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Development and Evaluation of an E-learning System using the CodeIgniter framework to Support Informatics Learning at SMA Negeri 1 Tanjung Raja

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Keyword

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Abstract

This study aims to develop and evaluate a web-based e-learning system to support Informatics learning at SMA Negeri 1 Tanjung Raja. The research employed a Research and Development (R&D) approach using the Waterfall model, consisting of requirements analysis, system design, implementation, testing, and maintenance. The system was developed using the CodeIgniter 4 framework with the Model–View–Controller (MVC) concept. Functional testing was conducted using the Black Box Testing method, executed on 13 different test scenarios by three expert validators with information technology education lecturers with backgrounds in software engineering. All 13 test items were evaluated independently by each validator, resulting in a 100% pass rate (13 out of 13 items were functional in the third validator). Usability testing using the System Usability Scale (SUS) instrument with 30 respondents comprising 29 Grade X students and 1 Informatics teacher, resulted in an average SUS score of 89, which is classified as Very Good. These findings indicate that the system has robust functionality and is considered very easy to use in this particular school context. Limitations include the single-school setting and relatively small sample size, and further validation across different educational contexts is recommended.

1. Introduction

Digital learning technologies have increasingly penetrated secondary education globally, yet their effective implementation remains uneven, particularly in under-resourced school contexts [1]. While e-learning platforms offer documented benefits including greater flexibility in time and place of access, support for student-centered learning, and more efficient delivery of structured instructional content many schools in Indonesia continue to rely on conventional, teacher-centered approaches that limit student engagement and learning continuity [2]. The lecture-centered approach has well-documented constraints: it accommodates a narrow range of student learning styles and tends to reduce motivation when not complemented by more varied instructional modalities [3]. Furthermore, restricted classroom time means students have insufficient opportunity to engage with learning materials beyond scheduled sessions.

One form of technology-based learning innovation that has developed rapidly is e-learning. The rise of e-learning has revolutionized education, driven by technological advancements and the growing need for flexible learning [4]. E-learning is a learning process conducted through computer networks either the internet or

intranet which allows students to access learning materials without limitations of space and time [5]. The implementation of e-learning encourages a shift in the learning paradigm from teacher-centered to student-centered, enabling students to have greater flexibility in managing their time and learning methods [2]. In addition, e-learning is considered capable of improving efficiency and comfort in the learning process [6].

Developing an e-learning system certainly requires reliable supporting technology. One such framework is the CodeIgniter framework, which is widely used for application development. The CodeIgniter framework was chosen for e-learning development because of its several advantages, including its light weight, speed, use of the MVC (Model-View-Controller) concept, and ease of development for developers in building structured applications. Using CodeIgniter is expected to make e-learning development more efficient, easier to manage, and able to meet the needs of both teachers and students [7]. Previous studies have shown that the implementation of CodeIgniter in online learning systems can provide key features such as materials management, discussion forums, and assignment submission, which effectively support the learning process [6]. The development of web-based systems further requires a structured methodology to ensure both functional correctness and user satisfaction, as demonstrated in recent studies that integrate systematic development approaches with usability evaluation across various institutional contexts [8].

However, a critical examination of Syakti and Hutrianto's [6] work reveals several unresolved limitations. First, systems developed were evaluated solely through Black Box Testing, which measures only functional correctness without assessing user acceptance, satisfaction, or actual learning effectiveness. Second, existing implementations lack interactive communication features such as real-time discussion forums or automated assessment mechanisms, limiting the system to a one-directional information delivery model. Third, prior studies were conducted within a single institutional context without validating whether the developed system is scalable or adaptable to schools with varying infrastructure and pedagogical needs. These gaps indicate that while foundational e-learning systems using CodeIgniter have been established, there remains a significant need for systems that incorporate richer interactive features, validated through comprehensive user-centered evaluation methods across diverse institutional settings.

Based on preliminary interview results conducted with one Informatics teacher at SMA Negeri 1 Tanjung Raja, the learning process is still dominated by the use of textbooks, lecture methods, and group discussions. The lecture method has limitations because it is less interactive and does not fully accommodate various student learning styles, which can reduce interest and learning effectiveness if not combined with more varied instructional methods [3].In addition, limited classroom learning time also causes students to experience difficulties in understanding the materials more comprehensively. The results of a needs assessment questionnaire distributed to 26 Grade X students at SMA Negeri 1 Tanjung Raja indicate that all students already own smartphones that can be utilized for learning purposes. Students also showed a high level of interest in using a web-based learning system that provides materials in the form of text, images, and videos, as well as discussion and online assignment submission features. Based on the questionnaire results, approximately 60% of students reported having previously used an e-learning platform such as Google Classroom; however, the remaining 40% had never used any e-learning platform before. Therefore, the development of a dedicated e-learning system is considered relevant as a learning innovation that aligns with students' characteristics and needs [9].

