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User Interface User Exprience Gamification-Based E-Learning with Design Science Research Methodology

Viva Arifin[1], Velia Handayani[2], Luh Kesuma Wardhani[3], Hendra Bayu Suseno[4], Siti Ummi Masruroh[5]
Syarif Hidayatullah State Islamic University Jakarta, Indonesia

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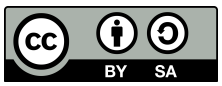
ABSTRACT

In 2020, the Islamic Elementary Teacher Working Group (KKG MI) held an E-Learning Training for Islamic Elementary School Teachers in DKI Jakarta about one of the gamification applications, Quizizz. According to observation, many teachers are still perplexed when utilizing the Quizizz program. This is due to the application's design and different functionalities, which still appear complicated to some teachers who aren't used to using it. The existing gamification application is also considered not to meet the learning needs at Islamic elementary schools in Jakarta. This study intends to analyze and design User Interface (UI) and User Experience (UX) designs for gamification-based e-learning applications as solutions to the problems found. Data collection begins with an observation and also a literature study, questionnaires, and interviews. For the design, Design Science Research Methodology (DSRM) is used, which consists of six stages: Problem Identification & Motivation, Define the Objective for a Solution, Design & Development, Demonstration, Evaluation and Communication. The results of the evaluation of the gamification-based e-learning design designed with the User Experience Questionnaire (UEQ) and Task Success show that the e-learning design is considered attractive and users can interact with e-learning effectively and easily.



Corresponding Author:

Siti Ummi Masruroh,
Department of Informatics,
Syarif Hidayatullah State Islamic University, Jakarta, Indonesia,
Email: ummi.masruroh@uinjkt.ac.id

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1. INTRODUCTION

The expanding popularity of internet-based information technology makes educational institutions are investing in cutting-edge teaching and learning technologies. Electronic learning, sometimes known as e-learning, is an educational internet-based, electronic-based information technology program. It can be defined as the use of internet technology to deliver knowledge and resources to individual learners [1]. E-learning has advantages of huge learning resources, enthusiastic learners, friendly interaction and flexible spacetime [2]. Online e-learning provides students a flexible and efficient pathway to access course materials, communicate with the instructor, interact with classmates, participate in different online activities and perform online assessments [3]. The flexibility that e-learning gives goes beyond the learners; it gives flexibility also for the instructors. In addition, educational institutions are implementing E-learning technologies to improve the communication among learners and instructors for better knowledge exchange as well as to strengthen the learning community to accomplish personal objectives [4].

Several problems arise in the learning process in schools, such as teachers only providing subject matter and rarely motivating students in the classroom. Students feel unenthusiastic about learning and tend to be passive in receiving explanations from the teacher. The increasing transfer of information makes it difficult to deliver education to individuals because rapid developments in the field of technological innovation require people to adapt quickly [5]. The application of the concept of gamification in e-learning is assessed as a technique that can help students understand the material provided so that students can be more motivated to participate actively in the learning process. Gamification is thought to be able to help students increase their enthusiasm for learning. Gamification helps in the development of critical thinking and multitasking skills in individuals [6].

The existence of e-learning is inextricably linked to the design of the e-learning service. User Interface (UI) and User Experience (UX) are becoming increasingly significant and altering user expectations and needs as a result of technological advancement and new interaction patterns. Students' attitudes toward adopting e-learning can be influenced by bad UI and UX in the context of e-learning. This can lead to a misunderstanding or misuse of e-learning, affecting academic institutions' acceptability, satisfaction, and efficiency. Failure to adhere to high-quality UI UX components can lead to dissatisfaction, misunderstanding, or incorrect usage, which can result in criticism and low acceptability of the e-learning platform [7].

Various educational institutions have begun to employ e-learning as a means of adapting to technology changes while also improving the quality and effectiveness of education. Observations during an e-learning program for Islamic elementary school teachers in DKI Jakarta Province in January 2020 corroborated this. The program seeks to increase teacher technological skills, particularly in the application of e-learning in the classroom. Quizizz, a gamification-based learning tool (gamified learning platform), is one of the things being taught. However, many Islamic elementary school teachers are still perplexed while utilizing the Quizizz program, based on observations made during training. This is due to the application's look and different functions, which might be confusing to certain teachers who aren't used to using it. That condition is aligning with [8] that states "Different learners may have different learning needs, and different users may have different requirements on how the program content should be displayed".

