Development of a Gamification-Based Quiz Management System with Leaderboard Feature

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Abstract

Conventional quiz administration using paper-based methods or basic digital platforms often leads to ineffective score documentation and low student engagement. This research aims to develop a web-based quiz management system integrated with a dynamic leaderboard feature to support gamification-based learning, thereby streamlining assessment processes and fostering student motivation. The study employed the Research and Development (R&D) method following the Waterfall model, consisting of requirements analysis, system design, implementation, testing, and maintenance. The system was developed using PHP with the CodeIgniter framework. Functional testing was conducted using Black Box Testing across 71 test cases, while usability was evaluated using the System Usability Scale (SUS) questionnaire involving 32 respondents (one teacher and 31 students) at a middle school in Surakarta. The Black Box testing achieved a 100% success rate after improvements, confirming that all system features function reliably. The usability assessment yielded an average SUS score of 88.35, categorizing the system as "Excellent" (Grade B) and falling within the "Acceptable" range. The leaderboard feature successfully visualized student rankings based on scores and completion time, promoting healthy competition. It can be concluded that the developed quiz management system, QuizFun, is highly feasible and acceptable for supporting gamification-based learning. The integration of the leaderboard effectively transforms conventional assessments into engaging, interactive experiences while providing teachers with efficient tools for managing and documenting student performance.

1 Introduction

The quiz serves as a critical component in the teaching and learning process, primarily functioning as a short evaluation tool to measure students' skills, knowledge, intelligence, and aptitude (Murphy et al., 2023). When administered effectively, quizzes can motivate students, encourage active participation, and enhance self-assessment capabilities, ultimately improving learning outcomes. However, the traditional methods of delivering quizzes, often using paper sheets or basic digital platforms, have demonstrated several drawbacks, such as poor score documentation and inefficient time management for educators in preparing assessments. This absence of interactive elements contributes to a dull learning environment, making it challenging for students to concentrate, thereby demanding more engaging, beneficial, and less monotonous educational experiences.

In line with the demands of the Industrial Revolution 4.0, which necessitates the integration of technology into education, there is an urgent need for innovative learning methods. Interactive quizzes, packaged within specially designed software, offer a solution to these issues. By leveraging technology, quizzes can be transformed into gamification-based assessments, utilizing game elements such as challenges and time limits to stimulate student interest and, consequently, improve learning outcomes. Gamification is the application of game design elements and mechanics in non-game contexts (Deterding et al., 2011; Landers, 2014), proven effective in enhancing motivation and engagement, promoting a spirit of competition, and reducing the fear of making mistakes.

A key component of gamification crucial for motivational purposes is the leaderboard. A leaderboard visually displays the accumulated points and rankings of participants, guiding them to set specific goals and providing a visible representation of their performance (Werbach & Hunter, 2020; Zichermann & Cunningham, 2011). A systematic review by Li et al., (2024), confirmed that using leaderboards can have a beneficial influence on students' learning motivation, engagement, and performance, although their effectiveness largely depends on their designs. The ranking system inherently promotes competitive behavior among students to catch up with higher-ranked peers. Conversely, the lack of a visible ranking display, common in basic quiz platforms, fails to utilize this powerful mechanism to drive students toward achieving the highest possible scores. Given that most contemporary students are digital natives constantly engaged with smartphones for various activities, including games, integrating competitive and interactive elements like a leaderboard becomes essential to align with their preferred learning style.

