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Gamification in Education: Enhancing Distance Learning Engagement and Performance

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Abstract

Innovative education methods have been made possible through technological advancements, such as the integration of gamification in distance learning. This approach involves adding gaming elements to the learning process to encourage student engagement and competition. In this study, a gamification system was implemented and evaluated using the System Usability Scale (SUS) method, involving 50 students. The data analysis revealed a 71.86% increase in student learning scores after introducing the gamification system. Furthermore, the SUS evaluation demonstrated an excellent usability score of 86.6, with three critical statements receiving the highest rating of 4. These statements indicated that the gamification system was user-friendly, accessible to others, and possessed intuitive features. This study highlights how gamification can be an effective way to make distance learning more enjoyable. It provides valuable information for teachers and professionals who want to improve student participation in remote learning environments**Keywords:** Gamification, System Usability Scale, Physics

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I. INTRODUCTION

Natural Science subjects are introduced in the educational curriculum from the elementary school level. his is due to forming students' thinking frames in logical thinking. Science subjects are now being developed into Science, Technology, Engineering

, and Mathematics (STEM). STEM is included in the education curriculum's school. In the education of junior and senior high school grades, science students are separated into several majors, such as Mathematics, Physics, Biology, Chemistry, and Electrical Engineering.
Students see STEM as a complex and scary subject. This is due to the existence of definite numerical formulas and calculations. Subjects such as Physics in STEM require a learning model that invites students to engage cognitively and generate learning motivation. Technological developments in education have developed, generating motivation and student involvement, namely Gamification[1]. A study shows that applying quizzes in Gamification involves more student interaction than quizzes using paper[2]. The data shows that quiz gamification can motivate students to learn[3]. Several elements can increase student motivation when using Gamification, such as prizes and competition[4]. Prizes can bind users to be loyal to Gamification. In an educational context, gamification rewards can increase student motivation and loyalty in learning to use Gamification. Badges and leaderboards are other elements that affect student motivation in learning to use Gamification. This element can display the performance of students[5]. The peculiarities of Gamification are point and level[6]. Users will be challenged to increase points by increasing the level of the questions provided. Students are challenged to solve more challenging questions when they can solve problems at the previous level.
The elements contained in Gamification bridge the difficulties of students who generally say that Physics is complicated. Building Gamification of pedagogical elements is an essential concern to maintain the essence of science.

A. Pedagogy In Gamification

As an online learning model, Gamification is considered a solution when face-to-face teaching and learning activities are challenging to fulfill. Especially when the world is being hit by the Covid 19 outbreak [7], all life activities, including educational activities, are paralyzed. As a result, online distance learning is a way to keep teaching and learning activities going. However, there are drawbacks to the online learning model from a pedagogical perspective. The development of information and communication has a major impact on the development of science. The use of appropriate computer applications can help students learn[8]. Currently, students are more interested in learning to use media such as online games and videos[9].

Online Gamification is a type of e-learning and e-exam that can reach all students when face-to-face teaching and learning activities are strenuous. Online distance learning keeps innovative pedagogy in mind. A study shows the lack of online learning in terms of pedagogy, namely cheating[7] . Any receiving, giving, and evaluating material cannot fully control online learning. Based on the shortcomings of online pedagogy aspects affecting student graduation rates. The exact level of accuracy cannot be guaranteed, and there is no consolidation of the high literature that causes the quality of education to decline.

Online Gamification increases students' motivation to be faithful in learning even though the subject matter is considered problematic. There is an increase in motivation, which can be seen from the increase in student grades. However, concerns about students' level of comprehension and readiness to be involved decreased[10]. The pedagogical method in the game forms a character and perception for students to understand new learning methods by playing[11] .

Online learning requires training technology to strengthen pedagogy and instruction. Online learning requires an effective, practical pedagogy. A study explains that there are three pedagogical theories, namely andragogy, constructivism, and trans-formational learning [12]. Andragogical theory defines self-learning and identifies the four competitions required to direct independent learning. Andragogy aims to diagnose learning needs and identify human resources for the material being studied. Constructivism is a theoretical basis that can provide information about online teaching. This principle is a learning perspective that can encourage students to accept the perspectives and experiences of others to explore essential areas. Transformative learning is thinking critically and evaluating basic assumptions and a meaning-making framework.