Research by [9], proposes an interactive learning story framework and design a UI that follows the concept of flat design and responsive mobile design, as well as to conduct testing and evaluation with interactive prototypes. However, it would be better if teaching materials such as content, infographics, and animations need to be correlated with the learning experience and student learning environment.

The study by [10], develops a web-based e-learning system Code Mania (CoMa) and applies the gamification concept to increase student interactivity, motivation and student engagement using e-learning. The e-learning also has an automatic evaluation feature to evaluate student work. The result from the testing shows that the e-learning system could run well as specified in the system requirement. The usability of the system is not yet known so it is suggested that further study should examine the system usability for a better user experience in using e-learning.

Research by [11], designed and built a training application for elementary science questions using gamification and the Mersenne twister algorithm. But the design has a drawback, namely the need for the addition of other gamification elements so that it can be more interesting and motivate students to use it.

Research by [12], shows that user-centered gamification is able to increase student interaction, engagement, and satisfaction in e-learning systems. However, there are a few obstacles/ineffectiveness when analyzing the use of the system, including cheating when one of the student's posts an assignment through a discussion forum, so there is a possibility of partial data in the analysis results.

Research by [13], develops e-learning applications by applying the gamification method to the implementation of its features or content. No errors were found in the e-learning application by testing using Whitebox testing and BlackBox testing, but there is still a lack of application of gamification elements, less in-depth calculations on tests using the User Engagement Scale (UES), as well as test objects to be increased larger or more significant.

This article will review some of the UI and UX literature to determine the requirements and criteria for creating an e-learning gamification system that meets the needs and experiences of students and teachers, as well as learning standards and user environments in Islamic elementary schools in Jakarta. The evaluation is carried out using the User Experience Questionnaire (UEQ) which will show that the e-learning design produced has been effective and efficient for users.

2. RESEARCH METHOD

There are five methods for solving the problems that have been mentioned above. The first process is Problem Identification, which begins with observing the surrounding environment and then continues with a systematic literature review. Data Collection with observation, interview and questionnaire are the methods use for collecting research data. The next step is Data Analysis with Design Science Research Methodology (DSRM), which will producing a prototype as a design solution. The prototype will undergo a design evaluation process using the User Experience Questionnaire (UEQ) and Usability Evaluation based on the simulation results with the Cognitive Walkthrough obtained from the Demonstration stage.

Table 1. Research Flow

Problem Identification	Environmental Observation	Systematic Literature Review
Data Collection	Observation Interview Questionnaire	E-Learning Training Semi-Structured Interview to Respondent Distributed Questionnaires
Data Analysis	Design Science Research Methodology	Problem Identification & Motivation Define the Objective for a Solution Design and Development Demonstration Evaluation Documentation
Result Evaluation	Solution Design	Prototype
Conclusion Drawing	Study Summary	

2.1. Collecting data

1. *Observation*
   The author had the opportunity to directly observe the E-learning Training activities for Islamic Elementary School Teachers of DKI Jakarta Province held by the DKI Jakarta Elementary School Teacher Working Group (KKG MI) on January 20 & 22 2020. In this activity, the participants who are a teacher from various public and private islamic elementary schools in Jakarta receive training on Quizizz, which is a gamification application to create interactive quiz games used in classroom learning.
2. *Literature Study*
   The author collects data relevant to research on e-learning, UI, UX, gamification, similar research and studies the methods to be used. The author obtained research-related data from 12 e-books, 24 journals, 4 theses and 8 websites.
3. *Questionnaire*
   In this study, the authors distributed questionnaires to respondents who were determined by the Non-Probability Sampling method, namely Purposive Sampling. The respondents in this study are from one of the State Islamic Elementary Schools in Jakarta, MIN 4 Jakarta with some criteria as follows:
   (a) Teachers or students grade 4-6
   (b) Have used e-learning, Quizziz, or Kahoot

   The questionnaire includes questions related to self-identity, use of ICT tools, experiences of using e-learning, and expectations regarding the e-learning design developed. For questions regarding the experience of using e-learning, the User Experience Questionnaire (UEQ) consists of 26 questions.

