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Level Up Your Learning: Gamification as an Effective Strategy to Increase Student Engagement in Algorithm Classes

Muhammad Rinov Cuhanazriansyah[1], Sri Bahmiati[2],
Dina Meilina Anggraini[3], Zacky Nur Octavian[4], Aisya Candra Ashiyam[5]
[1,2,3,4,5] Pendidikan Teknologi Informasi, IKIP PGRI Bojonegoro, Indonesia

Muhrinov15@gmail.com

Abstract

Student engagement is a crucial factor for learning success, particularly in the Algorithm course, which requires abstract thinking, problem-solving, and persistence. This study aimed to compare student engagement between gamified learning and traditional methods through a quasi-experimental design involving two groups: the experimental class (n = 36) applying gamification and the control class (n = 36) receiving conventional instruction. A student engagement questionnaire covering behavioral, emotional, and cognitive dimensions was employed, supported by classroom observations and Learning Management System logs. The findings revealed that both groups had similar pre-test scores (3.12 and 3.09), but at post-test the experimental class improved significantly to 4.21, while the control class only reached 3.34. Dimension analysis showed the experimental group outperforming the control in behavioral engagement (4.35 vs. 3.41), emotional engagement (4.18 vs. 3.29), and cognitive engagement (4.09 vs. 3.32), with a large effect size (d = 0.85). Student perceptions also highlighted leaderboards (78%) and step-based missions (70%) as the most effective gamification elements, followed by achievement badges (65%). In conclusion, this study demonstrates that well-designed gamification aligned with students' needs can serve as a more effective pedagogical strategy than traditional methods in enhancing student engagement in the Algorithm course.

Keywords: Gamification, Student Engagement, Algorithm, Higher Education, Quasi-experiment.

1. Introduction

Student engagement is a fundamental factor in successful learning at university, particularly in algorithm courses that require abstract thinking, problem solving, and perseverance in practice. The challenge of understanding algorithmic concepts often demotivates students, requiring innovative approaches to increase their engagement. One increasingly popular strategy is gamification, which involves applying game elements such as points, badges, leaderboards, and missions to the learning process. Several studies show that gamification has the potential to increase motivation, engagement, and learning outcomes, although its effectiveness is highly dependent on the design of the intervention and the context of its application [1].

In computer education, particularly programming and algorithms, the positive impact of gamification has been identified. A recent meta-analysis found that gamification has a significant effect on student motivation and academic outcomes, while its effect on cognitive load is relatively small [2]. Other research emphasises that gamification designs that merely add points or scoreboards without mature pedagogical support can produce minimal effects [4].

Therefore, the effectiveness of gamification is largely determined by the extent to which game elements are appropriately integrated to support meaningful learning processes.

In the current era of educational technology advancement, gamification is not only seen as a teaching support tool, but also as a strategic method for building an adaptive and personalised learning environment. Based on a recent study conducted by [2], gamification equipped with learning analytics can increase student participation through direct feedback that adjusts the level of difficulty of the material according to individual performance. Therefore, contemporary gamification systems can function as a form of learning that is responsive to students' learning styles.

Various studies related to gamification and learning media in information technology and computer education are currently continuing to develop the potential of educational gamification. One example is the implementation of Game-Based Learning 'Monopoli Digital (MonDig)' in the learning process of students at IKIP PGRI Bojonegoro, which shows that the use of GBL can increase motivation and interest in learning through a more interactive learning experience compared to conventional methods. Although this study did not specifically evaluate the

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three dimensions of engagement (behavioural, emotional, and cognitive) simultaneously in the Algorithms course, the results indicate that game elements and attractive designs have positive potential [5].

Student engagement itself is a multidimensional construct that encompasses behavioural, emotional, and cognitive aspects [6]. Research that focuses solely on academic outcomes risks overlooking a comprehensive understanding of how gamification affects the learning process. Theoretically, Self-Determination Theory explains the importance of fulfilling basic needs for autonomy, competence, and relatedness to foster intrinsic motivation [7], while the Theory of Gamified Learning asserts that game elements can influence behaviour and affect, which in turn impact learning outcomes [8]. These two frameworks provide a strong conceptual basis for assessing the impact of gamification on algorithm learning. According to [9], the use of gamification in learning can increase student motivation, engagement, and sense of autonomy, although its influence on competence is often limited and diminishes when the design is not properly crafted. In line with this [10] emphasise through Self-Determination Theory that intrinsic motivation grows when basic needs such as autonomy, competence, and relatedness are met, but its application can be less effective in learning contexts that emphasise external control.

