

A Web-Based Student Learning Outcome Assessment System for Secondary Education: Design, Development, and Empirical Evaluation

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Abstract

Student learning outcome assessment is an essential component in ensuring the quality of learning and accountability in secondary education. However, in practice, many schools still implement fragmented, semi-manual assessment systems, resulting in low efficiency, poor data accuracy, and limited pedagogical use of assessment results. This study aims to design, develop, and empirically evaluate an integrated web-based student learning outcome assessment system to support assessment management in secondary schools. The study used a mixed-methods approach, combining qualitative system development and quantitative evaluation. The system was developed using the Waterfall model and Unified Modeling Language (UML). Empirical evaluation was conducted through system trials with 20 students as end users and validation by media, information technology, and language experts. Quantitative data were analyzed descriptively, while qualitative data were analyzed thematically. The results show that the developed system has a very high level of feasibility in terms of usability, functional reliability, and language clarity, and can improve assessment management efficiency while minimizing data inconsistencies. These findings have global implications for the development of efficient and sustainable digital assessment systems, particularly in developing countries with limited resources and varying levels of technological readiness.

Keywords: Web-Based Assessment; Learning Outcomes; Secondary Education; Educational Information Systems; Digital Assessment

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Introduction

Digital transformation in education has become a global agenda, inseparable from efforts to improve the quality of learning and the governance of educational institutions. Advances in information technology are encouraging schools to adopt digital systems in various aspects of educational management, including lesson planning, evaluation, and reporting student learning outcomes. Globally, digitalization of assessment systems is seen as a strategic tool for improving data accuracy, process efficiency, and transparency in educational decision-making (Alruwais et al., 2018; Caena & Redecker, 2019; Kucs & Mert, 2024; Tracey & Francesca, 2019).

Assessment of student learning outcomes plays a central role in the educational process because it serves as the basis for assessing the achievement of learning objectives, monitoring student progress, and designing appropriate pedagogical interventions. An effective assessment system assesses not only cognitive aspects but also affective dimensions, attendance, and participation in student self-development activities. However, the effectiveness of assessment depends heavily on the system used to manage and integrate the assessment data (Gnambis et al., 2025; Mohan, 2023).

A number of international studies have shown that implementing technology-based assessment systems can improve data consistency, speed up reporting, and support evidence-based assessment practices (Tuna Pusa & Dinçer, 2025; Wahas & Syed, 2024). Web-based assessment systems enable data integration across educational stakeholders, provide real-time access, and reduce reliance on manual documentation. Furthermore, digital systems open up opportunities for broader use of assessment data for learning analytics and instructional improvement.

However, recent studies have also shown that implementing digital assessment systems at the secondary education level still faces various challenges, particularly in developing countries. These challenges include limited infrastructure, low

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user technological literacy, and the use of unintegrated and fragmented systems (Alamr et al., 2023; Margiene & Ramanauskaite, 2022). Many schools still rely on spreadsheet applications or desktop software that are not specifically designed for educational assessment needs, resulting in a fragmented, error-prone, and difficult-to-manage assessment process.

In Indonesia, this situation is still common in secondary schools, especially in areas with limited resources. Assessment practices are often conducted separately by subject teachers, class teachers, and school administrators, and the results are compiled manually to produce learning outcome reports. Previous research in the national context has tended to focus on the development of academic information systems in general or on aspects of online learning, while studies specifically examining integrated, empirically validated student learning outcome assessment systems remain limited (El Marsafawy et al., 2022; Goss, 2022; Zhu & Wang, 2023).

Based on this state-of-the-art review, clear research gaps emerge. First, there are still a few comprehensive, web-based student learning outcome assessment systems designed to take into account the pedagogical and administrative needs of secondary education. Second, most system development research has not included adequate empirical evaluation, either through end-user trials or multidisciplinary validation by media, information technology, and language experts. Third, there are few studies that integrate qualitative and quantitative approaches to holistically assess the feasibility of digital assessment systems.

