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Scrum-Based Development for an E-Learning Prototype: Usability (SUS) Findings and Implications for Engagement

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Abstract *– Higher education continues to struggle with rapidly shifting requirements in learning and teaching. Existing e-learning systems often fail to adapt to these changes. Current open-source learning platforms are unable to accommodate the dynamic needs of students, faculty, and academic administrators, thereby hindering the effectiveness of the learning process. This study aims to design and develop an e-learning prototype by applying a Scrum-based development methodology, combined with needs analysis using the Ishikawa diagram. The Scrum approach was employed to support iterative and incremental development, enabling continuous user feedback and risk management. A usability evaluation was conducted using the System Usability Scale (SUS), involving 164 respondents, and yielded an average score of 54.1, categorized as marginally acceptable. The evaluation results indicate that the prototype provides a functional solution but still requires further refinement through additional iterations to meet user expectations. This research contributes to the development of adaptive e-learning systems in higher education, with Scrum serving as the methodological foundation. Furthermore, it provides empirical evidence regarding current usability limitations and recommends iterative strategies to enhance user engagement in subsequent development cycles.*

Keywords: *E-learning, Ishikawa Diagram, Scrum, System Usability Scale (SUS), User Engagement*

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Abstrak *– Pendidikan tinggi menghadapi tantangan dalam memenuhi perubahan kebutuhan yang cepat dalam pembelajaran. Sistem pembelajaran yang ada sering kali gagal beradaptasi dengan perubahan tersebut. Sistem pembelajaran sumber terbuka yang tersedia saat ini tidak dapat mengakomodasi kebutuhan dinamis mahasiswa, dosen, dan administrator akademik, sehingga menghambat efektivitas proses pembelajaran. Penelitian ini bertujuan untuk merancang dan mengembangkan prototipe e-learning dengan menerapkan metodologi pengembangan berbasis Scrum, yang dipadukan dengan analisis kebutuhan menggunakan diagram Ishikawa. Pendekatan Scrum digunakan untuk mendukung proses pengembangan iteratif dan inkremental, yang memungkinkan umpan balik pengguna dan manajemen risiko yang berkelanjutan. Evaluasi kegunaan dilakukan dengan System Usability Scale (SUS) yang melibatkan 164 responden, dengan hasil rata-rata skor 54,1 (kategori marginally acceptable). Hasil pengujian menunjukkan bahwa prototipe memberikan solusi fungsional, namun masih memerlukan penyempurnaan melalui iterasi lanjutan agar memenuhi harapan pengguna. Penelitian ini berkontribusi pada pengembangan sistem e-learning adaptif dalam Pendidikan tinggi, dengan Scrum sebagai fondasi metodologis.. Selain itu, penelitian ini menyajikan bukti empiris mengenai keterbatasan kegunaan saat ini dan merekomendasikan strategi iteratif untuk meningkatkan keterlibatan pengguna pada siklus pengembangan berikutnya.*

Kata Kunci*: E-learning, Diagram Ishikawa, keterlibatan pengguna, Scrum, System Usability Scale (SUS).*

I. INTRODUCTION

The transformation of higher education, especially with the advent of innovations such as “Independent Learning, Independent Campus”, underscores the importance of utilizing technology in the learning process [1], [2]. However, the current open-source e-learning systems employed by universities have not yet been able to meet the rapidly evolving needs, especially in terms of adaptability to changes and user demands. This situation creates a need for a more flexible and responsive development approach.

The primary issue identified is the misalignment between the existing e-learning system and the changing needs of higher education. The system also fails to meet the needs and expectations of students, faculty, and administrators, resulting in reduced effectiveness of the learning process and hindering the achievement of desired educational outcomes [3], [4]. Therefore, the critical issue to be addressed is how to design and develop an e-learning system that can quickly accommodate changes, meet user needs, and enhance the effectiveness of the learning process [5]. To respond to this challenge, this research applies the Scrum Methodology to guide the development of an e-learning system [6], [7]. Scrum enables more adaptive development, greater user involvement, and more effective management of risks and changes [8], [9], [10].