The UEQ questionnaire which has been compiled in the form of a Google Form is then distributed online to respondents with the criteria described previously. Then obtained as many as 164 respondents filled out the questionnaire. This amount is sufficient for the author's target, which refers to the research suggestion by Roscoe in [14] that the appropriate sample size in the study is between 30 to 500.

4. *Interview* At this stage, the authors conducted semi-structured interviews which include several things, namely the identity of the respondent, experience of using ICT and details of the respondent's experience related to e-learning (strengths, goals, tasks & needs, pain points, and user expectations) both gamification-based e-learning or not. The interview participants amounted to 6 people consisting of 3 teachers and 3 students.

2.2. Analysis of Data

1. Design Science Research Methodology

The method used to design this e-learning is Design Science Research Methodology (DSRM). DSRM is an information system design-oriented methodology. There are six stages in this method, as follows:

1. Problem Identification & Motivation
2. Define the Objective for a Solution
3. Design and Development
4. Demonstration
5. Evaluation
6. Documentation

3. RESULT AND ANALYSIS

3.1. Problem identification and motivation

This stage focuses on identifying and understanding user conditions and needs. This understanding is obtained through the data collection process that has been carried out, namely observations, questionnaires, and interviews.

The observation results show that there are still many Islamic elementary school teachers who are confused when using one of the existing gamification applications, Quizizz. This is due to the appearance, language, and various features of Quizizz which still seem complicated for some teachers who are not used to using it. In addition, Quizizz and Kahoot are considered not to cover all learning needs at Islamic elementary schools in Jakarta because they only cover part of the tasks in the learning process.

Based on data obtained from 164 questionnaire respondents including 97 women (59.1%) and 67 men (40.9%), there are 17 teachers (10.4%) and 147 students (89.6%) consisting of 21 students in grade 4 (14.3%), 50 students in grade 5 (34%), and 76 students in grade 6 (51.7%) with an age range of 30-56 years for teachers and 9-12 years for students.

The most widely used ICT devices by respondents to access e-learning are computers/laptops and smartphones. For the use of e-learning, the majority of respondents (86.5%) use E-learning Madrasah (the e-learning provided by the Ministry of Religious Affairs specifically for Islamic elementary schools in Indonesia). In addition, there are 14 respondents (8.5%) who use another e-learning, namely Google Classroom. For gamification-based e-learning, only 8 respondents (4.9%) used Quizizz and only 2 respondents (1.2%) used Kahoot.

Based on further data obtained from interviews, respondents also use various applications other than e-learning for teaching and learning activities, especially during Distance Learning (PJJ). These applications include Google Forms, Zoom, and WhatsApp. At the data collection stage using the UEQ questionnaire, the authors asked the respondents' experiences and perceptions of the e-learning they used. Then, the following results were obtained.

Table 2. UEQ Scales (Mean and Variance)

Aspects	Impression Value	Evaluation Value
Attractiveness	1.671	1.54
Perspicuity	1.813	1.40
Efficiency	1.707	1.43
Dependability	1.645	1.24
Stimulation	1.716	1.71
Novelty	0.671	2.34

Based on the results of the UEQ questionnaire analysis related to the respondent's experience in using e-learning, of the six aspects of the questionnaire (Attractiveness, Clarity, Efficiency, Accuracy, Stimulation, and Novelty) the lowest impression value is in the Novelty aspect. The novelty aspect includes components: creative / boring, inventive / conventional, ordinary / advanced, conservative / innovative. This shows that the e-learning applications that respondents use do not yet have innovative and creative product designs, do not attract the attention of users and seem monotonous.

3.2. Define the objectives for a solution

Proper citation of other works should be made to avoid plagiarism. When referring to a reference item, please use the reference number as in [1] or [1, 3, 5, 6] for multiple references. The use of Ref [5] ... should be employed for any reference citation at the beginning of sentence. For any reference with more than 3 or more authors, only the first author is to be written followed by et al (e.g. in [4]). Examples of reference items of different categories shown in the References section. Each items in the references section should be typed using 9 pt font size.