Although a number of empirical studies support gamification, there is still limited research that specifically compares student engagement in algorithm courses using a gamification approach and traditional methods. In fact, this course is an important foundation in the computer science curriculum. In summary, based on the above problem design, the following questions can be asked: How does the level of student engagement, which includes behavioural, emotional, and cognitive dimensions, differ between learning Algorithms with a gamification approach and traditional methods, and which gamification elements most support this engagement? Therefore, this study was conducted to analyse and compare the level of student engagement in Algorithms courses between gamification and traditional methods, as well as to identify gamification elements that contribute signific ntly to increasing student engagement.

[11] explain that collaborative elements in gamification, such as ‘group missions,’ play a significant role in increasing social interaction and academic empathy among students. This indicates that gamification does not only focus on competitive aspects but also has the potential to encourage effective cooperation and communication among students. The application of this social dimension is particularly important for education in the field of information technology, which requires collaborative skills in programming projects.

A study by [12] in Indonesia also confirms that the use of gamification tailored to the local context, such as the application of traditional game themes in conjunction with digital technology, can strengthen students' sense of cultural connection and learning identity. This approach is in line with the principle of contextual learning, which emphasises the importance of the relationship between teaching materials and students' real-life experiences.

From a methodological perspective, measuring student engagement should not only rely on questionnaires, but should also be combined with digital behavioural data (digital footprint data) such as click activity, time spent learning, and mission completion rates. This methodology, as stated by [13], provides objective data and enriches our understanding of student engagement patterns in online environments.

2. Methods

This study utilised a quasi-experimental design with two groups of students enrolled in the Algorithms course, namely an experimental group that received gamification-based learning and a control group that followed the traditional method. This design was chosen because it is suitable for comparing two learning approaches in a real context without fully manipulating student placement, as recommended in applied educational research [1].

The research subjects were students majoring in Informatics at a state university, with approximately 72 participants. The two groups were balanced in terms of number of participants, gender distribution, and prior programming experience. The sample was selected purposively, namely students who were officially enrolled in the Algorithms course in the current semester. This approach follows similar research practices in the field of educational gamification, which often utilise real classrooms as the experimental context [2]; [14].

In the experimental group, learning was designed with the integration of gamification elements such as points, achievement badges, leaderboards, and step-by-step missions for each algorithm topic. Gamification was implemented through a Learning Management System (LMS) that supports game features. This is in line with research by [4], which shows the effectiveness of integrating gamification into digital platforms to increase student engagement. Meanwhile, the control group followed conventional learning in the form of lectures, discussions, and exercises without additional game elements.

The research instrument was a student engagement questionnaire adapted from the Student Engagement Scale framework with three main dimensions: behavioural engagement, emotional engagement, and cognitive engagement [6]. This instrument was used in pre-tests (at the beginning of the semester) and post-tests (at the end of the semester)

to measure changes in student engagement. In addition, secondary data was obtained from student activity logs in the LMS and classroom observations. This data triangulation approach is recommended in engagement studies to increase the validity of the results [8].

The research procedure was carried out over one semester (14 meetings). At the beginning of the semester, students from both groups completed the pre-test questionnaire. During lectures, the experimental group learned using a gamification approach, while the control group followed traditional methods. At the end of the semester, students again completed a post-test questionnaire to measure the level of engagement achieved.

The data were analysed using a difference test (independent samples t-test or Mann-Whitney U test, depending on the data distribution) to compare engagement scores between the two groups. In addition, the effect size was calculated to identify the magnitude of the influence of gamification on student engagement, as suggested in the gamification meta-analysis study [2]. Additional descriptive analysis was used to explore students' perceptions of the gamification elements that were considered to contribute most to their engagement.

3. Results and Discussions

To provide a clearer picture of the research findings, this section presents the results of the analysis from the initial to final scores, comparisons of each dimension of engagement, and student responses to the gamification elements used.

3.1 Pre-test and Post-test Scores

The initial results show that the level of engagement of the two groups was relatively balanced. As shown in Table 1, the average pre-test score for the experimental class was 3.12 (SD = 0.45), while that for the control class was 3.09 (SD = 0.48). The difference was not significant ($p = 0.74$). However, after one semester, the difference became clear. The experimental class, which used gamification, increased to an average of 4.21 (SD = 0.39), while the control class only reached 3.34 (SD = 0.42). Statistical tests showed a significant difference ($p < 0.01$).

Table 1. Comparison of Pre-test and Post-test Scores

Class Pre-test Post-test Improvement (M±SD) (M±SD)
Experiment 3.12± 4.21± ±1.09
0.45 0.39
Control 3.09± 3.34± ±0.25
0.48 0.42

Description: The data shows the average student engagement scores before (pre-test) and after (post-test) the learning intervention. The notation M ± SD indicates the mean (M) and standard deviation (SD). There was a higher increase in the experimental group than in the control group.