While previous studies [6], [7] have examined the effectiveness of Scrum in general software development, there remains a research gap in its application to the development of adaptive e-learning systems within higher education, particularly in Indonesia. Moreover, earlier research has seldom integrated structured requirements analysis tools, such as the Ishikawa diagram, with Scrum-based development to capture user needs. Likewise, evaluations of e-learning prototypes in the Indonesian context have rarely employed standardized usability measures such as the System Usability Scale (SUS). Therefore, this study addresses these gaps by combining Scrum methodology with Ishikawa-based requirements analysis and evaluating the resulting prototype using SUS, thereby contributing both methodological and contextual novelty.

Furthermore, the issue of user engagement has not been adequately addressed in prior studies. Student engagement is widely recognized as a multidimensional construct—encompassing behavioural, emotional, and cognitive aspects—and as a critical determinant of learning success. Empirical evidence from Indonesian higher education demonstrates that engagement in online learning remains relatively low. Kristiana et al. (2023), found that many students exhibited limited participation, low motivation, and inconsistent involvement across behavioural, emotional, and cognitive dimensions [11]. These findings emphasize the necessity of e-learning systems that go beyond functional adequacy and actively foster engagement through adaptive features and iterative development. Consequently, this research operationalizes engagement based on the behavioural, emotional, and cognitive indicators, ensuring that the objective of "enhancing engagement" is both measurable and grounded in empirical evidence from the Indonesian higher education context. Through iterative sprints and continuous user feedback, Scrum methodology is expected to inform design improvements that directly enhance student engagement.

This study is grounded in the need for a solution that is responsive to the dynamic changes in the higher education environment [12], [13], [14]. Innovations in the educational system demand an approach that is both adaptive and responsive to the needs of students, faculty, and administrators. Higher education institutions must possess the agility to embrace the ongoing transformation of education in Indonesia. In this context, the university must be agile to navigate these changes.

The main objective of this research is to develop a design and prototype of an e-learning system that not only addresses current needs but also possesses the ability to adapt rapidly to future changes. Through the active involvement of users throughout each stage of system development, the design process becomes more attuned to their actual needs and expectations. Within this framework, the adoption of the Scrum methodology serves not only as a development guide but also as a mechanism that enables more reliable time planning, structured problem resolution, and incremental progress, all of which contribute to faster development cycles while maintaining system quality. Furthermore, the integration of Ishikawa-based requirement analysis provides a systematic approach for mapping and prioritizing user needs at the outset, ensuring that potential issues are identified early. To complement this, usability testing through the System Usability Scale (SUS) offers an empirical and standardized measure of how well the developed prototype is received by users. Framed in this way, the investigation of which functionalities and characteristics are deemed acceptable becomes central, particularly when the ultimate aim is to foster greater user engagement and to ensure that technological adoption translates into meaningful learning experiences. [15], [16].

This study addresses the following research questions:
RQ1: What functionalities and characteristics of an e-learning system are acceptable to users?
RQ2: How can user engagement be enhanced by designing an e-learning system prototype developed using the Scrum Methodology?

II. METHOD

The research method consisted of four main stages: user needs analysis, iterative system design, prototype development, and periodic usability evaluation. The methodology employed was Scrum, which enables iterative and incremental software development, continuous user feedback integration, and effective risk management. In the case study of Universitas Mahkota Tricom Unggul, the primary issue identified is the misalignment between the existing e-learning system and the changing needs of higher education. In designing a method for implementing an e-learning system, the researcher considers three key factors: application design, application features, and user interaction. These aspects have been well-documented in the literature and must be taken into account when studying the development of user-centred applications [17], [18], [19].

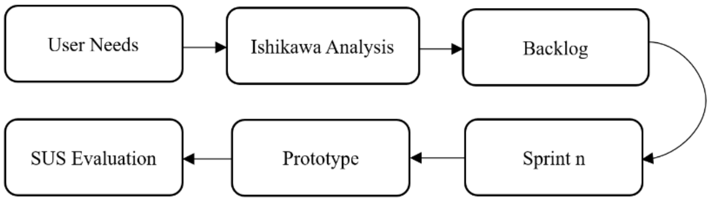

Figure 1. Flow Diagram

The flow diagram illustrated in Figure 1 is the systematic process for enhancing an e-learning system, starting from understanding user requirements to evaluating the usability of the developed prototype.