B. Playing While Learning Physics

Teachers have an essential role in developing students' thinking skills. Pedagogical knowledge for a teacher is the basis for the development of his / her education. Pedagogical skills are needed to improve one's thinking skills in understanding the subject matter [13]. Pedagogy describes a person's ability to understand the concept of science, the application of knowledge, and the benefits of that science. A teacher's capacity regarding pedagogical abilities can be observed through classroom teaching in conveying

information verbally and practically[13]. Students' abilities after attending class lessons can be reviewed based on learning outcomes and interest in learning[14].

Teaching STEM (Science, Technology, Engineering, Mathematics) trains cognitive and psychomotor abilities. STEM learning has a positive effect on improving students' educational abilities. Students who receive STEM education can master the material appropriately, analyze problems in detail, and think about mathematics well [14]. The media used in learning affects students' interest in learning [15]. Simulation-based learning is attractive to current students in receiving and understanding material[15].

Physics lessons require understanding complex concepts and proper analytical thinking skills [16]. Students need innovation in physics learning so that it is easy to understand and not boring[16]. Teachers' understanding of physics theories or concepts needs to be conveyed to students interestingly to improve their abilities in science and mathematics [17]. The learning environment and technology used in physics learning are a priority in improving physics learning abilities [17].

The current quality of teaching needs to be updated in digital pedagogy. Europe is currently using digital pedagogy as a learning model approach using digital learning. Digital learning focuses on the active role of students in the learning process [18]. Game-based learning has an appeal for students to understand the subject matter easily. Gamification is appropriate for learning by incorporating material knowledge, technological developments, and students' critical thinking skills [1].

C. Related Literature

Gamification is an exciting topic to discuss in learning methods in the digital age. Continuous education demands processes and results. Education development requires a new learning model that follows technological developments and the development of student learning. Figueiro and Raufflet researched new teaching methods for experiential learning and simulation game techniques [1]. A study revealed that Gamification uses games' benefits to encourage desired behavior in science[19]. Currently, Gamification is used in learning environments to increase motivation and learning outcomes [6]. The topic of Gamification has been tested in a study with the results of increasing student achievement from continuous refinement and incorporating Gamification into educational activities [20]. For effective Gamification of education, a study shows the importance of personal motivation that can be processed over time to gamification potential[21].

II. RESEARCH METHOD

This study uses the Spiral model as a research method. The Spiral model is a development of the Prototype model. The Spiral Model is the development of a product on a large scale. The Spiral Model has six stages that are carried out repeatedly, namely Planning, Risk Analysis, Engineering, Construction and release, Customer Evaluation, and Customer Communication[22].

The planning stage is the planning stage running between the user and the developer. The planning stage includes an analysis of user needs to suit the needs. The planning stage is a continuation of the communication stage with customers. The communication stage is the basis for the developer to plan and analyze all possible risks[23].

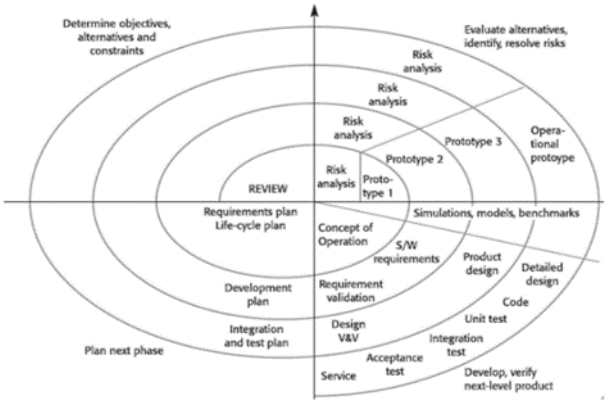


Fig. 1. Spiral Model

The Spiral Model was chosen as the research method because this model is intended for large-scale development. Multiple cycles show that this model considers the failure rate of development. The risk analysis stage is a bridge between planning and execution. If there is development in the middle of the road, then the analysis stage helps the developer evaluate the running product.