To address this gap, this study aims to design, develop, and empirically evaluate an integrated web-based student learning-outcome assessment system for secondary education. This system is designed to accommodate various assessment components, including academic performance, attitudes, attendance, and extracurricular activities, on a centralized platform with user role-based access controls. Methodologically, this study combines system development using the Waterfall model and Unified Modeling Language (UML) with empirical evaluation through trials on 20 students and validation by media, information technology, and language experts.

This research contributes both theoretically and methodologically. Theoretically, this research enriches the discourse on the digital transformation of educational assessment by presenting a contextual and adaptive web-based assessment system model. Methodologically, this research employs an evaluation approach to the educational assessment system that integrates qualitative and quantitative analysis, yielding stronger empirical evidence on the system's feasibility and effectiveness. Therefore, this research is expected to serve as a reference for the development and implementation of digital assessment systems in various secondary education contexts, particularly in schools facing resource constraints.

Method

This study uses a mixed-method approach that integrates qualitative system development with quantitative evaluation to assess the feasibility and effectiveness of a web-based student learning outcome assessment system. This approach was chosen because developing an educational information system not only demands technical accuracy but also requires empirical evidence on user acceptance, pedagogical suitability, and system reliability in the context of secondary education (Takona, 2024; Venkatesh et al., 2024).

Research Framework and System Development Model

The system development in this study adopted the Waterfall model as the primary methodological framework. The Waterfall model was chosen because it provides a systematic, sequential workflow, allowing a clear link between requirements analysis, system design, implementation, and evaluation. This model is appropriate for educational institutions with relatively stable operational needs and a clear organizational structure (Mokhtar & Khayyat, 2022; Natarajan & Pichai, 2024).

As shown in Figure 1, the system research and development process begins with the needs analysis phase, which aims to identify problems, user needs, and the characteristics of the existing assessment system. This phase serves as the basis for formulating the system's functional and non-functional specifications. Next, the system design phase is carried out to translate these needs into a conceptual design using the Unified Modeling Language (UML), focusing on user interactions and system workflows. The implementation phase involves developing a web-based student learning outcome assessment system in accordance with the established design. The system is built with a server-based architecture and a centralized database to support the integration of assessment data from various educational actors.

The final phase is system evaluation, which includes user trials and expert validation to empirically assess the system's feasibility.

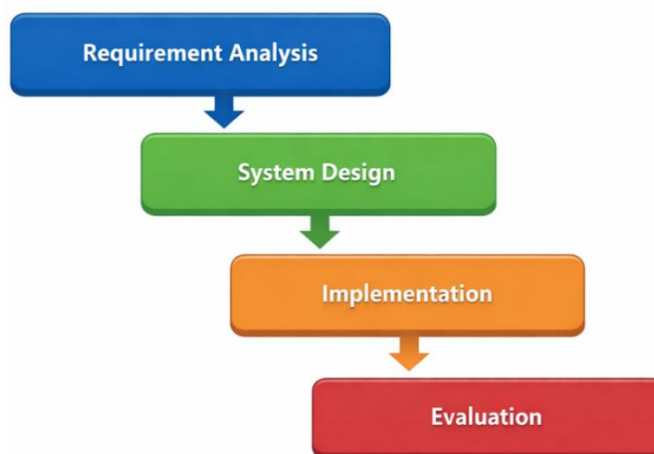


Figure 1. Research and System Development Framework Based on the Waterfall Model

Research Subjects and Participants

This study involved two groups of participants. The first group consisted of 20 secondary school students selected through purposive sampling. Student selection accounted for diverse academic achievement levels and class backgrounds to provide a representative picture of the end-user experience. The second group consisted of three expert validators: a media expert, an information technology expert, and a linguist, each assessing the system from a different perspective.

Data Collection Instruments and Techniques

The research data was collected using qualitative and quantitative techniques. Qualitative data were obtained through observations of system usage and semi-structured interviews with teachers and school administrators to understand the implementation context and system needs. Quantitative data were collected using a closed-ended questionnaire with a five-level Likert scale, administered to students and experts after the system usage and evaluation process. The questionnaire instrument was designed with reference to the learning system evaluation framework and software quality, which includes aspects of usability, functional reliability, interface clarity, and language suitability (Hasan et al., 2025; Laplante & Kassab, 2022). In addition, open-ended questions are provided to obtain more in-depth qualitative feedback.