A. User Needs

This initial stage involves identifying the primary needs, preferences, and challenges of e-learning users. Data are collected through interviews, surveys, or observations of user interactions with existing systems. The insights obtained serve as the foundation for next analysis.

B. Ishikawa Diagram (Fishbone Analysis)

Once user needs are established, a root cause analysis is conducted using the Ishikawa diagram. This method helps map out factors affecting user experience, such as people, methods, technology, and environment. It ensures that the development process focuses on addressing the most critical issues impacting system effectiveness.

C. Backlog

Based on the Ishikawa analysis, a prioritized backlog of features, improvements, or tasks is created. Items are ranked according to urgency and expected impact on user experience, enabling a more structured and efficient development process.

D. Sprint n

The development phase is carried out iteratively using Scrum. Each sprint delivers a functional version of the system, allowing the team to implement backlog items incrementally while continuously evaluating progress and incorporating user feedback.

E. Prototype

The result of the sprints is a prototype of the e-learning system that can be tested by users. This prototype reflects the key features developed, providing early insights into system performance and usability before full-scale implementation.

F. System Usability Scale (SUS)

The final stage involves evaluating the usability of the prototype using the System Usability Scale. Users respond to the system by answering ten questions using a Likert scale, generating a score range from 0 to 100 that indicates overall user satisfaction and ease of use. This evaluation serves as a key measure of the prototype's effectiveness before full deployment.

The Scrum methodology was adopted to structure the development of the e-learning prototype through iterative cycles called Sprints. The Scrum team in this study consisted of the Product Owner (researcher), Scrum Master (project coordinator), and Development Team (system developers). Each Sprint included Sprint Planning, Daily Scrum discussions, Sprint Review, and Sprint Retrospective. These stages allowed continuous integration of user feedback gathered during each iteration, enabling a flexible and user-centred development process. The method diagram (Figure 2) reflects this iterative process tailored to address the objectives of this study.

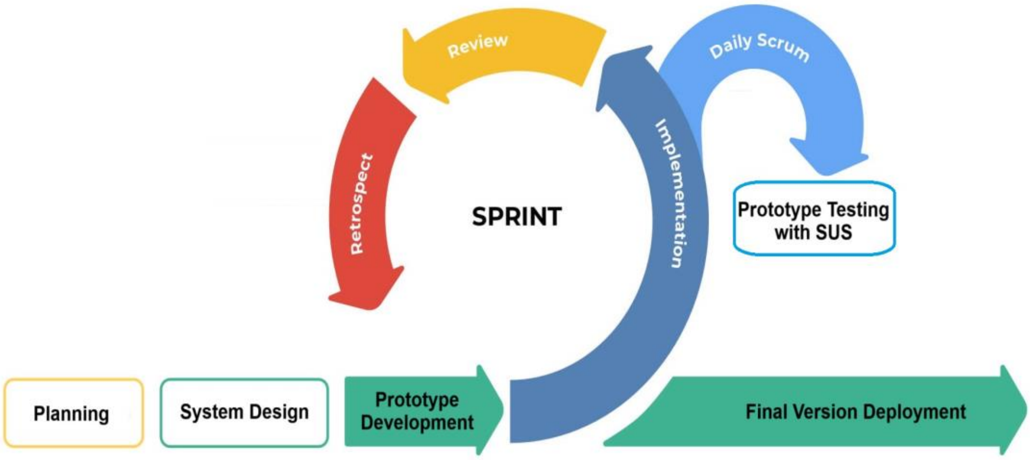

Figure 2. Stages of the proposed method

The development process consisted of 2 Sprints, each lasting 2 weeks. The Product Backlog contained 3 prioritized user stories, derived from the Ishikawa-based user needs analysis. Each Sprint focused on implementing one or two user stories. Progress was monitored using story points and velocity. Completion of each user story was assessed against the Definition of Done and Acceptance Criteria, including feature implementation, device testing, and approval by the Product Owner. Through iterative sprints and continuous user feedback, the Scrum methodology informed design improvements that directly enhanced student engagement.

