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Leaderboard as an Element of Gamification and Student Self-Efficacy for Performance Achievement

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Abstrak

Kegiatan pembelajaran yang kurang inovatif berdampak pada suasana belajar yang tidak menyenangkan. Pembelajaran berbasis proyek (PjBL) dengan pendekatan gamifikasi menyajikan pembelajaran inovatif untuk meningkatkan motivasi, keterlibatan, dan pencapaian kinerja pebelajar. Sebagai mekanisme gamifikasi, papan peringkat memberikan umpan balik dengan melaporkan pencapaian dan kemajuan pebelajar. Tujuan penelitian ini adalah untuk menganalisis secara komprehensif dan memberikan bukti pengaruh penggunaan papan peringkat dan tingkat efikasi diri siswa terhadap pencapaian kinerja mereka dalam pembelajaran berbasis proyek. Penelitian ini menggunakan metode kuantitatif quasi eksperimen dengan desain eksperimen factorial 2x2. Sampel penelitian terdiri dari 94 mahasiswa S1 yang mengikuti mata kuliah Multimedia Interaktif. Metode pengumpulan data menggunakan observasi dan kuesioner. Instrumen penelitian menggunakan lembar kuesioner. Data dianalisis dengan statistik inferensial menggunakan uji ANOVA dua arah. Hasil penelitian menunjukkan adanya menunjukkan perbedaan yang signifikan dalam skor kinerja rata-rata antara kelas yang menggunakan papan peringkat dan kelas yang tidak menggunakan papan peringkat. Penerapan metode gamifikasi mekanika leaderboard memberikan dampak positif terhadap prestasi belajar siswa dalam pembelajaran berbasis proyek. Hasik penelitian juga menunjukkan bahwa tingkat efikasi diri memiliki dampak yang signifikan terhadap pencapaian kinerja mahasiswa.

Kata Kunci: *PjBL, Gamifikasi, Papan Peringkat, Self Efficacy*

Abstract

Less innovative learning activities have an impact on an unpleasant learning atmosphere. Project-based learning (PjBL) with a gamification approach presents innovative learning to increase motivation, engagement, and achievement of learner performance. As a gamification mechanism, the leaderboard provides feedback by reporting learner achievement and progress. This study aims to comprehensively analyze and provide evidence of the effect of the use of leaderboards and students' self-efficacy levels on their performance achievement in project-based learning. This study uses Quasi-experimental quantitative method with 2x3 factorial experimental design. The research sample consisted of 94 undergraduate students who took the Interactive Multimedia course. The data collection method used observation and questionnaires. The research instrument used a questionnaire sheet. Data were analyzed with inferential statistics using a two-way ANOVA test. The results showed a significant difference in the average performance score between the class that used the leaderboard and the class that did not use the leaderboard. The application of the leaderboard mechanism as a gamification method has a positive impact on students' learning achievement in project-based learning. The results also show that the level of self-efficacy has a significant impact on student achievement.

Keywords: PjBL, Gamification, Leaderboard, Self Efficacy

1. INTRODUCTION

Project-based learning (PjBL) is an approach that involves completing projects that present challenges, allows students to engage in extensive inquiry processes and fosters independence and creativity (Rati et al., 2017; Rizky & Puspita, 2022; Ulya et al., 2022). However, the effectiveness of PBL can be further enhanced by integrating gamification elements. Adopting game elements in non-game contexts is increasingly explored in

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educational settings to increase learner motivation and engagement (Dichev & Dicheva, 2017; Wichadee & Pattanapichet, 2018). Integrating gamification into PjBL, students can utilize game mechanisms such as leaderboards and points to encourage efficient goal setting, increase learning motivation, and facilitate a more engaging learning environment (Park & Kim, 2021). Leaderboards promote motivation and encourage students to set goals and improve performance. Research finds that incorporating leaderboards into instructional design significantly increases student engagement with projects (Landers et al., 2017; Park & Kim, 2021). This effect is especially pronounced compared to students who do not have access to leaderboards. Thus, digital leaderboards allow learners to rate themselves by comparing their achievements with those of their peers.