3.2 Engagement Based on Dimensions

When examined in more detail for each dimension, the differences are also consistent. The data in Table 2 shows that the experimental class is superior in all aspects of engagement.

Table 2. Engagement Scores Based on Dimensions

Gamification Elements	**Support students presentations**
Leaderboard	78%
Badge	65%
Phased Missions	70%

Note: The data shows engagement scores based on three main dimensions. The notation M ± SD indicates the mean (M) and standard deviation (SD). The experimental group outperformed the control group in all dimensions, with the largest difference found in the behavioural aspect.

3.3 Students' Perceptions of Gamification Elements

In addition to quantitative scores, students were also asked to evaluate the gamification elements they experienced. The results can be seen in the table below.

Table 3. Students' Perceptions of Gamification Elements

Gamification Elements	**Support students presentations**
Leaderboard	70%
Badge	65%
Phased Missions	70%

Description: The data shows the percentage of students who rated certain gamification elements as most useful. Leaderboards were considered the most motivating, followed by progressive missions and badges.

Discussion

The results of this study indicate that gamification significantly increases student engagement compared to traditional methods. The increase in the average score in the experimental class was +1.09, which was much greater than that of the control class, which was only +0.25. This confirms that the application of game elements in learning can create a more interesting and meaningful learning experience for students. When viewed based on the engagement dimensions in Table 2, it can be seen that:

a. Behavioural Engagement

The experimental class scored 4.35, much higher than 3.41 in the control class. These results indicate that students with gamification were more active in attending, participating in discussions, and completing assignments. The leaderboard was the main trigger, as students felt motivated to maintain their position above their peers. This healthy competition fostered a sense of responsibility for their activity in class. Behavioural engagement is defined as student participation or activity that can be observed during class. When students are actively involved in the learning process, they will have a high learning ethic, which will lead to improved learning achievement and help them complete their studies. Based on the opinions presented, it can be said that behavioural engagement is one indicator of student engagement, as students demonstrate observable activities, including behaviour, effort, participation, and involvement at school.

b. Emotional Engagement:

The experimental class scored 4.18 compared to 3.29 in the control class. This shows that gamification makes students more excited, enthusiastic, and enjoy the learning process. Badges play an important role because they give appreciation for individual achievements, which evoke a sense of pride and satisfaction. In addition, an interactive classroom atmosphere reduces boredom and increases a sense of belonging to the learning process. Emotional engagement makes learners feel more 'connected' to the material, which helps them understand the concepts presented because learning is able to touch on emotional aspects [15]. Furthermore, this emotional engagement has a positive impact on the development of students' character and emotional intelligence, such as empathy, openness, and responsibility [16]. Therefore, learning designs that trigger emotional engagement are necessary to create an effective learning process with long-term impacts [16]. Emotional engagement accelerates students' social skills and empathy, according to various studies [17]. Learning that encourages positive emotional responses can make primary education enjoyable and safe. The combination of compelling stories and reflective activities such as group discussions or journal writing helps students express their feelings and increases their motivation to learn. Ultimately, this combination helps students achieve better learning outcomes.

c. Cognitive Engagement:

The experimental class scored 4.09, higher than the control class's score of 3.32. The gradual missions designed in gamification helped students break down complex algorithmic material into smaller, more achievable targets. This strategy made students more focused, persistent, and able to manage their own learning. Thus, gamification supports the development of self-regulation skills and more effective learning strategies.

The students' perceptions in Table 3 further reinforce these findings. Most students rated the leaderboard and step-by-step missions as the most useful elements. The leaderboard created healthy competitive motivation, while the step-by-step missions reduced cognitive load and made students more focused on clear learning objectives. Although badges were rated lower (65%), this element still plays a role in maintaining student learning consistency.

Overall, the findings of this study prove that the success of gamification does not only lie in the addition of game elements, but in how these elements are designed to support student learning needs. This method combines game elements, such as point collection, badges, and scoreboards, with the aim of increasing student engagement in the learning process [18]. In recent years, gamification has become a popular approach in the field of education. The goal is to encourage student interest and enthusiasm for learning, while creating a more engaging and interactive learning environment. Gamification can increase student motivation through competition and cooperation inherent in this method. Effective gamification can increase engagement in three dimensions simultaneously: behavioural, emotional, and cognitive, which together contribute to achieving more optimal learning outcomes.

4. Conclusions

This study aims to analyse and compare student engagement in Algorithms courses between gamification-based learning and traditional methods. The results show that the application of gamification has a significant impact on overall student engagement. In terms of behaviour, students in gamification classes are more active in attendance, discussion, and task completion compared to traditional classes. Emotionally, students showed greater enthusiasm, interest, and enjoyment of learning. Cognitively, students were more diligent, able to manage their learning strategies, and more consistent in understanding complex material.