1. *Conceptual Design*

   At this stage, mapping and grouping of the results of questionnaires and interviews that have been obtained at the data collection stage are carried out. The goal is to map information, opinions, and expectations from many users into priority notes that can be used as insights for the next stage. The data and information that have been collected are then grouped based on several things, namely goals & desires, tasks & needs, pain points, and applications used by respondents for teaching and learning activities.

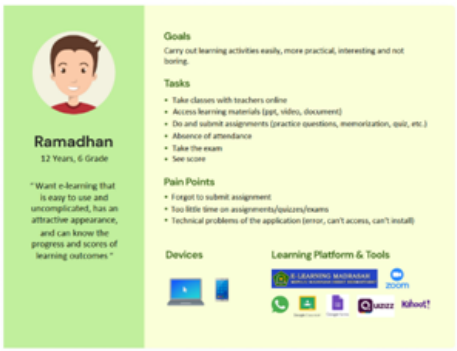

Figure 1. Student Persona

Based on the information and analysis results from the previous stage, the authors conclude several criteria for e-learning applications that become the needs, expectations, and solutions to problems faced by users. Departing from the data that has been obtained in the previous stage, an analysis is carried out which then produces the user persona of the respondents who are students and teachers.

Figure 2. Teacher Persona

The features developed are obtained from the needs and tasks of the user. In addition, the feature also refers to research by [12] regarding user behavior references in e-learning systems based on three suggested categories to facilitate users when using gamification-based e-learning systems. The three categories are Interaction, Communication, and Performance.
After analyzing the three categories and user needs, the authors determine several features or functions for the e-learning design to be developed, namely Interaction which includes access to the material (either in the form of documents, presentations, or videos), Communication in the form of class discussion forums and Performance in the form of practice questions, assignments and exams. In addition, the author also adds several features obtained from user needs and tasks, namely grade reports, profiles, classes, absences, and notifications.

2. *Concrete Design*
Concrete Design is the process of designing the interface concept of the application design. As the identity of the e-learning application itself, the author adds a logo made based on the color and purpose of the application. The illustration of the book was chosen as the meaning of "learning". There is also a molecular illustration which is defined as a group or a group of atoms bonded to each other. In the logo, the molecules harness the science used together. This is expected to be in line with the purpose of the application, which is to be a medium for learning various lessons & knowledge so that it becomes knowledge for students.

Figure 3. E-Learning Logo

There are two types of fonts, namely serif and sans serif. The sans serif typeface is used in this e-learning design, namely DM Sans. Sans serif typefaces are characterized by fonts that do not have fins/legs DM Sans was chosen because of its simple, clean, easy-to-read form, and creates a friendly, modern, and fun impression. This font is used in its entirety for both the headline and body text of the application.

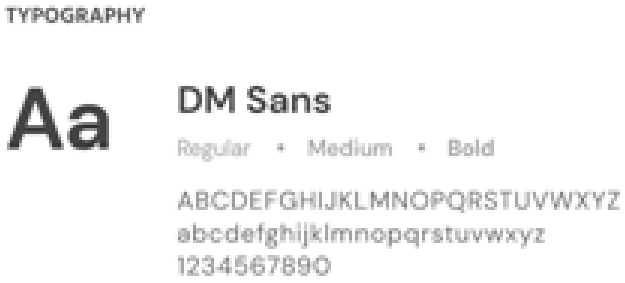

Figure 4. E-Learning Design Typography

There are several color groups used in designing the e-learning design in this study. The green color (Dark Cyan to be precise) with the color code HEX $\#008f87$ was chosen as the primary color for the e-learning application. while the color with the HEX code $\#68D212$ and the HEX code $\#FF7171$ is used as a color marker for the success or failure of the system. The other color details can be seen in the following image.