In the development of Gamification, the authors consider gamification patterns. The gamification pattern lies in the level of the question quiz. This level shows the difficulty level of a stage, where it becomes a stage to measure the user's self-ability in a game. Each level has a different point weight. Level 1 will get 1 point until level 5 will get 5 points. The gamification method in Figure 2 shows the levels and flow stages of the Gamification. In the system built, the point level is obtained from each correct answer the student enters. If each student answers correctly, the level will go up, whereas if the student answers wrong, the level will go down. Every three levels, the difficulty level of the questions will increase. The problem difficulty is divided into C1 to C5. Each level of difficulty has a different number of points. The more complex the problem difficulty will affect the number of points students get. The accumulated points obtained are used to calculate the ranking of each student so that it can motivate students to get the best grades.

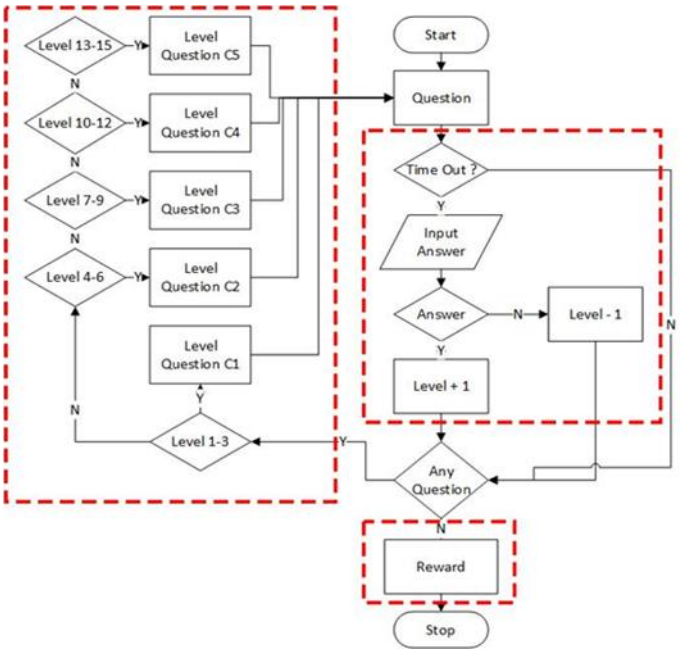


Fig. 2. Gamification Flow

Figure 2 illustrates the overall quiz gamification. Quizzes are used in Gamification because, in previous studies, it was found that gamification quizzes using rankings had a good effect on motivating children to answer correctly [3]. The quiz game will start when the questions come out. The questions used are multiple choice. Each question has a time limit according to the level of the question it has. Multiple choice is used because it is easy to use and can minimize errors when students answer[6].

Kode	Badge	Level Minimal	Level Maksimal	Poin	Opsi
C1		1	3	1	
C2		4	6	2	
C3		7	9	3	
C4		10	12	4	
C5		13	15	5	

Fig. 3. Gamification Badge

When the question is answered successfully, students will level up. Meanwhile, when students answer incorrectly, the accumulated level of students will decrease. Each correct answer will get points and will be recorded as the accumulated rating of the students. The points earned will increasingly adjust to the level of questions students answer. Existing question levels will have their respective badges. The function of using badges in Gamification as game mechanics is to show mastery of an important task. Badges are expected to show students how far they have achieved [24].

Gamification will end when the allotted time is up, or students complete all exam questions with the most challenging level. Three students with the best ranking will get a predetermined prize in planning this Gamification using challenges, rankings, badges, achievements, points, levels, and rewards. These elements make students excited and motivate students to learn and answer questions correctly[2].

III. RESULTS AND DISCUSSION

This study uses system testing using the System Usability Scale (SUS) method to determine how far this system is functioning. The SUS method is an instrument used to evaluate systems based on human interaction with the system. Users give scores about the usefulness of the products used[25]. The SUS method is a Human-Computer Interaction (HCI) approach that is commonly used for evaluating Information Systems (SI)[26]. This study tested the gamification system for Physics lessons for 9th-grade junior high school students and 74 students for 12th-grade high school students.