Using PjBL with gamification presents an innovative learning approach, offering opportunities to enhance students' critical thinking, learning motivation, and problem-solving skills. This allows learners to create dynamic, immersive learning experiences that prepare them for real-world challenges (Hujjatusnaini et al., 2022; Sumardiana et al., 2019). Gamified learning has potential benefits, but previous research has highlighted challenges that must be overcome for effective implementation. Gamification scenarios must be aligned with learning objectives to increase learner engagement and motivation (Leitão et al., 2022; Wijaya et al., 2021). Gamification mechanisms, such as challenges, competitions, rewards, and levels, are essential for achieving learning objectives (Duggal et al., 2021; Idris et al., 2020; Leitão et al., 2022). Therefore, the combination of game elements enhances learner motivation and performance achievement.

Research has shown a strong relationship between a person's belief in their abilities and academic performance. Previous research results from 51 studies highlight a significant correlation, indicating that individuals with greater self-efficacy tend to be better learners and generally achieve better academic performance (Honicke & Broadbent, 2016). Other research also shows that students with higher levels of efficacy, compared with students with low levels of efficacy, are more likely to choose challenging tasks, persist in working on complex tasks, and adopt more effective learning strategies when facing difficulties (Arsyad et al., 2020; Mega et al., 2014; Wulandari & Agustika, 2020). One effective way to overcome this challenge is to introduce PjBL. A study successfully implemented a learning approach that actively involved students in real-life projects and product development (Chen & Yang, 2019; Pratiwi et al., 2018). The results showed that PjBL had a more beneficial effect on student learning outcomes than traditional learning methods (Hilman, 2022; Mariatul Kibtiyah, 2022). PjBL is known to be flexible and includes student autonomy, constructive inquiry, collaboration, goal setting, communication, and reflection on real-world practices (Ardianti et al., 2017; Yahya & Irfan, 2018). PjBL is a student-centred approach that focuses on authentic learning. Learners are responsible for designing, implementing, and evaluating projects with real-world applications outside the classroom. Previous research has been conducted on the relationship between self-efficacy and performance achievement. A meta-analysis of studies in educational settings found that more specific indicators of self-efficacy significantly impacted academic outcomes (Kurniawati et al., 2022; Wulandari & Agustika, 2020). In addition, a strong relationship exists between self-efficacy and performance, adjustment, and overall satisfaction.

Extensive research has been conducted on PjBL including comprehensive design methodology analysis, successful learner product realisation, and targeted skill acquisition. In particular, gamification has emerged as an exciting approach, utilizing key game design elements to enhance learner motivation in educational contexts. However, there has been no previous research on how much influence an element, namely the leaderboard, has on increasing learners' intrinsic motivation in completing a project. Students' self-efficacy as a moderator variable has also been studied in various situations, conditions, and abilities as

independent and dependent variables. Research on self-efficacy in academic performance has also been explored previously. However, there has been no discussion on learners' self-efficacy in completing a project with a gamification approach, especially when using the leaderboard element to improve their performance. Based on this, this study aims to comprehensively analyze and provide evidence of the influence of the use of leaderboards and students' self-efficacy levels on their performance achievements in project-based learning.

2. METHOD

The research uses Quasi-experimental quantitative method with 2x2 factorial experimental design due to the inability to randomly select the control and experimental groups. The independent variable in this study is gamification mechanics, which consists of leaderboard and non-leaderboard mechanics. The moderator variable determined in this study is the level of student self-efficacy. Then, the dependent variable observed is the achievement of performance in project-based learning, which in this study is an assessment rubric for the results of interactive learning media products consisting of four products. Table 1 describes the rubric of product assessment based on Mayer's multimedia learning principles showed in Table 1.