Figure 5. E-Learning Colors

3. *Gamification Design*
   Based on the literature study that the author conducted on 12 literature that applies game elements to the e-learning system, it can be concluded that the most widely used gamification elements are Level, Points, Leaderboard and Badges. Some literature also applies Feedback, Challenge, Progression, Customization and Social. Then based on benchmark results from two best practice gamification applications, namely Quizizz and Kahoot, it was found that both of them used the elements of Leaderboard, Points, Customization, Progress Tracking & Feedback.
   Based on these analyzes, several game elements were found that will be applied to the e-learning design of MIN 4 Jakarta, namely, Points,Level, Mission, Badge, Progress Bar, Avatar, Leaderboard, Feedback

3.3. Design and development

1. Wireframe
   After all the concepts and flows have been defined in the previous stage, the next step is to sketch (wireframe) the application. The sketch is obtained based on the data that has been collected in the previous stage. All wireframes designed below are based on the needs of users, namely students and teachers for e-learning. The following is a wireframe of e-learning for teacher and student accounts.

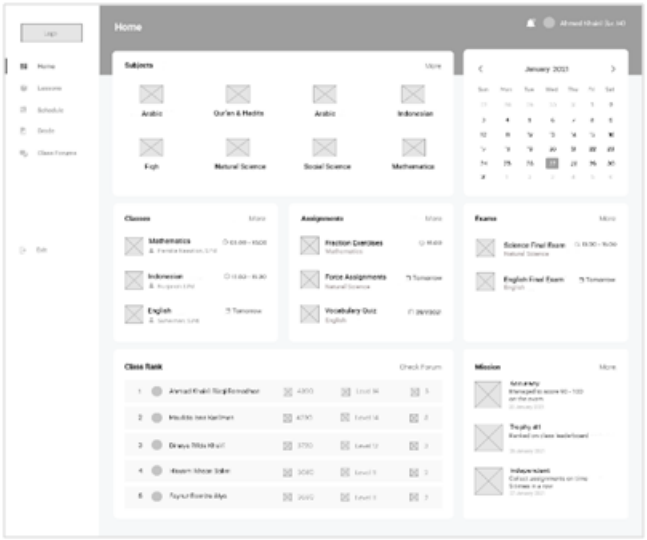

Figure 6. Wireframes for Student

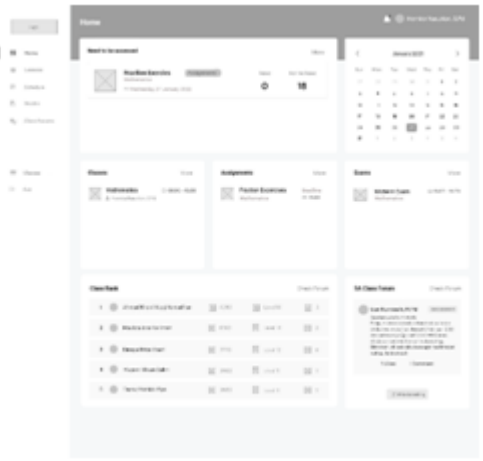

Figure 7. Wireframes for Teacher

2. *Mock Up* After designing the wireframe, the next step is to design a gamification-based e-learning design mockup. The design of the mockup is done by providing colors, icons and images that have been initiated in the previous stage. The placement of elements in the mockup refers to those that were previously created in the wireframe. The following is a mockup of e-learning for teacher and student accounts.

