedback, possible grading errors, and the limited frequency of assessment.

The findings of the study indicate that the developed web-based assessment tool was effective and useful for mathematics assessment. The questionnaire results indicate that respondents generally agreed that the system was easy to use, provided immediate feedback, improved students' understanding of mathematics, reduced assessment errors, saved assessment time, increased students' interest in mathematics, was reliable and efficient, and supported independent learning.

Furthermore, the pre-test and post-test analysis showed an improvement in students' performance after the implementation of the web-based assessment tool. The paired-samples t-test revealed a statistically significant difference between the pre-test and post-test scores, $t(19) = 23.012$, $p < .001$. This indicates that students performed significantly better after using the web-based assessment system.

The study therefore concludes that the web-based automated learning assessment tool provides an effective alternative to traditional paper-and-pencil assessment.

IX. RECOMMENDATIONS

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

1. Integration of the web-based assessment tool: Abia State College of Education (Technical), Arochukwu should consider adopting the web-based

automated learning assessment tool for mathematics assessment and assessment for other courses in the institution.

2. Training of lecturers: Lecturers should be adequately trained on how to create assessments, manage question banks, monitor students' performance, and interpret the results generated by the system.

3. Student orientation: Students should be introduced to the platform through practical demonstrations and orientation programmes before taking assessments to ensure that difficulties on how to navigate the website do not affect their performance.

4. Improvement of internet facilities: The institution should improve internet connectivity and provide reliable network access to support uninterrupted online assessments.

5. Provision of digital devices: The institution should provide or expand access to computers and other appropriate digital devices for students who may not have personal devices.

6. Continuous assessment: Lecturers should utilize the system for regular formative assessments, quizzes, and practice tests so that students can receive timely feedback and identify areas requiring improvement.

7. System maintenance and improvement: The institution should provide technical support and regularly maintain and update the platform to ensure security, reliability, and efficient performance.

8. Further research: Future researchers should investigate the effectiveness of web-based assessment tools using larger samples, different institutions, longer intervention periods, and additional variables such as students' engagement, retention, and problem-solving ability.

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