System Evaluation Procedure

System evaluation was conducted after the implementation phase was completed. Students were asked to use the system in a simulated learning-outcome assessment scenario, while experts conducted assessments using the provided evaluation instruments. The evaluation process was conducted in a controlled environment to ensure consistency of results and minimize external factors that could influence the assessment.

Data Analysis Techniques

Quantitative data analysis was conducted using descriptive statistics, including calculating the average value and percentage of the system's feasibility level. The feasibility level was determined based on the learning media evaluation criteria, with scores above 80% categorized as very feasible, 61–80% as feasible, and below 60% as less feasible. Qualitative data were analyzed using thematic analysis, which involves data reduction, theme grouping, and interpretation. To increase the validity of the findings, triangulation of methods and data sources was conducted by comparing the results of observations, interviews, and questionnaires.

Research Ethics Considerations

This research was conducted in accordance with ethical principles of educational research. All participants participated voluntarily and were given an explanation of the study's objectives. Data collected will be kept confidential and used solely for academic purposes.

Results and Discussion

Result

This section presents the empirical research results obtained from the system implementation process, student usability testing, and expert validation. The presentation focuses on the performance of the web-based student learning outcome assessment system, the system's usability from an end-user perspective, and its feasibility based on a multidisciplinary assessment. All results are presented objectively without in-depth theoretical interpretation.

System Implementation Results

The system implementation resulted in an integrated, web-based student learning assessment application accessible by various educational stakeholders based on their roles and authorities. The system is designed to manage academic assessments, attitude assessments, student attendance, and extracurricular activities within a single, centralized database. During the trial, all key system modules performed as designed, including role-based user authentication, assessment data management, data validation, and learning outcome report generation.

One key feature implemented is a dedicated dashboard for subject teachers, serving as a central hub for managing student learning outcomes. This dashboard allows teachers to select classes and semesters and manage student knowledge and skills scores based on predetermined minimum completion criteria. Figure 1 displays the subject teacher dashboard used during the system's trial.

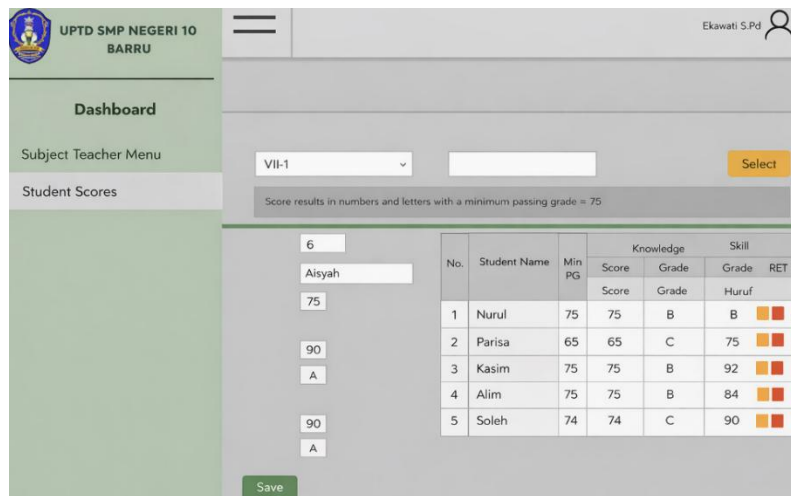


Figure 2. Subject Teacher Dashboard for Student Learning Outcome Assessment

The dashboard enables a more systematic and consistent assessment process than using separate documents. During the trial, teacher-entered grade data were consistently stored in a centralized database without the need for manual merging. Therefore, to provide a brief overview of the subject teacher dashboard's functionality, Table 1 summarizes the interface's main functional components.

Table 1. Functional Components of the Subject Teacher Dashboard

System Components	Main Function	Managed Data
Class and semester selection	Determining the context of assessment	Class, semester
Knowledge assessment	Cognitive value input and updating	Numeric and letter values
Skills assessment	Input and update of skill values	Numeric and letter values
Minimum completion criteria (KKM)	Evaluation standardization	Passing threshold value
Centralized storage	Assessment data integration	Learning outcomes database

Results of System Usability Test by Students

A system usability test was conducted to assess the system's ease of use and understandability from the perspective of students as end users. Twenty secondary school students participated in the trial. The evaluation used a five-level Likert-scale questionnaire covering aspects of ease of use, display clarity, clarity of assessment information, and ease of

navigation. Descriptive statistical analysis showed that the system achieved high feasibility scores across all evaluated aspects. Table 2 presents a summary of the results of the student usability test.

