The 2nd International Innovation Technology Proceedings
Vol 2 No 1 (2024): October
E-ISSN: 3030-9948
https://iite-proceeding.poltekindonusa.ac.id

Gamification-Based Project Learning to Improve Computational Thinking Skills

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Received:	Revised:	Accepted:	Published:
July 5, 2024	July 12, 2024	July 31, 2024	October 5, 2024

Abstract

One effort to optimize the benefits of digital transformation is by integrating digital technology into learning. Gamification is a learning innovation that is suitable for use in learning that uses technology. It is hoped that the use of this technology will be able to improve students' computational thinking to face the challenges of the 21st century. This research aims to determine the effect of implementing gamification-based project learning on computational thinking. The research was conducted on students who were taking the Intelligent Systems course. The research results show that the implementation of gamification-based project learning can improve students' computational thinking.

Keywords: *project learning, gamification, computational thinking*

1. Introduction

In this 21st century era, the world of education has the task of preparing its graduates with 21st century skills. This is done so that graduates can face today's global demands and challenges. One of the skills needed in the 21st century is computational thinking. In this regard, universities need to prepare learning innovations to create more meaningful learning. One of the learning innovations that can train problem-solving skills is by integrating computational thinking [1]. Computational thinking (CT) is a way of understanding and solving complex problems using the four foundations of CT including decomposition, pattern recognition, abstraction, and algorithms [2]. CT does not have to involve computers but humans must have computational thinking abilities [1] [3]. Through CT, students are directed to have critical, creative, communicative thinking skills and collaboration skills to solve problems [4]. The advantages of mastering computational thinking include increasing students' abilities in problem solving, analytical,

creativity, abstract thinking, and collaboration. This ability will really help someone identify problems, develop strategies, and make better decisions. Computational thinking also increases creativity and the ability to work collaboratively, providing significant benefits in the current era of information and technology [5]. One of the learning innovations that can be done to hone computational thinking is the use of technology in learning.

The development of information and communication technology is currently very rapid. In the current digital era, information and communication technology has played a very important role in many aspects of human life. This also has an impact on the world of education, especially in the learning process, where information and communication technology is an integrated part of the learning process [6]. One form of technology that can be integrated into learning is gamification-based technology. Gamification is a learning approach using elements in games or video games with the aim of motivating students in the learning process and maximizing feelings of enjoyment and engagement with the learning process. Apart from that, this media can be used to capture things that interest students and inspire them. to continue learning [7]. It was further stated that gamification aims to gain knowledge, foster habits and foster understanding in the classroom in a digital environment [8]. One form of gamification application that can be used is Genialy. Genially is a free, web-based learning medium that increases the interactivity of educational materials [9]. Genially has various features that can be used such as presentations, infographics, interactive images, video presentations, guides and training materials [10]. The advantages of Genially are that it is easy to use, especially for lay users, and is more suitable for creating game learning media in the board game genre [11].

The advantages of gamification-based learning are then combined in project-based learning. Project-based learning is an innovative learning model that prioritizes products as learning outcomes [12]. Furthermore, it is stated that the project-based learning model is an approach that emphasizes implementing projects or small research activities in the learning process [5]. This learning involves students in problem solving, allows them to work autonomously, and produces valuable work products. Apart from that, it was also stated that the project-based learning model has advantages such as increasing learning motivation and student involvement [7], [13]. Based on the explanation above, this research aims to improve computational thinking through gamification-based project learning using genially.

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2. Method

This research is an experimental research with a one group pretest posttest design [14], [15]. The subjects of this research were 40 students who were taking the Intelligent Systems course. The research was carried out by providing a gamification-based project learning model treatment. The gamification application used in this research is Genially. The instruments used to measure effectiveness in this research are tests and observations. The effectiveness measured is the effectiveness of the gamification-based project learning model on computational thinking. The computational thinking indicators measured in this research consist of four, namely decomposition, pattern recognition, abstraction and algorithm [16], [17]. Effectiveness testing was carried out using the t-test by comparing pretest and posttest scores. The pretest is a test given before being given treatment, while the posttest is a test given after students have been given treatment.

3. Result and Discussion

3.1. Result

The prerequisite analysis tests conducted in this study are the normality test and the homogeneity test. The normality test is used to determine whether the data is normally distributed or not. The results of the normality test are shown in Figure 1. The homogeneity test aims to test whether two or more groups of data in a homogeneous study are equal. The results of the homogeneity test are shown in Figure 2. These two tests were conducted with the help of SPSS software.