Table 1. Multimedia Product Assessment Rubric

Indicators	Descriptions
Multimedia Principle	Combining words and pictures enhances learning more than using words alone.
Spatial contiguity	Related words and pictures should be presented closely on the page or screen to enhance learning.
Time contiguity	Individuals have a greater learning capacity when they are presented with verbal and visual information concurrently instead of consecutively.
Coherence	When related words and visuals are positioned nearby on a page or screen, individuals have an improved learning experience.
Modality	Research has indicated that individuals comprehend and retain information more effectively when it is presented through visuals and spoken explanations than when animated content and text are displayed on the screen.
Redundancy	Research indicates that individuals exhibit superior learning retention when exposed to a combination of graphics and narrations as opposed to animation and on-screen text.
Personalized	Research indicates that individuals retain information more effectively from multimedia lessons delivered in a conversational tone rather than a formal delivery style.
Interactivity	Research indicates that individuals retain information more effectively when instructional content is presented using a warm, human voice rather than a machine-generated one.
Signaling	Research suggests that individuals experience improved learning outcomes when provided with cues emphasizing the organization of essential materials.

(Mayer, 2009)

The study focused on undergraduate students of Educational Technology who took part in Interactive Multimedia courses, totaling 94 students. All offerings were categorized into two groups to divide the treatment group. Offering A and B, with a total of 47 students, are the control group, which is given a gamification scenario without a leaderboard; offering C and D, with a total of 47 students, are the experimental group, which is given a leaderboard scenario. The methods used to collect data are observation and questionnaires. This research began with field observations, preparation of gamification-PjBL lesson plans, web leaderboards, and self-efficacy instruments developed by (Solikhin, 2020). The next stage is the implementation of research, which is carried out for eight weeks. The students' self-efficacy questionnaire was administered during the third week of the research to assess their self-efficacy. The questionnaire consists of 23 statements about six indicators. The instrument used to measure student self-efficacy can be found in Table 2 for reference.

Table 2. Student Self-efficacy Instrument

Indicator	Statement
choice of activity	I find it tough to tackle challenging assignments given by lecturers.
	I always aim high in every MMI task.
	I generally prefer to be assigned manageable tasks by instructors.
	I don't set high targets for achievement in completing tasks. The important thing is that they are done.
	I worked hard to complete the MMI assignment, no matter how difficult it was on the contract date.
	I made an effort to complete MMI assignments by maximizing contract time.
	I do not maximize my ability to complete MMI tasks.
persistence	I persist in completing the assignments in this course despite obstacles.
	I stick to the achievement targets (contract agreements) that I have set.
	I give up easily if there are obstacles in completing this course project.
	I give up easily when completing the contract agreements I set for myself when completing MMI tasks.

To implement the project, the experimental and control classes completed the same task: to complete four instructional media products, namely linear media, presentation media, interactive media, and free choice (tutorial/drill and practice). Each finished product will be given points using an assessment rubric based on Meyer's nine multimedia principles. In the experimental class, every point earned by students will be displayed on the web leaderboard, updated daily, and accessed by all experimental class students. Meanwhile, in the control class, students can only see the acquisition of their points without knowing the ranking or points of their classmates. The data we gathered was analyzed using both descriptive and inferential statistics. Descriptive analysis helped us to provide a detailed description of the students' performance achievements after they completed the entire project. The research hypothesis was tested using a two-way ANOVA to answer the question. Before that, prerequisite normality and homogeneity tests were carried out.

3. RESULT AND DISCUSSION

Result

Descriptive statistics help us understand the qualities of a set of collected data. Table 4 presents the results of descriptive statistical calculations of performance achievement scores in experimental classes given the gamification method with Leaderboard mechanics (GL) and control classes given the gamification method without Leaderboard mechanics (GNL),

Learner self-efficacy can be categorized into three groups: high (HSE), medium (MSE), and low (LSE). Descriptive statistics showed in Table 3.