Previous research has successfully explored the development of quiz management systems or educational games using platforms like Kahoot and other web-based applications (Ebadi et al., 2023; Wang & Tahir, 2020). In the Indonesian context, similar studies have confirmed the positive impact of gamified quiz platforms on student motivation and learning outcomes (Anggraini & Erviana, 2023). These studies confirm the positive impact of digital quiz systems on student motivation and learning achievement. However, a specific gap exists: many prior systems focused solely on basic quiz management and evaluation, failing to implement the crucial leaderboard feature to stimulate competition immediately after the quiz completion. Furthermore, while Li et al., (2024) highlight the potential of leaderboards, they also note that most existing reviews have only investigated the holistic impact of gamification, calling for more research on the individual use of leaderboards. The novelty of this research lies in the specific integration of a dynamic, performance-based leaderboard directly into the web-based quiz management system, providing immediate feedback and ranking to support active gamification-based learning. This approach also considers the complexities of leaderboard design, as studies like Papadopoulos et al., (2024), show that leaderboard effects can vary, underscoring the need for careful, theory-based implementation.

Based on the issues of ineffective manual assessment and documentation, the need for innovative technological support, and the identified gap in integrating the leaderboard feature, this study aims to address these challenges. Therefore, the primary objective of this research is to develop a quiz management system with a leaderboard feature that effectively supports gamification-based learning. This system is expected to streamline the assessment process for teachers and cultivate a competitive spirit among students, thereby enhancing engagement in daily evaluations.

2 Methodology

2.1 Research Design and Development Model

This study employed the Research and Development (R&D) method, which systematically aims to formulate, test, and evaluate the effectiveness and practicality of a product or procedure. The product developed is a web-based quiz management system equipped with a leaderboard feature designed to support gamification-based learning. The research design utilized the Waterfall Model, as illustrated in Figure 1, chosen due to its systematic and sequential phases that provide a structured approach to software development, ensuring clarity and traceability throughout the project. The R&D approach was

critical because the research aimed to create a novel technological tool to address existing problems in conventional assessment, thereby innovating the learning process.
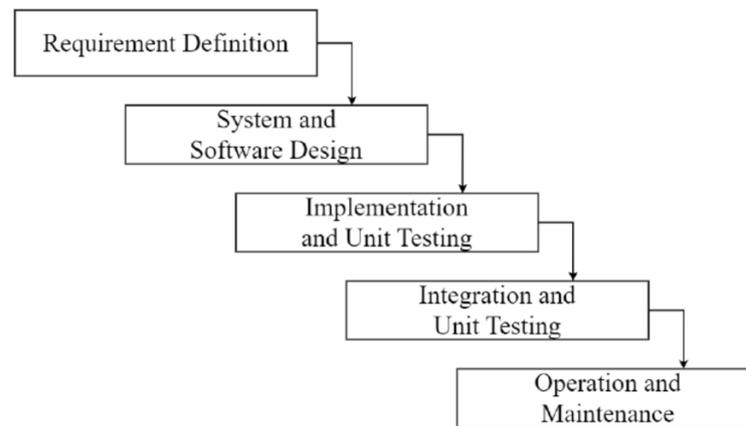

Figure 1: The Waterfall development model

The development process strictly adhered to the five sequential phases of the Waterfall Model, as defined by Sommerville (2011). The initial phase, Requirements Analysis and Definition, involved primary data collection through interviews with an IPA subject teacher and direct observation of manual daily assessment processes at a middle school in Surakarta. This phase identified critical needs, such as overcoming ineffective score documentation and the necessity for a technological innovation to manage daily quizzes efficiently. Following this, the System and Software Design phase translated these needs into technical blueprints, including the database schema and architectural design using the Unified Modeling Language (UML) to visualize system components clearly.

The third phase, Implementation and Unit Testing, involved coding the system using PHP with the *CodeIgniter* framework. The system was then subjected to rigorous functional checks using Black Box Testing to verify that every feature, menu, and button functioned correctly according to the defined requirements. This step was crucial to ensure the reliability of the system before integration and final testing. The fourth phase, Integration and Unit Testing (or Integration and System Testing, as implied by the integration of the whole system), confirmed that the entire web-based quiz management system operated cohesively and met all initial requirements before being deployed for final user trials.