One-Sample Kolmogorov-Smirnov Test

		Pre-Test	Post-Test
N		20	20
Normal Parameters[a,b]	Mean	68,1500	85,2500
	Std. Deviation	5,86044	3,65449
Most Extreme Differences	Absolute	,172	,131
	Positive	,108	,131
	Negative	-,172	-,098
Test Statistic		,172	,131
Asymp. Sig. (2-tailed)		,122[c]	,200[c,d]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

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Figure 1. Normality Test Results

Normality testing was performed using the Kolmogorov-Smirnov test. Figure 1 shows that the asymp. Sig (2-tailed) value for both Pre-Test (0.122) and Post-Test (0.200) > 0.05, so the data is normally distributed.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	2,230	1	38	,144
	Based on Median	1,692	1	38	,201
	Based on Median and with adjusted df	1,692	1	27,041	,204
	Based on trimmed mean	2,118	1	38	,154

Figure 2. Homogeneity Test Results

The homogeneity test used is the Levene Test method. The significance value of Based on Mean in Figure 2 is 0.144 (> 0.0.5). This shows that the results of the pre-test and post-test are homogeneous with Levene Statistic 2.230. The hypothesis test used is the paired sample T-Test. This test is used to determine whether there is a difference in the average of two paired samples. The results of the paired sample T-Test are shown in Figure 5.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	68,1500	20	5,86044	1,31043
	Post-Test	85,2500	20	3,65449	,81717

Figure 3. Descriptive Statistic Results

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-Test & Post-Test	20	-,147	,537

Figure 4. Paired Sample Correlations Results

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pre-Test - Post-Test	-17,10000	7,34775	1,64301	-20,53885	-13,66115	-10,408	19	,000

Figure 5. Paired Samples Test Results

Figure 3 presents the summary results of descriptive statistics from both samples or pre-test and post-test data. The data presented include the mean, number of data, standard deviation and standard error mean. It can be seen in Table 3 that the average post-test score (average 85) is higher than the pre-test (average 68).

Figure 4 shows the results of the correlation or relationship between the two data, namely pre-test and post-test. The significance value is 0.537 (> 0.05) which means that these two variables (pre-test and post-test) are not related.

The basis for decision making in paired samples t-test is the significance value. If the Sig. (2-tailed) value is <0.05 then there is a significant difference between the two related variables. The data in Figure 5 shows that the Sig. (2-tailed) value is 0.000 (<0.005) then it can be concluded that there is a significant difference between the final project value in the pre-test and post-test data.

3.2. Discussion

Gamification combined with project based learning aims to improve computational thinking skills. Each stage of project based learning is packaged to be more interesting with the help of gamification. The results of the paired samples t-test stated that there was a significant difference between the final project scores on the pre-test and post-test data. The average post-test score was higher than the pre-test score, which was 85. All groups of students were able to work on searching problems well after being given the Gamification-based Project Learning treatment. This indicator of good problem solving is also related to improving computational thinking skills.

Good learning organization can have a positive impact on computational thinking skills [18]. Essential questions help students identify the information needed [19]. In the first stage of project based learning, students are required to decompose in the computational thinking stage. A total of 15 groups of students succeeded in identifying the information needed to solve the Depth First Search (DFS) problem, while 5 other groups still needed guidance. The initial process of each stage is an important start for students to build initial knowledge to complete the project [20].

At the stage of designing project activities and making schedules, students are organized to improve their ability to recognize patterns. This step requires students to recognize and develop patterns, relationships, or similarities to understand the information and strategies used [21]. If the ability to recognize patterns can be honed well, it will greatly assist the resolution process when facing similar problems [22]. All student groups succeeded in doing this stage with different times.

Monitoring activities are carried out throughout the completion of the project but will be more intensive at the abstraction and algorithmic thinking stages. The abstraction stage will encourage students to sort out which information is important and appropriate for the project completion steps [23]. The ability to abstract will be directly proportional to a person's ability to solve problems quickly and accurately [24]. A total of 11 student groups succeeded in abstracting the DFS problem quickly while 9 others needed guidance.

At the algorithm thinking stage, students will describe the logical steps used to complete the project, namely the problem of finding the closest distance using the DFS searching method [25]. The steps chosen consider efficiency and effectiveness from various sides according to the DFS method, namely patch costs and memory used [26], [27]. All groups succeeded in completing this stage with different time records.

The assessment carried out is a process assessment. The initial to final stages get their own points. The process assessment becomes a complex and comprehensive assessment so that authentic results are obtained [28]. The final process to close the learning activity is reflection where student representatives tell the experiences they have gained. Reflection is an important activity for sharing experiences and improving further learning [29].

4. Conclusion

Project-based gamification applied to intelligent systems courses has successfully improved students' computational thinking skills. The organization of activities presented can significantly influence four indicators of computational thinking, namely decomposition, pattern recognition, abstraction and algorithms. The form of gamification can be varied as needed to obtain maximum results.

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