Table 3. Descriptive Statistics

Method	Self-efficacy	Mean	Std. Deviation	N
Leaderboard (GL)	LSE	77.50	6.535	6
	MSE	78.58	4.924	36
	HSE	83.80	5.805	5
Method	**Self-efficacy**	**Mean**	**Std. Deviation**	**N**
Non-Leaderboard (GNL)	LSE	72.80	5.029	10
	MSE	77.00	4.505	28
	HSE	76.33	3.708	9
	Total	75.98	4.702	47
Total	LSE	74.56	5.910	16
	MSE	77.89	4.775	64
	HSE	79.00	5.711	14
	Total	77.49	5.250	94

The information in the table indicates that the GL class students have an average score of 79, while the GNL class students have an average score of 75.98. This means that, on average, the GL class students performed better than the GNL students. The data above also shows that GL students with SEH levels have the highest average score of 83.80 compared to other groups in GL and GNL classes. Studies show that students in the GL class with LSE tend to perform better on average compared to students in the GNL class. On average, GL class students with LSE achieve a performance score of 77.50. Several conditions must be met before hypothesis testing is conducted to conduct a two-way anova analysis. the results of the normality test are shown in Table 4.

Table 4. The Normality Test Results

Standardized Residual for Nilai	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
	0.070	94	0.200*	0.993	94	0.880

The data in this study was subjected to a normality test using the Shapiro-Wilk test, a statistical method for evaluating the normality of data, at a significance level of 95%. The results of the standardized residual normality test (sign=0.880) surpassed the alpha value ($p > 0.05$), suggesting that the data follows a normal distribution.

Table 5. The Homogeneity Test Results

Levene's Test of Equality of Error Variances			
F	df1	df2	Sig.
0.758	5	88	0.582

Furthermore, the homogeneity test utilizing Levene's Equality of Error Variances test yielded a significant result (sign=0.582) higher than the alpha value ($p > 0.05$), leading to the conclusion that the data is homogeneous, thus meeting the requirements for the two-way ANOVA test.

The first hypothesis is a significant difference in the performance achievement of learners who are given gamification with leaderboard mechanics and gamification classes without leaderboards. Results of the two-way ANOVA test showed in Table 6.

Table 6. Results of the Two-way ANOVA Test.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	480.839	5	96.168	4.063	0.002	0.188
Intercept	338658,580	1	338658.580	1430.632	0.000	0.994
Method	294,825	1	294.825	12.458	0.001	0.124
SE	170,035	2	85.018	3.592	0.032	0.075
Method * SE	106,465	2	53.233	2.249	0.112	0.049
Error	2082,650	88	23.666			
Total	566996,000	94				
Corrected Total	2563,489	93				

Based on the findings from the ANOVA test, the leaderboard mechanism has an impact on learners' performance and achievement scores. The data in Table 5 shows a calculated F value of 12.458 with a significance of p = 0.001, indicating that the result is smaller than α 0.05 ($p < 0.05$). As a result, H_o is rejected, and H_a is accepted. This suggests a significant difference in performance achievement scores between the GL class, which utilized the gamification learning method with leaderboard mechanics, and the GNL class, which used the non-leaderboard gamification method. The evidence consistently supports the conclusion that the student performance achievement in the experimental class, using the GL method, surpasses that of the control class, which uses the GNL method. This is evident from the higher average performance of the GL class compared to the GNL class, as indicated by the ANOVA test results and the mean performance of each class.

The study also examined whether there was a variation in academic achievement scores among students with varying levels of self-efficacy, specifically low, medium, and high levels. The results of the ANOVA test in Table 5 indicate that the level of SE has a significant influence on student performance achievement. This is supported by the calculated F value of 3.592 for the performance achievement score based on the level of SE, with a significance level of p = 0.032. Since the p-value is less than the significance level of 0.05 ($p < 0.05$), we reject H_0 and accept H_a. This finding indicates a notable disparity in performance achievement among students with low, medium, and high levels of self-efficacy. To ascertain which level of the independent variable differs significantly from the others, a post hoc test was performed, and the results are detailed in Table 6.