In the initial three stages in Figure 2, the researcher designs and comprehends the overall context of the application and its functionalities, and how it interacts with its users. During the system design phase, modelling is conducted by software engineering methodologies to demonstrate how the software components interact with users. Subsequently, the System Usability Scale (SUS) is applied to evaluate the prototype of the newly developed application. SUS has been utilized as a comprehensive system testing method to assess the usability of the application with the proposed solution. SUS has long been recognized as one of the most widely used questionnaires and has been proven effective in studies involving as few as five questionnaire participants [20].

In the System Design step, a thorough study and modelling are conducted to compile a list of application requirements. This serves to identify the purpose of use and the characteristics of the users. To this end, an Ishikawa diagram is created to establish a foundation for understanding the application's characteristics and intended purposes [21], [22], [23], [24].

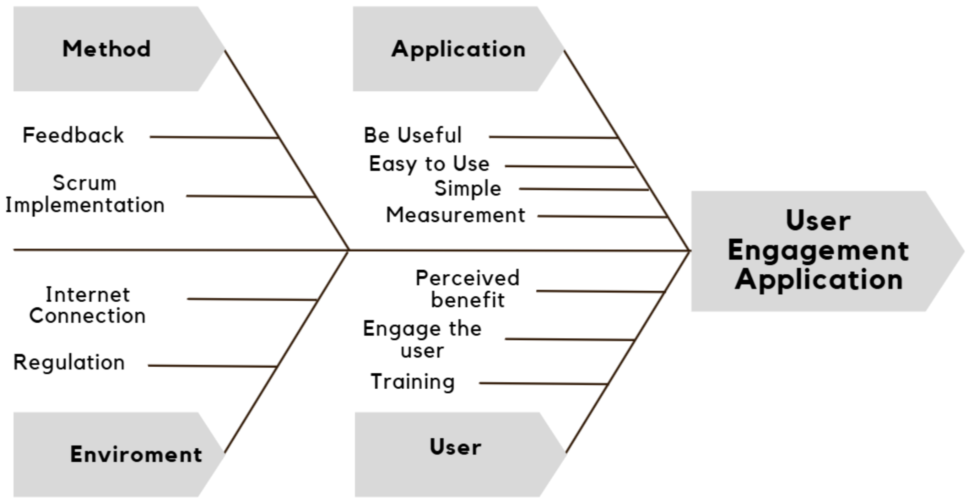

Figure 3. Analysis of E-Learning Prototype

The prototype system was developed based on the results of user needs analysis, as illustrated in the Ishikawa diagram. The four primary factors—user motivation, expectations, development strategy, and environmental support—guided the design of the system's features. Each interface component in the prototype (Courses Page, Subject Page, Dashboard, and Activity Menu) was designed to directly respond to these identified factors, ensuring that the functionalities are aligned with user needs. For example, the Dashboard centralizes personalized user data to increase engagement, while the Activity Menu allows lecturers to create interactive learning modules that encourage participation. The Ishikawa diagram in Figure 3 illustrates the data derived from the researcher's analysis. It highlights four main aspects: the factors that motivate users to utilize the application, the type of application users expect, the development methods employed, and the external environment that supports its implementation. As part of the prototype's design, the courses page (Figure 4) was developed to act as a focal point for accessing and managing instructional materials, tasks, and class activities. By employing a clear and organized structure, this feature helps users navigate course resources smoothly and maintain focus on the learning process.