Furthermore, students' perceptions indicated that leaderboards and progressive missions were the most effective gamification elements in increasing engagement, while badges played a role in maintaining learning consistency. Overall, the results of this study confirm that gamification, when well designed, can be a more effective pedagogical alternative than traditional methods in increasing student engagement in algorithm courses. These findings can be used as a basis for lecturers and learning designers to strategically integrate gamification elements to create a more interesting, meaningful, and quality-oriented learning experience.

In general, these findings and additional analyses further emphasise that gamification is a teaching strategy that is in line with the era of digital learning 4.0 and society 5.0. Gamification can not only increase enthusiasm for learning, but also assist in the mastery of 21st-century skills such as collaboration, communication, and critical thinking. To achieve long-term success in implementation, educators need to design gamification systems that are inclusive, sustainable, and adaptable to the diverse characteristics of students.

Recommendations and Implications

This section highlights the theoretical and practical implications of the research findings and provides recommendations for further research. The results of this study reinforce the Self-Determination Theory [7] and Gamified Learning [8] theories, which emphasise that the application of game elements can stimulate intrinsic motivation through increased autonomy, competence, and social connectedness among students. In the context of algorithm learning, this is evident from increased learning activities, participation in discussions, and positive perceptions of the gamified learning process.

Theoretically, these findings expand our understanding of the relationship between game element design and student engagement. Gamification is not only a means of increasing interest in learning, but can also serve as a medium for shaping adaptive learning behaviours through instant feedback, tiered goals, and achievement recognition [9]. These findings indicate that the success of gamification lies in the balance between competition and collaboration, so that the learning atmosphere becomes more productive without neglecting the social and affective aspects of students [10].

From a practical perspective, this study has implications for educators and learning media developers. Lecturers are advised to systematically integrate gamification elements into Learning Management Systems (LMS) such as Moodle or Google Classroom to make learning more interactive. Additionally, digital education system developers can use the results of this study to design gamification features that are adaptive to user characteristics, for example by adjusting missions based on difficulty levels or providing more personalised rewards [19].

The limitations of this study lie in the scope of the sample, which was limited to one course and one institution. Therefore, further research is recommended to test the effectiveness of gamification in more diverse contexts and fields of study, including project-based and collaborative courses. Future research could also explore the long-term impact of gamification on student learning outcomes and retention using a mixed-method approach to gain a more comprehensive understanding.

Overall, these findings provide a strong basis for the development of innovative gamification-based learning models that can improve the quality of learning in higher education, while strengthening the link between motivation theory and modern pedagogical practice.

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Biographies of Authors

Muhammad Rinov Cuhanazriansyah works at IKIP PGRI Bojonegoro as a lecturer and researcher. He was born on 15 November 1991 in Bengkulu City. He completed his undergraduate degree in Information Technology at Bengkulu University and his master's degree in Technology and Vocational Education, specialising in Computer Engineering and Information Technology Education, at Padang State University. Both universities awarded him the degrees of S.T. and M.Pd.T. in computer science education. He can be contacted via email at muhrinov15@gmail.com. His office is located at Jalan Panglima Polim, Bojonegoro, East Java, Indonesia, at IKIP PGRI Bojonegoro. His areas of expertise include Gamification, Technology Education, and Artificial Intelligence.

Sri Bahmiati She was born on August 16, 2005 in Bojonegoro, East Java, Indonesia. She is currently studying at IKIP PGRI Bojonegoro, Bachelor of Information Technology Education Study Program, Faculty of Mathematics and Science Education. She can be contacted via email sribahmiati22@gmail.com.

Dina Meilina Anggraini She was born on May 4, 2005 in Bojonegoro, East Java, Indonesia. She is currently studying at IKIP PGRI Bojonegoro, Bachelor of Information Technology Education Study Program, Faculty of Mathematics and Science Education. She can be contacted via email dinameilina455@gmail.com. Currently she works at Nurul Ulum Kemiri Islamic Middle School as an Administrative Staff (TU), her workplace is located at Jalan Desa Kemiri No. 100, Malo District, Bojonegoro Regency

Zacky Nur Oktavian was born on October 7, 2003, in Bojonegoro, East Java, Indonesia.

He is currently studying at IKIP PGRI Bojonegoro, in the Bachelor's Degree Program of Information Technology Education, Faculty of Mathematics and Science Education.

He can be contacted via email at zackynur1424@gmail.com.

Aisya Candra Ashiyam

She was born on November 10, 2002 in Bojonegoro, East Java, Indonesia. She is currently studying at IKIP PGRI Bojonegoro, Bachelor of Information Technology Education Study Program, Faculty of Mathematics and Science Education. She can be contacted via email aisyacandra10@gmail.com.