Based on these problems and needs, it is necessary to develop an e-learning system tailored to the Informatics learning requirements at SMA Negeri 1 Tanjung Raja. This study offers several contributions that distinguish it from prior e-learning development research. First, unlike previous studies that only relied on Black Box Testing, this study integrates functional and usability evaluations including the System Usability Scale (SUS) to provide a more comprehensive assessment of meeting elements such as usability or perhaps user experience [10]. Second, the developed system incorporates more interactive learning features, including structured discussion forums and assignment management, which aim to support two-way communication and active student engagement rather than one-directional content delivery. Third, this study is conducted in the context of a public senior high school with varying levels of student familiarity with digital platforms, thereby providing

insights into the adaptability and practicality of implementing e-learning systems in diverse educational settings. Therefore, this research not only focuses on system development but also contributes to a more holistic evaluation approach and practical implementation model for e-learning in secondary education.

2. Research Method

This study uses a Research and Development (R&D) approach with the Waterfall software development model. The Waterfall model was chosen because the Waterfall Method is a classic software development life cycle model in which the application development process is carried out sequentially from each stage, and has proven to be very suitable and relevant for web-based information system design projects, because each phase produces the right output that is aligned with user needs [11]. The five stages of the Waterfall model as applied in this study are described below :

2.1 Analysis

This stage aims to identify problems and user needs regarding the e-learning system. The analysis was conducted through classroom observations, interviews with one Informatics teacher, and distribution of questionnaires to class X students at SMA Negeri 1 Tanjung Raja with a total of 26 respondents. Observations were used to examine the current learning process and the use of technology in the classroom. Interviews provided detailed insights into the teacher's needs and challenges, while the questionnaires gathered students' perceptions, difficulties, and expectations regarding the use of an e-learning system [12].

2.2 Design

The design stage was carried out based on the results of the requirements analysis. The system design was visualized using use case diagrams, as this model effectively represents user–system interactions in a simple and structured manner. This model was chosen because the system has relatively straightforward functionalities, making a simple representation more efficient than complex models. The use case diagram delineates the relationship between various actors and the actions they can perform within the application [13].

2.3 Implementation

This stage involves developing the system based on the prepared design. The e-learning system was developed using the CodeIgniter framework by applying the Model-View-Controller (MVC) concept, which was selected to separate application logic, data processing, and user interface, thereby improving maintainability and scalability. The development process referred to the use case diagram to ensure that all defined system functionalities and user interactions were properly implemented. He main features developed include learning materials management, discussion forums, assignment submission, and user management [14]. The implementation specifically leveraged PHP and JavaScript for front-end and back-end functionalities, respectively, with Vue.js utilized for dynamic user interface component [15].

2.4 Testing

The testing stage was conducted to ensure that the system operates according to requirements and is free from functional errors. Functional testing was performed using the Black Box Testing method to evaluate the conformity of system outputs with the given inputs. In addition, usability testing was conducted using the System Usability Scale (SUS) instrument to assess the system's ease of use from the users' perspective. Usability testing using the SUS instrument with 30 respondents comprising 29 Grade X students and 1 Informatics teacher.

2.5 Maintenance

The maintenance stage was carried out after system implementation. This stage includes system evaluation and improvements, particularly in refining the user interface and optimizing system performance. Adjustments were made based on feedback from validators to ensure the system remains effective, user-friendly, and aligned with user needs.

3. Result and Discussions

3.1 Result

The development of the web-based e-learning system in this study was carried out using the Waterfall model, which consists of the stages of requirements analysis, system design, implementation, testing, and maintenance. Each stage was conducted sequentially and systematically to produce a learning system that meets user needs.

3.2 Analysis

3.2.1 User Requirements Analysis

At this stage, user requirements were analyzed to ensure that the developed e-learning system aligns with the needs of the learning process. The data were obtained from classroom observations, interviews with an Informatics teacher, and questionnaires distributed to 26 tenth-grade students. The summary of findings is presented in Table 1.