Finally, the Operation and Maintenance phase outlined the necessary support and upkeep required once the system was deployed at the receiving institution. This phase acknowledged that continuous maintenance, including fixing unforeseen errors and adjusting the system to evolving field needs, is necessary for the product's sustained usability and effectiveness as a medium for daily assessment. The detailed and systematic nature of the Waterfall model ensured that the developed system was both structurally sound and functionally verified against the initial user requirements before assessment

2.2 Research Subjects, Instruments, and Data Analysis

The development product underwent testing involving specific research subjects. Initial validation was performed by two subject matter experts: one lecturer in Informatics Engineering Education (as the product validator) and one IPA subject teacher at SMP Batik Surakarta, both possessing over five years of relevant experience. Following the system improvement based on the initial validation input, the final product evaluation involved 32 participants as respondents, consisting of the IPA teacher and 31 students from the school. These subjects were essential for assessing both the system's functional integrity and its practical usability in a real educational context.

Data collection utilized two primary instruments to ensure a comprehensive evaluation of the developed system: functional testing and user perception testing. Functional adequacy was primarily assessed using Black Box Testing, a method focused on verifying system functions without needing

internal code knowledge. The Black Box instrument comprised 71 test cases covering all features and menus accessible to Admin, Teacher, and Student roles, ranging from login features to the core functionality of quiz creation and leaderboard display. This testing was initially performed by the validators, and critical feedback, such as an inaccurate initial web description, was addressed immediately to ensure system correctness.

The practicality and user acceptability of the system were measured using the System Usability Scale (SUS) questionnaire, developed by Brooke (1996). The SUS instrument has been widely validated as a robust measure of perceived usability (Bangor et al., 2008; Lewis & Sauro, 2009). The SUS instrument consists of 10 statements using a 5-point Likert scale (1 to 5). The data analysis technique for the SUS instrument involved calculating a normalized score for each respondent; scores from odd-numbered questions were reduced by one (Score - 1), while scores from even-numbered questions were reversed (5 - Score). The resulting total raw score was then multiplied by 2.5 to produce a final SUS score ranging from 0 to 100.

The calculated mean SUS score was compared against established usability criteria to determine the system's final acceptability, adjective rating, and grade scale, as provided in Figure 2. The final outcome of the data analysis, combining the functional testing results and the subjective user perception data (SUS scores), was used to conclude whether the developed quiz management system with the leaderboard was deemed acceptable and feasible for supporting gamification-based learning. This dual-method approach ensured that both the technological functionality and the user experience aligned with the research objectives.
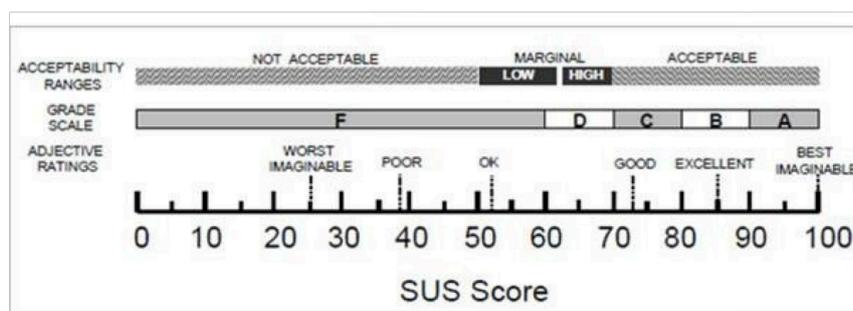

Figure 2: System Usability Scale (SUS) score criteria chart

3 Results and Discussion

3.1 Development Product and Functionality Testing

The developed product is a web-based Quiz Management System named *QuizFun*, created using the Hypertext Preprocessor (PHP) language with the CodeIgniter framework, complemented by Cascading Style Sheets (CSS) and Bootstrap. This system was engineered following the systematic and sequential phases of the Waterfall Model, ensuring that the system requirements were fully integrated into the final product design, particularly emphasizing the documentation of daily assessment scores and supporting the learning style of the digital generation. The system targets three main user roles: Admin, Teachers, and Students. The interactive and simple interface was deliberately designed to accommodate junior high school students, making the system easy to use and reducing cognitive load during the assessment process.