There are ten questions with code (Q), which will be explained in Table 2. The calculation process is based on a scale range of 1 - 5, then adding up the ten questions.

1. For each odd-numbered question, the score for each question obtained from the user's score will be reduced by 1.
2. For each even-numbered question, the final score is obtained from the value five minus the question score obtained from the user.
3. The SUS score is obtained from the sum of the scores for each question multiplied by 2.5.

$$X = \frac{\Sigma X}{n} \quad (1)$$

X = average score
∑x = total SUS score
N = number of respondents

The results of the ten questions (Table 1) are multiplied by 2.5 as the main formula for the SUS method. The multiplication results are added up and divided according to the number of respondents who gave a score.

TABLE 1. LIST OF SUS METHOD SCORE ASSESSMENT STATEMENTS

Qode	Description
Q1	I think I will use this system again
Q2	I find this system complicated to use
Q3	I find the system easy to use
Q4	I need help from other people or technicians in using this system.
Q5	I feel the features of this system are working correctly.
Q6	I feel that there are many things that are inconsistent with this system.
Q7	I feel others will understand how to use this system quickly.
Q8	I find this system confusing.
Q9	I feel there are no obstacles to using this system.
Q10	I need to familiarize myself before using this system.

Based on the system test results using the SUS method, the Physics gamification system achieved a value of 86.6 with the title of excellent. The test result data illustrates that the gamification system can be used by users easily and attractively.

From the recapitulation of the answers of 50 students, there are three questions with the highest average score of 4, namely questions 3, 5, and 7. The three questions of the SUS method show that the gamification system is easy to use, the Gamification features work correctly, and people easily understand this gamification system. This is evidenced by the pre-test results before using Gamification, with an average of 46 to an average of 89 after using Gamification. The average score of students has increased by 71.86%.

To find out which point the gamification system rating is functioning correctly or not based on a usability scale, Table 2 provides an explanation based on the rating limitations. The system test results based on Table 1 can be categorized as the Physical Gamification system in the excellent category.

Table 1 describes the ten statements that guide the filling of user scores. This statement is based on the human-computer interaction approach. The statement is based on experience used as the basis for making the questionnaire. The questionnaire focuses on achieving a good score on standardized coefficients to determine the scale's psychometric quality, validity, and reliability[27].

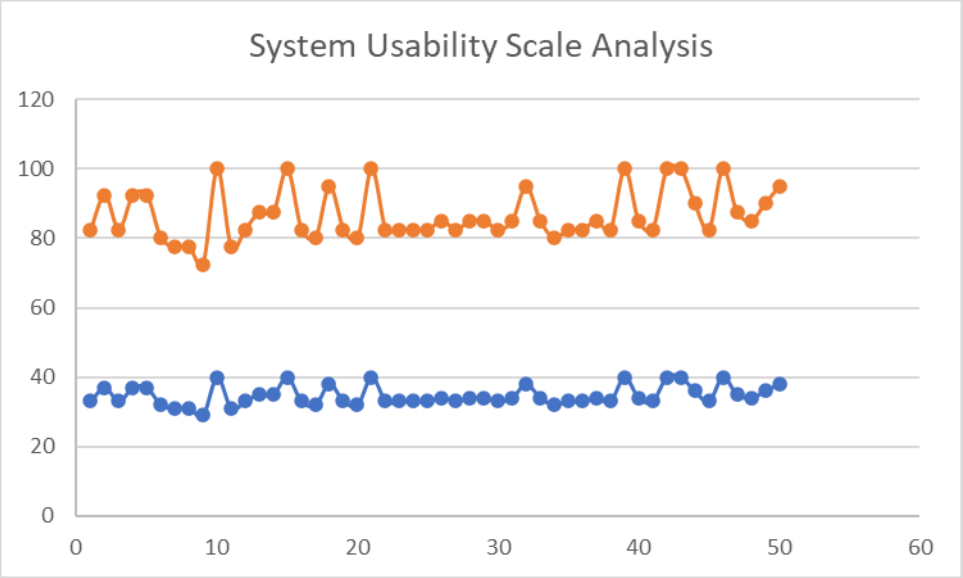
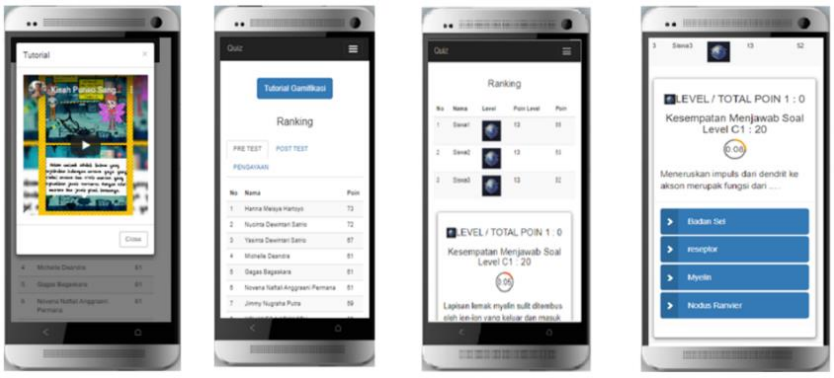