Table 7. Post Hoc Test Results

(I) Self-efficacy		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
LSE	MSE	-3.33*	1.360	0.043	-6.57	-0.09
	HSE	-4.44*	1.780	0.038	-8.68	-0.19
MSE	LSE	3.33*	1.360	0.043	0.09	6.57

(I) Self-efficacy		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
HSE	HSE	-1,11	1.435	0.721	-4.53	2.31
	LSE	4.44*	1.780	0.038	0.19	8.68
	MSE	1.11	1.435	0.721	-2.31	4.53

Based on the Table 7, it is evident that the mean difference between HSE and LSE is 4.44, with a significance of p = 0.038. This p-value is smaller than the critical value α of 0.05 (p < 0.05), indicating a significant difference in performance achievement between high and low self-efficacy students. There is a significant mean difference of 3.33 with a p-value of 0.043, which is lower than the α value of 0.05 (p < 0.05) between MSE and LSE. Therefore, it can be concluded that there is a notable difference in performance achievement between students with medium and low self-efficacy. The mean difference in performance achievement between MSE and MSE students has a significance of p = 0.721, greater than the α value of 0.05 (p < 0.05); both groups show no significant difference.

The third hypothesis in this study is to test whether there is an interaction effect between gamification methods and student self-efficacy on performance achievement. The outcome of the data analysis for testing the third hypothesis can be observed by examining the computed F score and the significance score in the method*SE column in Table 4. The table indicates that the interaction row between the method and self-efficacy yielded a computed F score of 2.249 with a significance of p = 0.112, which is higher than the alpha value of 0.05 (> 0.05). The results indicate that H_0 is accepted and H_a is rejected, concluding that there is no interaction effect between gamification methods (leaderboard and non-leaderboard) and the level of self-efficacy (low, medium, high) on student performance achievement scores.

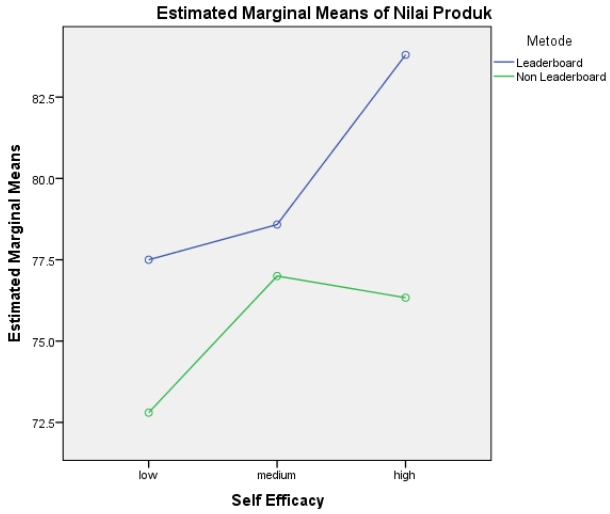

Figure 1. Profile Plot of the Method and Self-efficacy Interaction.

Based on figure 1, The profile plot shows no significant interaction between the gamification method and self-efficacy level on student performance achievement. The line illustrations in the figure above depict that the average performance achievement scores are consistently higher for students in the GL class (blue line) than for those in the GNL class (green line) across all three groups of self-efficacy levels (i.e., low, medium, and high shown as the x-axis). In addition, the lines are not far from parallel when comparing GL and GNL students with low and medium levels of efficacy, which means there is no significant

interaction between these groups. Meanwhile, when comparing the GL and GNL groups who had high levels of self-efficacy, the lines diverged (i.e., were not parallel). Consequently, there was a suspicion that the leaderboard method had an interaction effect when combined with a high level of self-efficacy.