The core functionality of the system is to transform conventional, paper-based assessments—which often lead to poor score documentation and lack student engagement—into an interactive and manageable digital process. The system features key menus such as '*Home*', '*About QuizFun*', '*Activity*', '*Start Quiz*' and '*Login/Register*'. The system's initial interface, shown in Figure 3, provides a brief explanation of *QuizFun* as a platform designed to measure student ability through quizzes and game-based learning. This initial view serves as the entry point, directing users to the appropriate role-based dashboard, where the system

facilitates gamification elements, most notably through the leaderboard.

Figure 3: System initial interface

Functional validation of the system was rigorously conducted using Black Box Testing (BBT), a technique focusing on verifying system functions without needing internal code knowledge. The initial BBT, performed by one lecturer and one subject teacher, covered 71 distinct test cases. This initial round of testing revealed two functional errors, resulting in a temporary failure rate of 2.89%, as shown in Table 1. Immediate system improvements were executed to resolve these identified bugs, ensuring all features functioned precisely according to the initial software requirements.

Table 1: Summary of black box testing results (after improvement)

Testing Round	Successful Test Cases	Failed Test Cases	Total Success Rate	Total Failure Rate
1st Round (Initial)	71	2	97.11%	2.89%
2nd Round (Post-Improvement)	71	0	100%	0%
Total After Improvement	**71**	**0**	**100%**	**0%**

After the necessary revisions were implemented, the system underwent a second round of BBT. As summarized in Table 1, the repeated testing yielded a perfect result, with 100% success across all 71 test scenarios for both the lecturer and teacher validators. This result confirms that all menus, buttons, and features, including user login, quiz creation by the teacher, and the critical leaderboard display for the student, are fully operational and reliable. The demonstrated 100% functionality confirms that the developed system is robust enough to proceed to user feasibility testing (usability testing) as a foundation for effective gamification-based learning.

3.2 Usability Assessment

The development product was assessed for its practicality and user acceptability through Usability Testing, which is a critical phase following functional verification. The test subjects included 32 respondents, specifically one IPA subject teacher and 31 students from a middle school in Surakarta. These participants utilized the *QuizFun* system by engaging in key features such as account registration, login, and using the various available functions, including the interactive quiz and the leaderboard. The evaluation instrument employed was the SUS questionnaire, originally developed by Brooke (1996). This instrument assesses user satisfaction and perceived usability across 10 statements using a 5-point Likert scale.

The raw data collected from the 32 respondents were processed using the standard SUS calculation method, where scores from odd-numbered questions are reduced by one, and scores from even-numbered questions are reversed (5 minus the score), with the total raw score then multiplied by 2.5 to yield a final score ranging from 0 to 100. Based on this calculation, the total SUS score accumulated from all respondents was 2827, resulting in a high average SUS score of 88.35.