Table 1. Summary of Observation, Interview, and Questionnaire Results

No	Findings	Description
1	Subject	Informatics
2	Laboratory Usage	Rarely used due to limitations
3	Device Ownership	Most students own smartphones and frequently use them for learning
4	Learning Platform	Previously used Google Classroom, but it lacks several features: (1) statistical and analytical reports, (2) flexible material structuring, (3) integrated discussion forums, and (4) tracking of students who have accessed materials
5	Expected Features	Learning materials (text, images, videos), discussion forums, and flexible assignment submission

Based on these findings, further analysis was conducted to map user needs into system requirements, as presented in Table 2.

Table 2. User Requirements Analysis

No	Criteria	Analysis Result
1	Users	Teachers and Grade X students of Informatics subject at SMA Negeri 1 Tanjung Raja
2	System Type	Web-based e-learning system accessible via smartphones and computers
3	Features	Teacher: (1) Manage materials (CRUD and view reader list), (2) Manage discussion forums, (3) Manage projects (CRUD and assessment), (4) Access statistical and analytical reports. Students: (1) Access homepage and about page, (2) View and select learning materials, (3) Participate in discussion forums, (4) Submit assignments/projects

The results of observations, interviews, and questionnaires indicate that the existing learning system has not fully supported Informatics learning needs. Limited laboratory utilization and the high ownership of smartphones among students emphasize the need for a flexible and accessible learning system. Although Google Classroom has been used, it does not adequately support learning activities due to the absence of analytical features, limited interaction facilities, inflexible material organization, and lack of monitoring of student engagement with learning materials. Therefore, a web-based e-learning system was developed to address these gaps by providing comprehensive features for material management, interactive discussions, assignment submission, student activity monitoring, and analytical reporting to support learning evaluation.

3.3 Design

The design stage was carried out based on the results of the requirements analysis. The system design includes the design of the system architecture.

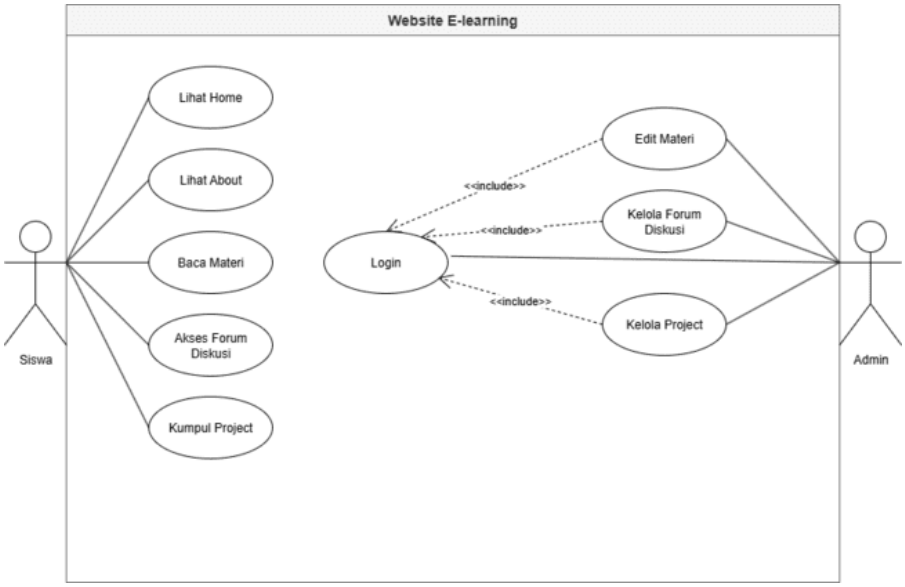

Figure 1. Use case diagram

Student actors can access various public features without needing to log in first. These accessible features include Home, About, Materials, Forum, and Project. However, student access is limited, meaning they can only view content and participate in a limited way in forums or available activities. Meanwhile, teacher actors are required to log in before they can use the system. After successfully logging in, teachers gain full access to all management features, including editing materials, managing discussion forums, and managing projects.

3.4 Implementation

The implementation results demonstrate that all core system features were successfully developed in accordance with the identified user requirements. Rather than presenting each interface in isolation, the implementation outcomes are summarized in terms of functional contributions to the learning process.