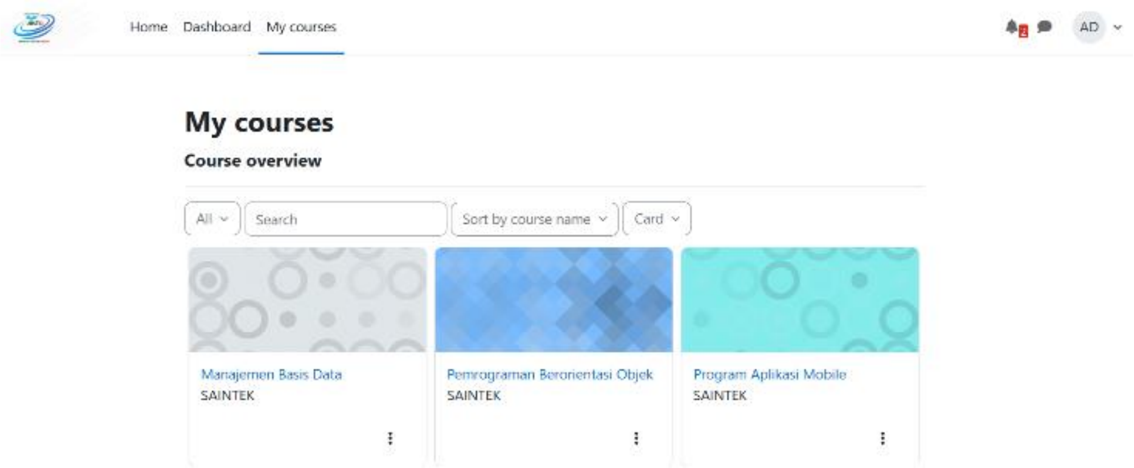

Figure 4. Courses Page

The subject page shown in Figure 5 presents the subject page, which provides direct access to course materials, assignments, and related activities. This section acts as the main interface for organizing and monitoring subject-specific learning.

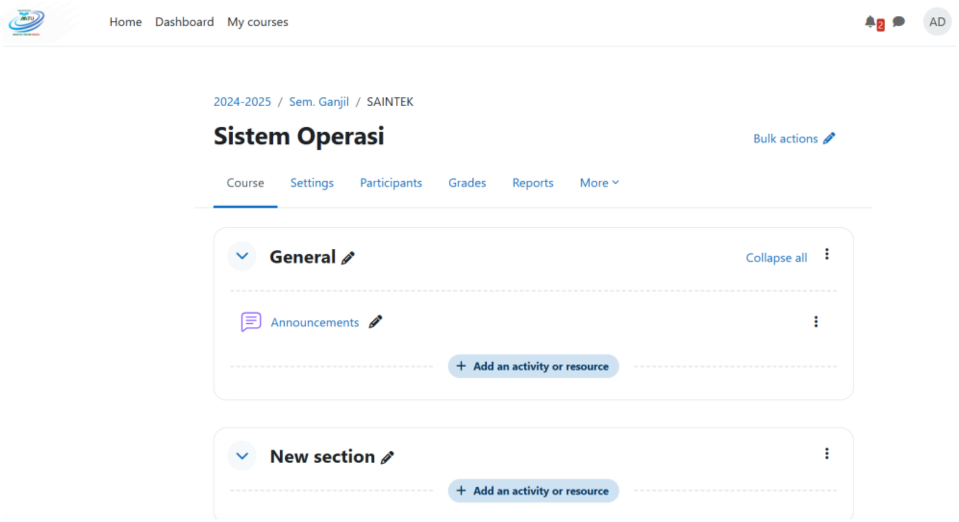

Figure 5. Subject Page

Figure 6 illustrates the "Add an Activity or Resource" menu, a feature that allows instructors to expand the course environment by integrating diverse tools, tasks, and materials that support learning. This menu provides a centralized interface for creating, managing, and organizing content and interactive activities.