The obtained average score of 88.359 was then interpreted based on the established SUS scoring criteria, as detailed in Figure 4. A score of 88.359 categorizes the system's usability as Excellent with a corresponding grade scale of B. Furthermore, in terms of acceptability ranges, this score places the system clearly within the Acceptable category, signifying that the developed system is considered highly feasible and acceptable for use as a quiz management system to support gamification-based learning.
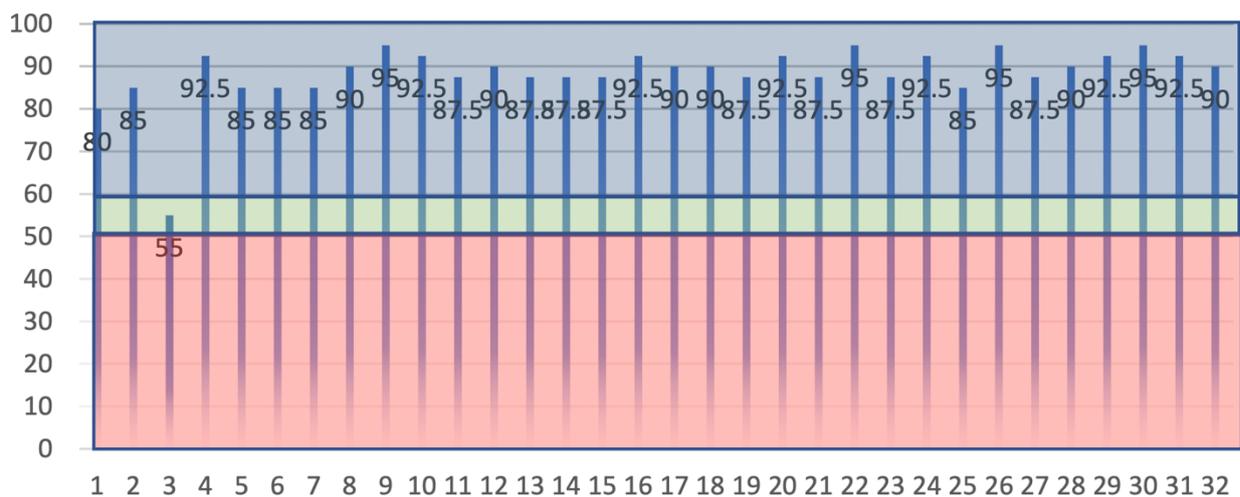

Figure 4: System usability score graph

Figure 4 visually represents the distribution of the individual SUS scores obtained from the 32 participants. The analysis of the individual scores showed that 31 out of the 32 respondents fell into the *'Acceptable'* category, as their scores were above the threshold of 71. Only one respondent was categorized as *'Margin High'* with a score of 55, while none fell into the *'Not Acceptable'* range. This highly skewed distribution towards the acceptable and excellent range strongly reinforces the finding that the system's design and functionality successfully meet user expectations for ease of use and practicality.

3.3   Discussion

The high success rate achieved during the Black Box Testing (100% functionality) and the outstanding SUS score (88.35, category Excellent) confirm that the developed quiz management system with the leaderboard feature is fully operational and highly accepted by its end-users: the teachers and students. The robust functionality ensures that the system can reliably manage daily quizzes, generate scores, and display results without technical failure, solving the manual assessment problems identified in the introduction, such as poor score documentation and inefficient time management. This technical reliability is the foundation necessary for successfully implementing gamification elements in the classroom, thereby supporting the study's primary objective.