Table 3. Mapping of System Requirements and Implemented Features

No	User Requirement	Implemented Feature	Functional Contribution
1	Flexible access to learning materials	Materials Page (student & teacher)	Enables self-paced learning accessible anytime
2	Monitoring student engagement	Reader tracking list	Allows teachers to monitor material access
3	Interactive learning	Discussion forum	Facilitates asynchronous communication
4	Assignment management	Project feature (submission & grading)	Supports structured assessment workflow
5	Learning evaluation	Statistical reports (dashboard)	Provides data for instructional decision-making

The system interface is structured into two main access levels: student access and teacher access. For students, the system provides access to learning materials, discussion forums, and project submission features through a web-based interface accessible via smartphones and computers. The Materials Page plays a central role by enabling structured and independent learning beyond classroom limitations, directly addressing the

constraints identified during the analysis phase. For teachers, the system includes management features integrated into a centralized dashboard. These features include material management, forum moderation, and project assessment. A key implementation outcome is the integration of reader-tracking functionality, which enables teachers to monitor student engagement—an identified limitation in previously used platforms.

In addition, the authentication mechanism ensures that only authorized users (teachers) can access management features, thereby maintaining system security while keeping learning content accessible to students. Overall, the implementation reflects a requirements-driven design approach, where each feature directly corresponds to previously identified user needs.

3.5 Testing

The system testing stage was conducted to ensure that the system operates in accordance with the requirements defined during the analysis phase.

3.5.1 Functional Testing

Functional testing was carried out using the Black Box Testing method by three expert validators.

Table 4. Functional Testing Results for Teacher

No	Function Tested	V1	V2	V3	Conclusion
1	Teacher login validation	SUCCEED	SUCCEED	SUCCEED	Functional
2	Manage Materials (CRUD + reader list)	SUCCEED	SUCCEED	SUCCEED	Functional
3	Manage discussion forum	SUCCEED	SUCCEED	SUCCEED	Functional
4	Manage projects (CRUD + grading)	SUCCEED	SUCCEED	SUCCEED	Functional

Table 5. Functional Testing Results for Students

No	Function Tested	V1	V2	V3	Conclusion
1	Display main page	SUCCEED	SUCCEED	SUCCEED	Functional
2	Display ASUCCEEDout page	SUCCEED	SUCCEED	SUCCEED	Functional
3	Display materials list	SUCCEED	SUCCEED	SUCCEED	Functional
4	Display material content	SUCCEED	SUCCEED	SUCCEED	Functional
5	Display forum list	SUCCEED	SUCCEED	SUCCEED	Functional
6	Save and display discussions	SUCCEED	SUCCEED	SUCCEED	Functional
7	Display project list	SUCCEED	SUCCEED	SUCCEED	Functional
8	SuSUCCEEDmit project	SUCCEED	SUCCEED	SUCCEED	Functional
9	Display project details	SUCCEED	SUCCEED	SUCCEED	Functional

Functional testing was conducted using the Black Box Testing method across a total of 13 distinct test scenarios, as detailed in Tables 1 and 2 below. Each of the three expert validators independently evaluated all 13 items, resulting in 39 total validation decisions (13 items × 3 validators). All 39 decisions returned a Functional (succes) result, yielding a pass rate of 100%.The testing results indicated that all features operated in accordance with the predefined expectations, reflecting a high degree of reliability and functional suitability [16].

The 100% pass rate reflects the conformity of system outputs with the expected behaviors defined in the requirements specification. This result aligns with the fundamental objective of Black Box Testing, which is to verify whether a system meets its functional specifications by evaluating input-output behavior without examining internal code structures. Black Box Testing emphasizes validation of functional requirements from the user's perspective to ensure that the system behaves according to predefined expectations. A high pass rate therefore indicates that the system has successfully fulfilled its externally observable functional requirements [17]. A comparable result was reported by Putri et al. [9], who found that all functional requirements of a web-

based e-learning system were validated during Black Box Testing reinforcing the observation that well-specified, requirements-driven development tends to produce functionally complete implementations. However, it should be noted that functional completeness as determined by Black Box Testing does not assess performance under load, security vulnerabilities, or edge-case behaviors, and these dimensions remain subjects for future evaluation.

3.5.2 Usability Testing

Usability testing was conducted using the System Usability Scale (SUS) instrument involving 30 respondents. Usability testing was administered to 29 Grade X student respondents and 1 teacher the primary end users of the facing system features. All respondents were enrolled at SMA Negeri 1 Tanjung Raja and had participated in at least one session of interaction with the deployed system prior to completing the SUS questionnaire.