Table 2. Results of System Usability Test by Students (n = 20)

Rated aspect	Average Score (%)	Category
Ease of use	88.5	Very worthy
Clarity of display	87.0	Very worthy
Clarity of assessment information	86.8	Very worthy
Navigation convenience	89.2	Very worthy
Overall average	87.9	Very worthy

The results in Table 2 show that no aspects fell below the very adequate category. The navigational ease aspect received the highest score, indicating that the menu structure and system usage flow were easy for students to understand.

Expert Validation Results

In addition to student usability testing, this study included expert validation to assess the system's feasibility from a professional perspective. Validation was conducted by three expert validators: an instructional media expert, an information technology expert, and a linguist. The assessment focused on the quality of the interface design, the system's reliability and functionality, and the clarity and appropriateness of the language. Table 3 presents the results of the expert validation of the web-based student learning outcome assessment system.

Table 3. Expert System Validation Results

Validator	Assessment Focus	Score (%)	Category
Media expert	Visual design and usability	88.0	Very worthy
Information technology expert	System functionality and reliability	90.5	Very worthy
Linguist	Clarity and appropriateness of language	85.7	Very worthy
Overall average		88.1	Very worthy

Based on the validation results, all aspects of the system are in the very feasible category, with the highest scores in system functionality and reliability.

Discussion

This discussion section interprets the study's empirical findings by linking them to theoretical frameworks and current research in educational assessment and learning technology. The discussion focuses on the significance of the findings, their pedagogical and organizational implications, and the research's contribution to the development of digital assessment systems in secondary education, without repeating the quantitative data presented in the results section.

The research results show that the developed web-based student learning outcome assessment system addresses the main problems in conventional assessment practices in secondary education, particularly data fragmentation and administrative inefficiency. From the perspective of educational information systems theory, assessment data fragmentation often hinders information integration and reduces the validity of using assessment results as a basis for pedagogical decision-making (Alhazbi et al., 2024; Drugova et al., 2024). The integration of various assessment components into a centralized system enables more consistent, reliable, and traceable data management, thereby supporting the principle of evidence-based decision-making in education. This finding aligns with studies (Adigüzel et al., 2025) which confirms that integrated digital assessment systems significantly improve data quality and decision-making effectiveness in school environments.

The high usability scores of the system based on student trials indicate that the system was designed with user-centered design principles in mind, a design approach that places user needs, characteristics, and experiences at the center of system development. Within the Technology Acceptance Model (TAM) framework, perceived ease of use and perceived usefulness are key determinants of the adoption and continued use of educational technology (Nikou & Economides, 2017). The results of this study indicate that the system has high acceptance among end users, suggesting the potential for continued use without resistance, a factor that is often an obstacle to the implementation of educational technology in schools.

From a pedagogical perspective, the system's transparency in providing assessment information supports the practice of assessment for learning. According to formative assessment theory, effective assessment serves not only as a tool for measuring outcomes but also as a means of supporting the learning process through clear, ongoing feedback (Altıntaş, 2022; Ropohl & von Aufschnaiter, 2022). Direct access to learning outcome information allows students to monitor their academic progress, identify weaknesses, and reflect on their learning strategies. Recent research shows that transparency and accessibility of assessment data are essential prerequisites for the development of self-regulated learning, where students actively manage their own learning goals, strategies, and evaluations (Mutluer, 2023; Panadero et al., 2023).

Expert validation strengthened these findings by demonstrating that the system had a balance of technical, pedagogical, and communicative qualities. From a digital learning design theory perspective, the balance between visual design, system reliability, and language clarity is key to creating an effective and inclusive user experience (Çeken & Tacsın, 2022). Media experts' assessments confirmed that consistent interface design reduces users' cognitive load, while information technology experts' assessments indicated that the system has adequate technical foundations to ensure data stability and security. Linguists' assessments of language clarity ensured that the system is accessible and understandable to users with diverse academic backgrounds, a crucial principle in developing inclusive educational technology.