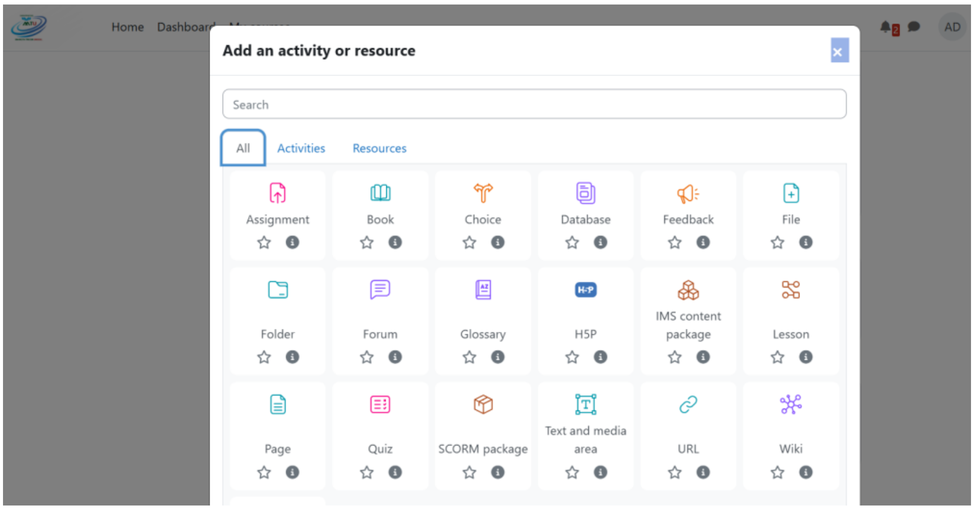

Figure 6. Activity or resource Feature

The Dashboard page (Figure 7) serves as the central hub within the e-learning system, providing users with a personalized overview of their progress, tasks, and notifications. Designed for both students and lecturers, the Dashboard acts as a quick-access interface that aggregates essential information, enabling users to efficiently manage learning or teaching activities.

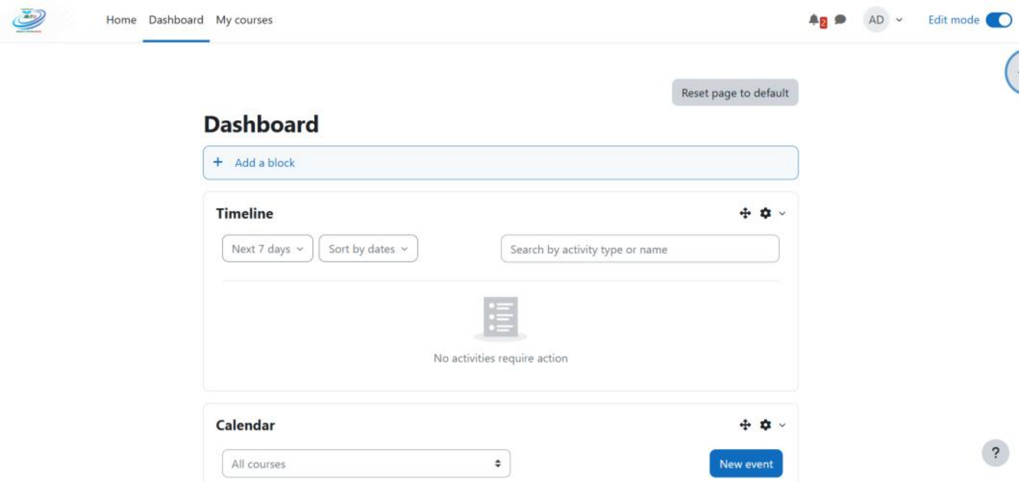

Figure 7. Dashboard Page

III. RESULTS AND DISCUSSION

The impact of implementing the e-learning system prototype on user engagement and acceptance is assessed through the interaction between both factors, where the study involves a total of 164 participants. In this research, the System Usability Scale (SUS) is employed as a system testing tool to evaluate the usability of the application in relation to the proposed solution. SUS has been extensively utilized as a usability assessment instrument and has proven to be accurate in its application [25]. Respondents are asked to rate their agreement with each statement regarding the features observed on a 1–5 scale in the SUS. A score of 1 indicates strong disagreement with the statement, while a score of 5 indicates strong agreement.

The respondents involved in this study totalled 164 individuals, consisting of 19 lecturers (11.6%) and 145 students (88.4%). Of the total respondents, 89% (146 individuals) had used the e-learning system prototype for less than 6 months, while the remaining respondents had used it for more than 6 months. The number of respondents was determined to ensure diversity and representation of actual users of the e-learning system. This sample size enhances the reliability of the findings and provides a comprehensive overview of user experience. The predominance of student respondents reflects their role as primary users of the system, whose interaction patterns and feedback are crucial for evaluating user engagement and system usability. Lecturers were included to complement the perspective and ensure functional relevance from the instructional side.

This study utilized the System Usability Scale (SUS) as an instrument to measure the usability of the application of the proposed solution. Participants rated their agreement with ten statements about the system on a 1–5 Likert scale, where 1 indicates strong disagreement and 5 indicates strong agreement. To obtain the SUS score on a 0–100 scale, the following steps were applied:

1. For positively worded items (Q1, Q3, Q5, Q7, Q9), subtract 1 from the participant's response.
2. For negatively worded items (Q2, Q4, Q6, Q8, Q10), subtract the participant's response from 5.
3. Sum the adjusted scores for all 10 items.
4. Multiply the total by 2.5 to obtain the final SUS score (0–100).