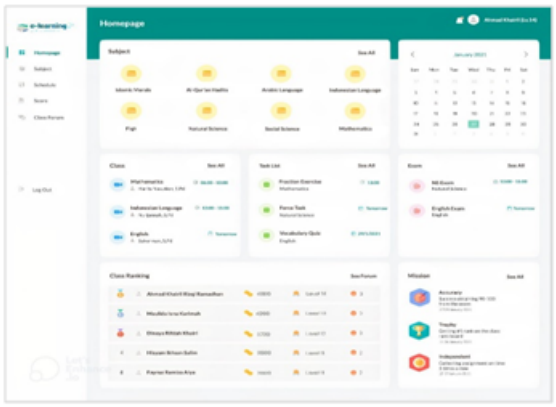

Figure 8. Wireframes for Teacher

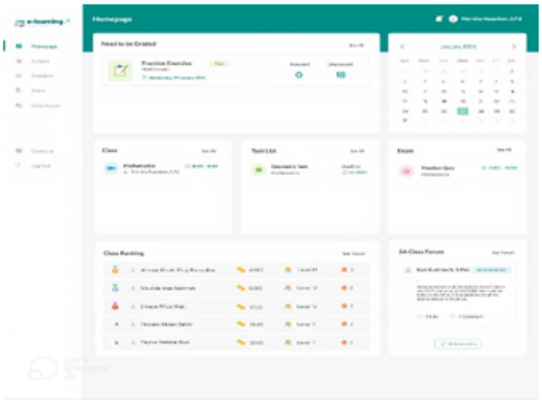

Figure 9. Mockup for Teacher

3.4. Demonstration

At this stage, the authors distributed the e-learning design prototype that had been made in the previous stage to 164 teachers and students (questionnaire respondents at the data collection stage) to try to interact directly with the e-learning design. After that, the respondents will be asked their willingness to give their assessment of the e-learning design by filling out the UEQ questionnaire.

Furthermore, the authors carry out a Usability Evaluation using the Cognitive Walkthrough method. This process involved 3 teachers and 3 students who were respondents at the interview stage.

3.5. Evaluation

The prototype of the e-learning design was given to 164 respondents/users who previously also became respondents at the data collection stage using a questionnaire. Thus, the respondents can interact and try to use the prototype directly so that they can provide an assessment and experience by answering the UEQ questionnaire given. After evaluating with the User Experience Questionnaire (UEQ) on the gamification-based e-learning design that was designed, the following results were obtained.

Table 3. UEQ Scales Evaluation (Mean and Variance)

Aspects	Impression Value	Evaluation Value
Attractiveness	2.149	0.80
Perspicuity	2.137	0.91
Efficiency	2.052	0.97
Dependability	1.986	1.17
Stimulation	2.044	1.18
Novelty	1.739	1.10

Based on the pictures and graphs above, it can be seen that all aspects resulted in a positive evaluation value (> 0.8). The aspect with the greatest value is Attractiveness (2,149) followed by Clarity (2,137), Efficiency (2,052), Stimulation (2,044), Accuracy (1,986) and Novelty (1,739). When compared with the results of the evaluation of the e-learning that the respondents used previously, there were significant differences in all aspects, especially the novelty aspect. This can be seen in the comparison chart below.

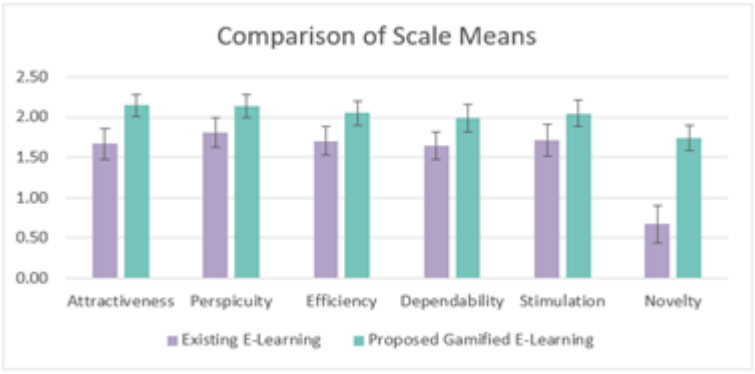

Figure 10. Result Comparison between Existing E-Learning & Proposed Gamified E-Learning

Based on the comparison above, it can be concluded that the gamification-based e-learning design designed in this study has resulted in positive evaluation values for all aspects tested in the UEQ. In addition, e-learning gamification resulted in a positive evaluation value (1.74) for the Novelty aspect which previously had a normal evaluation value (< 0.8). Therefore, it can be concluded that the designed gamified e-learning has been considered innovative and attractive by users.

Based on the results of the simulation using the Cognitive Walkthrough method at the Demonstration stage, an analysis is carried out based on the simulation results by measuring the simulation results using Performance Metrics. As for this study, the author uses one type of Performance Metric to measure the effectiveness parameter, namely Task Success. Based on the results of the simulation conducted by 6 people including 3 teachers with 10 Task Scenarios (ST) and 3 students with 8 Task Scenarios (ST), the following data were obtained.