Discussion

The data analysis results showed a difference in average performance between classes that used leaderboards and classes that did not. Students in classes that used the leaderboard mechanic gamification method tended to perform better than those who used the non-leaderboard gamification method. This is due to the following factors. First, the application of the leaderboard mechanic gamification method has a positive impact on student learning achievement in project-based learning. PjBL learning helps students acquire problem-solving skills, supports knowledge acquisition, helps them manage their work effectively, and ultimately enables them to create products (Chistyakov et al., 2023; Hujjatusnaini et al., 2022). In this case, PjBL offers more control to learners than other learning methods, and instructors play an essential role in supporting learners and developing their competencies and beliefs. Self-efficacy can be influenced by behavioural and achievement elements, including progress and feelings of achieving goals (Lidiawati et al., 2021; Wulandari & Agustika, 2020). This can also be influenced by social and environmental factors, such as comparing oneself with peers and receiving feedback from individual learning (Ambarriyah & Fachrurrozie., 2019; Khadifa et al., 2018). The leaderboard mechanism in this study serves as a form of social comparison and provides direct feedback on student performance results. Offering direct feedback during project-based learning can improve student achievement.

Second, applying the leaderboard mechanics gamification method supports exciting learning activities. The leaderboard is a way to rank students based on their performance digitally. This makes learning activities more interesting (Landers et al., 2017; Park & Kim, 2021). According to this theory, individuals naturally evaluate themselves compared to others. This comparison process significantly affects individual perceptions, emotions, and actions (Balci et al., 2022; Wijaya et al., 2021). Gamification in learning involves using game mechanics to solve problems and enhance the learning experience (Redy & Ariningsih, 2020; Yaniaja et al., 2021). It can be applied at various levels of education but is more commonly used in higher education. Research on incorporating gamification into visual programming courses shows that students respond positively to this activity (Khuluq et al., 2023; Soepriyanto & Kuswandi, 2021), and survey results show that gamification scenarios can increase student motivation. Using challenges, points, and rankings as game mechanics increases student engagement (Dias, 2017). Zamorano's research investigated the impact of incorporating gamification elements into active learning environments on student skill development, academic performance, and overall satisfaction (Murillo-Zamorano et al., 2021).

Third, the application of the leaderboard mechanics gamification method increases student motivation. In learning activities, students are given freedom on topics that will increase their interest in the project's importance and the product's originality. This allows students to connect their interests with learning content (Eccles & Wigfield, 2020; Marisa et al., 2020). In addition, the leaderboard creates a clear goal for students. When students see their position on the leaderboard, they become more motivated to try harder to move up the rankings and reach higher positions. Activities give them a sense of achievement and challenge that can spur their enthusiasm for learning. Leaderboards often make learning activities more interactive and exciting. When students know there is a leaderboard that measures their achievements, they may be more involved in the activities and tasks given. This can make the learning process more dynamic and enjoyable.

Research shows that when students receive immediate feedback and use it to improve their performance, they typically experience increased self-efficacy and motivation (Schunk & DiBenedetto, 2021). The study found that more confident people tend to engage in learning and work harder than those who are less confident. They also persist longer when things are difficult and achieve more success. These results are consistent with Bandura's theory, which emphasizes self-efficacy as a critical motivational process in social cognitive theory (Ambarriyah & Fachrurrozie., 2019; Wulandari & Agustika, 2020). The consequences of self-efficacy on motivation include choosing activities, exerting effort, showing persistence, and achieving success. Self-efficacy can emerge with support from the surrounding sociocultural environment (Aryanti & Muhsin., 2020; Hartati et al., 2021). In maintaining a meaningful and enjoyable learning environment, it is essential for teachers and educational institutions to participate in this effort actively. The limitation of this study is that this study only analyzes the effect of leaderboard implementation on student performance achievement. This study implies that the leaderboard mechanics gamification method can be used in learning activities to make them more enjoyable.

4. CONCLUSIONS

The findings show a significant difference in the average performance scores between classes that use leaderboards and classes that do not. Students in classes that use the leaderboard mechanic gamification method tend to perform better than those who use the non-leaderboard gamification method. This shows that the implementation of the leaderboard mechanic gamification method has a positive impact on student learning achievement in project-based learning. This study shows that the level of self-efficacy has a significant impact on student performance achievement. The average performance achievement in the experimental class shows a significant difference in performance scores among students with low, medium, and high levels of efficacy. Similarly, in the control group, there is a significant difference in performance metrics between the low and medium self-efficacy categories.

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