The findings of the SUS calculation are presented in Table I below.

TABLE I.
SUS Instrument

	Scales	
No	Question	Mean
Q1	I think that I would like to use this system frequently	3.5
Q2	I found the system unnecessarily complex.	2.8
Q3	I thought the system was easy to use.	3.4
Q4	I think that I would need the support of a technical person to be able to use this system.	3.3
Q5	I found the various functions in this system were well integrated.	2.8
Q6	I thought there was too much inconsistency in this system.	3.4
Q7	I would imagine that most people would learn to use this system very quickly.	3.3
Q8	I found the system very cumbersome to use.	3.5
Q9	I felt very confident using the system.	3.4
Q10	I needed to learn a lot of things before I could get going with this system.	3.3

The total SUS score was calculated using the standard formula:

$$SUS\ Total = (\sum_{i=1}^{10} S_i') \times 2{,}5$$

Where S_i' is the adjusted score for each SUS item:

- For positive items (Q1, Q3, Q5, Q7, Q9): $S_i' = S_i - 1$
- For negative items (Q2, Q4, Q6, Q8, Q10): $S_i' = 5 - S_i$

After transformation to the 0 –100 scale, the average SUS score is 54.1, with the lowest scores (low margin) observed in questions 1, 2, 4, 6, 8, and 10. This result corresponds to the "OK" category in the adjective ratings. According to [26], [27], "OK" is the level that the acceptability range is marginally acceptable (Fig. 8). Meanwhile, the average item scores on the original 1–5 scale ranged from 2.8 to 3.5.

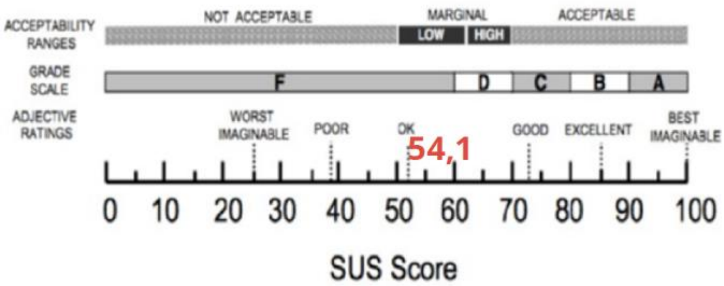

Figure 8. Adjective rating scale of SUS Scores [26]

Overall, the SUS scores for the e-learning system prototype illustrate the subjective assessment of students and lecturers, indicating that the proposed solution is largely perceived as neutral and still has considerable room for development (Figure 8).

Based on the System Usability Scale (SUS), the prototype of this e-learning system achieved an average score of 54.1 with a standard deviation of 12.7, which falls under the "OK" category with a "Marginally Acceptable" range. The standard deviation (12.7) reflects variability in user perception, potentially between students and lecturers or between novice and experienced users.

The internal consistency of the SUS questionnaire was evaluated using Cronbach's α, which resulted in a value of 0.842. Cronbach's α of 0.842 indicates high internal consistency, confirming that the SUS questionnaire reliably measures the usability construct across respondents. This indicates high reliability of the SUS items, confirming that the scale consistently measures the usability construct across respondents. This score indicates that while the system has basic functionality, users perceive significant room for improvement. For example, several questions in the SUS received low scores, such as those concerning system complexity, the need for technical support, and the consistency of its functions. This suggests that although users can operate the system, they still experience confusion or difficulties. While the prototype is functional, the results show the need for further iterations. The neutral evaluation implies that although the system is accepted by users, user engagement and system effectiveness can still be improved. Users may feel that the system has not fully met their expectations. In this context, the system developed is not flexible or intuitive enough for users to quickly adapt to changes in the dynamic educational environment.