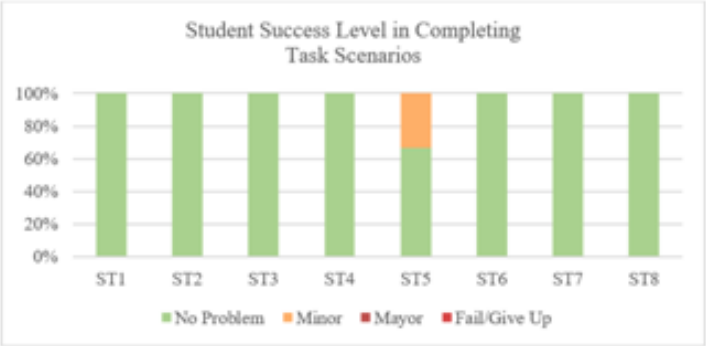

Figure 11. Student Usability Evaluation Results

All teachers can complete 6 task scenarios smoothly and without any problems. However, there were some teachers who experienced minor problems when working on several task scenarios (ST), including ST 3, ST 6, ST 7 and ST 8. As for ST 6, as many as 2 out of 3 respondents experienced minor problems when doing these assignments. The problems encountered include the teacher looking a little confused when faced with a series of steps that must be passed, looking for buttons and inputting student scores. Based on the results of the simulation conducted by 6 people including 3 teachers with 10 Task Scenarios (ST) and 3 students with 8 Task Scenarios (ST), the following data were obtained.

Figure 12. Teacher Usability Evaluation Results

Refers to [15] that there is no need to worry about the results of the evaluation with a success rate of 1 (no problems) and 2 (there are minor problems), what needs to be considered is the evaluation results with success rates of 3 (there are major problems) and 4 (failed/give up). Because of this level of success, it indicates the need for improvement and development of a better design. Therefore, it can be concluded that teachers and students can interact with e-learning easily and understand the flow of use of the e-learning design in this study.

Based on the comparison results that have been obtained previously, it shows that the gamification-based e-learning design produced is innovative and attractive to users, namely students. When compared with research [11], the evaluation results prove that the design can motivate students to use it.

3.6. Communication

At this stage, the authors document the problems, solutions and test results of the solution in the form of a gamification-based e-learning design in the form of journals to be communicated to related audiences and researchers.

4. CONCLUSION

This study succeeded in designing a gamification-based e-learning application in the form of a High-Fidelity Prototype using the Design Science Research Methodology method which consisted of 6 stages. Based on the results of the evaluation of the e-learning design at the Evaluation stage, the User Experience Questionnaire (UEQ) obtained positive evaluation results for both students and teachers which included Attractiveness, Clarity, Efficiency, Accuracy, Stimulation and Novelty. The aspect with the greatest value is Attractiveness (2,149) followed by Clarity (2,137), Efficiency (2,052), Stimulation (2,044), Accuracy (1,986), and Novelty (1,739). In addition, e-learning gamification resulted in a positive evaluation value (1.74) for the Novelty aspect which previously had a normal evaluation value (¡ 0.8). Therefore, it can be concluded that the designed gamified e-learning has been considered innovative and attractive by users. The design can meet the needs of students and teachers in carrying out learning in the user environment in Islamic elementary schools.

In addition, based on the results of an evaluation with one of the performance metrics, namely task success to measure effectiveness parameters, the results obtained for the success rate for students and teachers are levels 1 and 2, with the meaning 1 = users do not get problems in working on tasks, and 2 = users get a minor problem. The minor problem experienced by students is the lack of visibility of one of the buttons. While the minor problems experienced by the teacher were the lack of some information on the application and the lack of visibility of one of the buttons and tabs. Therefore, based on the overall evaluation results, it can be concluded that the e-learning design is considered attractive and users can interact with e-learning effectively and easily.

However, this research still has some shortcomings and weaknesses. Therefore, it is necessary to pay attention to several suggestions that can be used as a reference for better development in the future, namely:

1. Improving the design based on several recommendations for improvement that have been described.
2. It should be considered for design evaluation using other performance metrics such as task on time and error.
3. It would be better if the design is also developed for mobile.

5. ACKNOWLEDGEMENTS

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6. DECLARATIONS

AUTHOR CONTIBUTION

All authors conceived and designed the study. Study concept and design Viva Arifin, Velia Handayani, and Luh Kesuma Wardhani. Experiments, analyzed the data Velia Handayani, Hendra Bayu Suseno, Siti Ummi Masruroh.

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COMPETING INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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