Table 6. Summary of SUS Results

Metric	Value
Number of Respondents	30
Minimum Score	75
Maximum Score	95
Average Score	89

The mean SUS score of 89.0 places the system in the Excellent category according to the adjective rating scale developed by Bangor et al. [18], who proposed a graded interpretation framework mapping SUS score ranges to qualitative descriptors: scores above 80.3 are classified as Excellent, scores between 68 and 80.3 as Good, and scores below 68 as below average. It should be noted that Brooke's [10] foundational work established SUS as a reliable and valid psychometric instrument for post-hoc usability measurement, but it is Bangor et al.'s [18] adjective rating framework that provides the interpretive categories applied here. SUS scores do not directly measure task completion rates or error frequencies; rather, they capture subjective user perceptions of ease of use and learnability. Fahira et al. [19] similarly reported SUS scores in the Excellent range for a web-based academic information system in an Indonesian school context, corroborating the validity of this interpretation in comparable settings.

3.6 Maintenance

The evaluation stage was conducted based on the results of functional and usability testing, as well as feedback from validators. Several improvement suggestions were provided, including adjusting content labels, separating profile information from vision and mission statements, restricting file upload formats, and improving discussion forum management for both teachers and students. States that improvements to features such as navigation, content structure, and interaction management based on validator feedback improve the usability and acceptance of the system [20]. All revisions recommended by the validators were fully implemented prior to the final SUS usability testing, ensuring that the test results reflect the improved and refined version of the system.

3.7 Discussions

The 100% functional test pass rate confirms that the system fully meets the specified requirements without critical technical errors. This result is consistent with Putri et al. [9], who reported equivalent results for a comparable web-based e-learning system, reinforcing the finding that structured, requirements-driven development using a framework like CodeIgniter 4 tends to result in functionally complete implementations. Functionally, the system allows students to access learning materials, participate in discussion forums, and submit project assignments through a single integrated platform directly addressing the flexibility and accessibility gaps identified in the requirements analysis [6]. For teachers, the platform consolidates materials management, student monitoring, and assignment grading into a single interface, supporting a more structured and efficient teaching workflow [5].

The average SUS score of 89.0 (Excellent) indicates that student and teacher respondents found the system easy to use without significant navigational or technical difficulties. According to the adjective rating scale proposed by Bangor et al. [18], a score above 80.3 is classified as Excellent, while Brooke [10] confirmed the

SUS as a reliable and valid instrument for post-hoc usability measurement. High usability is particularly important in the secondary school context: when the interface presents a low cognitive load, students can direct their attention to the learning content rather than to the system operation a factor recognized as central to the effectiveness of digital learning environments. The system's high usability score is due in part to features directly derived from documented user needs, and in part to CodeIgniter 4 MVC architecture, which facilitates a clear separation between the teacher-facing management interface and the student-facing content interface.

From a practical standpoint, this system offers a more context-specific learning environment than general-purpose platforms previously used in schools. Features such as reading history tracking, student-initiated discussion forums, and integrated project assessment with teacher feedback are not available in tools like Google Classroom and address specific instructional needs identified during the requirements analysis. Additional user guides were also developed to support early adoption, particularly for the project submission feature, which was underutilized during initial implementation. This finding is consistent with research that considers technology adoption in educational settings requires structured facilitation and adaptation support.

However, several limitations limit the scope of these findings. First, the learning materials currently available in the system only cover specific topics and do not fully cover the Grade 10 Informatics curriculum, thus limiting the system's role as a self-learning resource. Third, the evaluation was conducted in a single class with a small and relatively homogeneous sample (29 students and one teacher), which limits external validity and generalizability. Future research should address content coverage, adaptive learning features, and school validation.

4. Conclusions

This study developed and evaluated a web-based e-learning system for Informatics learning at SMA Negeri 1 Tanjung Raja, using the CodeIgniter 4 framework and the Waterfall development model. The system provides learning materials management with reader tracking, discussion forums, project submission with assessments, and a teacher activity dashboard. Functional testing using the Black Box Testing method—conducted on 13 test scenarios by three independent expert validators—resulted in a 100% pass rate (39/39 validations), indicating that all specified functional requirements were correctly implemented. Usability testing using the System Usability Scale (SUS) with 30 respondents (29 10th-grade students and one Informatics teacher) yielded an average score of 89.0, classified as Very Good.

These results indicate that the system is functionally reliable and perceived as very easy to use by the primary student users in the testing context. However, this study has several important limitations that should be acknowledged. The evaluation was conducted in a single-class environment with a small and relatively homogeneous sample, which limits the generalizability of the findings. The SUS sample included only one teacher respondent, which is insufficient to generalize teacher usability perceptions. Future studies should include a larger, more representative sample of teachers. Future research should address these limitations through multi-school validation and evaluation of usability from a larger teacher perspective.

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