While the SUS score indicates the system's usability, it does not directly measure user engagement. Engagement in e-learning contexts is assessed through behavioural metrics such as completion rate (the proportion of users who complete a given activity), retention (the percentage of users who return to the system after a defined period, e.g., 7-day or 30-day), and time-on-task (the average time required to complete specific learning activities). These measures capture the extent to which users are actively involved and sustained in their interaction with the system. Since the present study collected only SUS data, the interpretation of engagement remains limited. Future research should therefore complement usability evaluation with engagement-focused metrics or standardized instruments such as the User Engagement Scale (UES-SF), Technology Acceptance Model (TAM), or UMUX-Lite to provide a more holistic assessment of learner experience.

This study employed the Scrum methodology to guide the development of the e-learning prototype. Although the prototype has been tested and assessed by users, the use of Scrum allows for further development focused on processing user feedback. This demonstrates that Scrum can provide a flexible framework for continuously developing and adapting systems based on user needs. Despite some shortcomings, this approach has enabled the development of features and functionalities that are more aligned with user needs. Involving users in the development process helped design interfaces that are more understandable and responsive to their needs, although some features still require further refinement. This study faces several limitations, including the limited testing time. Users need more time to adapt to the e-learning system to fully optimize the use of its existing features. As a recommendation, further testing should be carried out over a longer period to gain a deeper understanding of the system's effectiveness in the long term.

In terms of the iterative development cycles, Sprint-1 represented the initial version of the e-learning prototype, where usability was first evaluated through the SUS. The results from this initial evaluation provided insight into users' difficulties, particularly regarding navigation and access to activities, which were reflected in lower item-level scores. These findings directly informed the objectives of Sprint-2, where the development team introduced an Activity Menu to improve task accessibility and streamline navigation. Following this intervention, the SUS evaluation showed modest improvements in scores for items related to ease of use and efficiency, thereby suggesting that the design change had a measurable and positive effect on perceived usability. Although the increase was not substantial, it demonstrates a clear feedback loop between the Scrum iteration, the design intervention, and the resulting quantitative usability outcomes. This linkage between iterative design decisions and their measured impact is an important contribution of the study, as it illustrates how agile methodologies such as Scrum can operationalize user feedback in a systematic and evidence-based manner.

To contextualize the average SUS score of 54.1 obtained in this study, it is compared with several benchmarks from Indonesian higher education institutions that evaluated e-learning systems using the same scale. A study at Universitas Hindu Indonesia reported a SUS score of 61 [28], whereas Universitas Budi Luhur achieved 65.5 [29]. These comparative benchmarks indicate that the prototype's SUS score of 54.1 falls below the mean range typically reported in related research, underscoring the need for subsequent design enhancements to improve usability.

IV. CONCLUSION

This study proposes an e-learning system prototype developed by leveraging user involvement to ensure that the functionality and characteristics of the system are acceptable to users. The system development follows the Scrum methodology, with the model being tested through user involvement. This process is iterative and continues until the results are acceptable to the users. The findings of this study demonstrate that the e-learning prototype developed through Scrum has reached a level of functionality that users consider acceptable, particularly in terms of navigation and task accessibility. While the overall SUS score of 54.1 falls into the "OK" range, this result suggests that the system's usability is adequate but still leaves room for improvement. Iterative design, as facilitated by Scrum, played a pivotal role in aligning the system more closely with user needs—for instance, the introduction of the Activity Menu in the second sprint addressed navigation difficulties identified earlier and resulted in modest improvements in usability scores. The study is constrained by the limited testing duration, which did not provide sufficient time for users to fully adapt to the platform. In addition, engagement was evaluated solely through the SUS instrument, which captures usability but does not reflect broader behavioural aspects of engagement. Finally, a system that scores within the "OK" range on SUS does not automatically guarantee higher engagement, since engagement involves additional behavioural dimensions such as retention, time-on-task, completion rate, frequency of contribution, and other related metrics. Unfortunately, such data were not captured within the present study, representing another limitation. Therefore, future work is recommended to integrate complementary engagement metrics—whether behavioural indicators (e.g., session length, daily/weekly retention, task completion rate) or standardized engagement instruments (e.g., UES-SF, TAM, or UMUX-Lite)—to provide a more holistic understanding of how iterative Scrum-based development not only improves usability but also translates into meaningful user engagement.

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