The central mechanism enabling the gamification approach in this system is the leaderboard feature, visually represented in Figure 5. Unlike conventional platforms that merely provide final scores, this system immediately displays rankings based on combined factors of score and completion time. According to Kim et al. (2021), the visible ranking system acts as a guide for participants to set specific achievement goals and provides public representation of their performance. This design aligns with the theoretical framework proposed by Sailer et al. (2017), who found that leaderboards satisfy the psychological need for competence (Yıldırım & Şen, 2021), thereby enhancing intrinsic motivation. The visibility of student performance on the leaderboard inherently promotes a competitive spirit among students to strive for the highest scores, thereby transforming the traditionally boring assessment activity into a challenge.
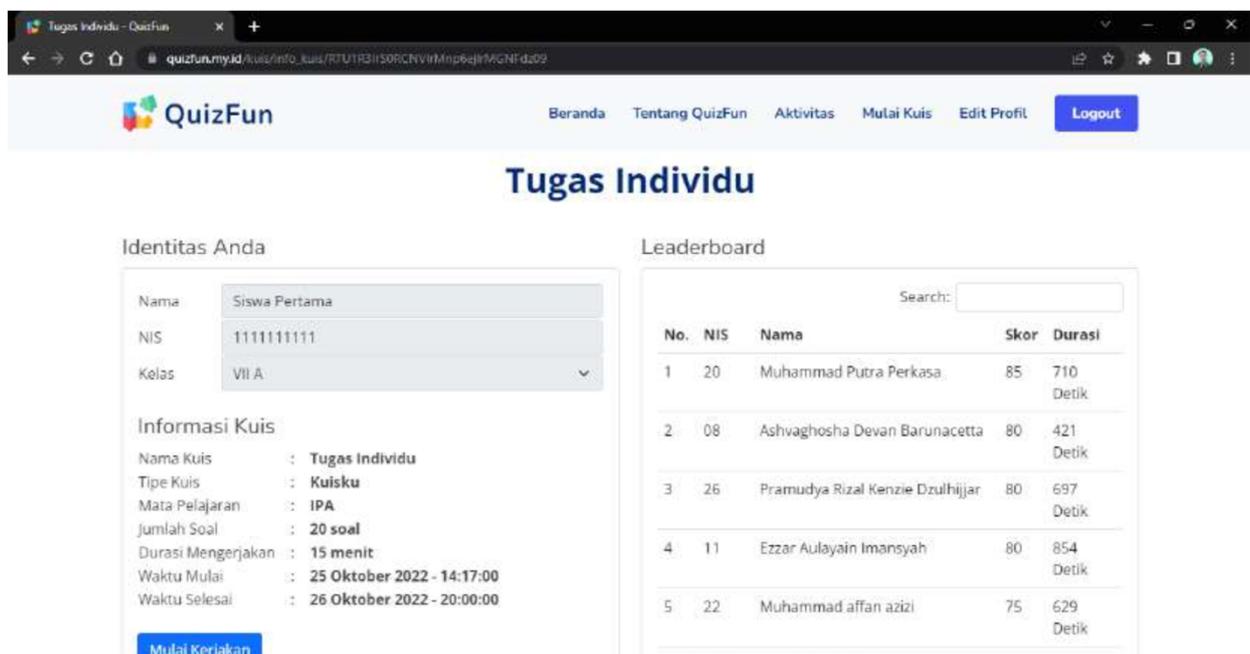

Figure 5: Student interface showing quiz leaderboard

The high mean usability score of 88.35 further validates the acceptance of this system as an interactive and engaging medium. The excellent usability indicates that users (students and teachers) perceive the system as easy to use and practical, requiring minimal support to operate. This ease of use is crucial because, as Puspitarini & Hanif (2019) suggested, learning media must be capable of motivating participants and effectively streamlining the learning process. The positive reception contrasts with the low engagement experienced during conventional, non-interactive quiz sessions, proving that the system successfully supports the digital learning styles of contemporary students

The implication of this research extends to improved management of daily assessment for educators. By utilizing this system, teachers are provided with an efficient platform to create quizzes, manage data, and automatically archive student scores, solving the issue of manual score documentation and misplaced assessment sheets. The system acts as a digital support tool, allowing teachers to easily monitor student

activity and performance in real-time through the data dashboard. This integration of effective data management alongside interactive student features ensures that the system serves both administrative and pedagogical goals effectively

4   Conclusion

Based on the results and discussion, it can be concluded that the developed quiz management system with the leaderboard feature, *QuizFun*, is highly acceptable and feasible for supporting gamification-based learning. The system achieved a 100% success rate in functional testing using the *Black Box* method after initial improvements, confirming that all features and menus function correctly and reliably. Furthermore, the system's usability, measured by the SUS across 32 respondents, yielded an average score of 88.35, which falls into the excellent category with a grade scale B, demonstrating high user satisfaction and practicality. The successful integration of the leaderboard feature effectively enhances student motivation, promotes a competitive spirit, and streamlines daily assessment management for teachers, thus validating the system's role as an interactive medium for modern digital learning

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