Fig. 4. Recapitulation of Analysis System Usability Scale

Figure 4 shows that the ratings graph varies based on user experience with the system. The assessment data shows that the gamification system has an average value of 86,6. The average value can be categorized as a well-functioning system. This system can be accepted as a learning method with Gamification (cf. Figure 4), although this system is not yet perfect. The blue line shows the sum of the questionnaire answers from each respondent. The orange line shows the analysis results based on rule number 3, using the 2.5 multiplier factor.



(a) (b) (c) (d)

Fig. 5. (a) Gamification display, (b) Display of Gamification pre-test participants, (c) Display of participant point level, (d) Multiple choice and answer display

Students will be shown a tutorial on using the gamification application when logging in, as seen in Figure (a). Then, on the main page, the ranking of each student who participated in the Gamification is displayed in Figure (b). This is expected to motivate students to get better grades than their peers. Entering the gamification quiz page can be seen in the top 3 ranking students with the best scores in Figure (c). With this display, it is hoped that students will compete for better grades. Then, in Figure (d), it can be seen that part of the gamification quiz uses multiple choice. In this system, the answers and questions are designed to be displayed randomly to minimize cheating. There are badges, levels, and total points to know where they are compared to other friends. Then, there is a timer that is used to replace the questions if the questions are not answered.

Gamification testing was carried out four times within four weeks. In the first week, it was found that the use of pictures on questions made it difficult for students to see the questions; this was because students had unstable connections and smartphones that did not support gamification games. This study was conducted for four weeks. In the first week, the system test encountered a problem. The problem was due to the question display on the participants not appearing. This resulted in participants being unable to access questions and answer questions. Based on the experience in the first week, we evaluated the shape of the problem by changing the problem from an image model to a text model. Changing the question from an image model to a text model can reduce the damage to the question display quality. This shows that the existing gamification system design must see the target targets of the students and not forget to pay attention to the facilities that students have. It was also found that students need applications that can be accessed by various devices because when running the system, online students will use existing equipment around them to access the system being created.

IV. CONCLUSION

This study tested a web-based gamification system. This test applies two factors, namely users (humans) and systems (computers). Testing the gamification system requires interaction between humans and computers as a testing factor. The test method used is SUS. The average test result was 86.6. This value is a good result for the system because users can use the system properly. This gamification system can still be developed to become the best imaginable system (Figure 7). The data shows that learning to use Gamification can improve students' understanding of the material. This is indicated by the increase in test scores after using Gamification by 71.86%. The SUS method in the system test submits ten statements relating to the system to be tested. There are three statements that get high scores, namely the value of 4. The three statements show that the gamification system is easy to use, other people can use it, and the features are easy to use. This study shows that Gamification can be an attractive distance-learning method for students.

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