Compared to previous research, this study's primary contribution lies in its focus on learning outcome assessment as the core of the system, rather than as an additional feature of an online learning system or learning management system. Many previous studies have positioned assessment as a supporting component of digital learning, thus paying less attention to the integration and quality of the assessment data itself (Bond et al., 2020). Thus, this study fills a research gap related to the development and evaluation of integrated digital assessment systems in secondary education, particularly in school environments with limited resources and varying levels of technological readiness.

However, this study has limitations that require critical consideration. The relatively limited number of student participants and the short duration of the trial limit the generalizability of the findings. Within the framework of educational research methodology, evaluations of technology systems should ideally be conducted longitudinally to capture the dynamics of acceptance and the long-term impact of system use (Creswell & Inoue, 2025). Therefore, further research with a longitudinal design and a larger sample size is needed to comprehensively evaluate the system's impact on student learning outcomes, teacher assessment practices, and school decision-making.

Overall, this discussion confirms that the developed web-based student learning assessment system is not only technically feasible but also pedagogically and organizationally relevant. By integrating principles of formative assessment, technology acceptance, and digital learning design, this study makes empirical and theoretical contributions to the global discourse on the digital transformation of educational assessment. Furthermore, this research opens the door to further development of an adaptive, sustainable, and data-driven assessment system to improve the quality of secondary education.

Conclusions and Suggestions

Conclusions

This study aims to design, develop, and evaluate an integrated web-based student learning outcome assessment system to support assessment management at the secondary education level. Based on implementation and empirical evaluation results, this study shows that the developed system can function effectively as an assessment platform that integrates various components of learning evaluation, including academic assessment, attitude assessment, attendance, and extracurricular activities, in a centralized database.

The results of the student usability test showed that the system had a very high level of ease of use, clarity of display, and understandability of assessment information. These findings indicate that the system was designed with user-centered principles in mind and has the potential to be well accepted by end users. Furthermore, validation by media, information technology, and language experts confirmed that the system met multidimensional feasibility criteria, encompassing technical, pedagogical, and communicative aspects.

From a pedagogical perspective, this web-based assessment system supports assessment-for-learning practices by providing transparent and easily accessible learning outcome information to students. This transparency has the potential to encourage the development of self-regulation-based learning, where students can monitor their learning progress and reflect independently. For teachers and school administrators, this system contributes to increased efficiency in assessment administration and consistency in data management, enabling more optimal use of assessment results in pedagogical and organizational decision-making.

Theoretically, this research contributes to the development of digital assessment systems by placing learning outcome assessment at the core rather than treating it merely as a supporting feature of digital learning. Practically, the findings suggest that an integrated web-based assessment system could be a viable solution for secondary schools, particularly in environments with limited resources and varying levels of technology readiness. However, this study has limitations, particularly related to the number of participants and the relatively short duration of the system trial. Therefore, future research is recommended to involve a larger sample, employ a longitudinal design, and explore, in greater depth, the integration of learning analytics or artificial intelligence features to support adaptive assessment and data-driven decision-making. With further development, it is hoped that the web-based assessment system will have a broader and more sustainable impact on improving the quality of secondary education.

Suggestions

Based on the research findings, further development of the web-based student learning assessment system is recommended to integrate learning analytics features to support continuous, data-driven monitoring of student learning progress. This feature enhancement has the potential to strengthen assessment's function as a pedagogical decision-making support tool, particularly in the context of secondary education in developing countries.

From a pedagogical perspective, future research could explore the application of adaptive feedback mechanisms and personalized assessments to support self-regulated and student-centered learning. This approach is relevant to the evolving digital education reform agenda in various national contexts, including Indonesia and Brazil.

Furthermore, the implementation of digital assessment systems needs to be supported by comprehensive institutional policies, including teacher training and strengthening digital literacy among education personnel. Cross-national research is also recommended to test the transferability and scalability of these assessment system models across different social and educational policy contexts.

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