The Effect of Project-Based Learning with Gamification and Self-Efficacy on The Software Operation Ability of Junior High School Students

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ABSTRACT

This study addresses the problem of limited software operation skills among junior high school students and the need for learning strategies that simultaneously enhance technical competence and learner confidence. The objective of this research is to examine the effect of gamification-based Project-Based Learning (PjBL) and students' self-efficacy levels on software operation skills in Informatics learning. A quasi-experimental method with a posttest-only control group design and a 2×2 factorial arrangement was used, with an experimental group receiving gamified PjBL and a control group receiving non-gamified PjBL. Data were analyzed using two-way ANOVA to identify the effects of learning strategy, self-efficacy, and their interaction on students' performance. The findings show that students who learned through gamified PjBL demonstrated higher software operation skills than those who experienced PjBL without gamification. The results also reveal a substantial difference in performance between students with high and low self-efficacy, indicating that confidence plays a crucial role in mastering digital technical skills. Although no statistically significant interaction was found between learning strategy and self-efficacy, descriptive analysis suggests that gamification provides greater benefits for students with low self-efficacy by helping reduce skill gaps. Overall, this study confirms that integrating gamification into PjBL effectively improves software operation skills, while reinforcing the importance of strengthening self-efficacy in technology-based learning environments.

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1. INTRODUCTION

The ability to utilize information and communication technology has become a fundamental competence for junior high school students. In line with the Merdeka

Curriculum for Informatics at the junior high school level, learning objectives aim to strengthen students' skills and understanding of basic Information and Communication Technology concepts [1]. One of the core competencies in Informatics education is students' comprehension of fundamental computer technology, software, and internet network concepts [2]. Learners are therefore required to possess practical technological skills and be capable of effectively operating digital tools and related software as essential competencies in the contemporary digital era [3], [4].

Software operation skills represent a critical component of Informatics learning. Along with the rapid advancement of technology, the ability to utilize software applications such as Microsoft Office and other digital tools has become increasingly vital. This aligns with educational goals emphasizing the development of 21st-century skills, where ICT plays a central role in modern learning environments. Software operation skills encompass not only cognitive understanding of how applications function, but also psychomotor abilities for practical use. Students are expected to move beyond theoretical knowledge and demonstrate proficiency in performing tasks such as document processing, presentation development, and data manipulation, which requires the integration of both cognitive and motor competencies.

Based on the researcher's professional experience as an Informatics teacher at SMP Negeri 1 Tana Tidung during the 2023–2024 implementation of the Merdeka Curriculum, most students demonstrated inadequate mastery of software operation skills, particularly in office applications such as Microsoft Word, Excel, and PowerPoint. This condition was reflected in summative assessment results for the 2023/2024 academic year, where 67% of students in the odd semester and 79% in the even semester scored below the established Minimum Learning Achievement Criteria (KKTP) of 70. Although the Merdeka Curriculum promotes flexible, student-centered learning, classroom practice indicates that many learners struggle to make the most of independent study time, especially when it comes to technical skills that require repeated hands-on practice.

During instructional activities, students in the low-ability group frequently hesitated and relied heavily on teacher assistance when completing practical assignments. Observations revealed an apparent discrepancy between conceptual understanding and actual performance. For example, during practice sessions, many students were unable to correctly apply formatting techniques or integrate Microsoft Word, Excel, and PowerPoint features. Despite theoretical explanations, students' comprehension did not fully translate into practical competence, as evidenced by frequent basic inquiries and reliance on teacher or peer support. This situation indicates a mismatch between instructional delivery and students' mastery of practical skills.

Furthermore, limited practice duration, inadequate computer-to-student ratios, and minimal independent practice outside class hours further contribute to students' underachievement in software operation competencies. These findings are consistent with previous research indicating that technology literacy among junior high school students remains relatively low, thereby hampering the development of ICT-related practical skills [5].

Previous studies indicate that approximately 40–50% of students demonstrate low mastery of basic ICT skills, suggesting that junior high school students' ability to use technology and software has not been fully developed [6], [7]. This condition is further supported by findings that the implementation of Informatics subjects under the Merdeka Curriculum at the junior high school level continues to face various challenges, resulting in low levels of technological competence and digital literacy [8]. These limitations arise from both internal factors, such as insufficient foundational skills, and external factors, including limited facilities and inadequate instructional support [9]. Another influential factor is students' confidence in using computers. Research has shown that self-efficacy significantly affects students' computational thinking skills, where low self-efficacy hinders learners' ability to operate software and develop ICT competencies [10]. Despite curricular efforts to improve technological literacy, suboptimal instructional implementation continues to constrain students' software operation skills.

To overcome these challenges, educators must design active, meaningful learning experiences that support students' mastery of ICT concepts and skills [11], [12]. Active learning promotes student participation and encourages learners to construct knowledge independently, leading to deeper and more meaningful learning outcomes [13]. One instructional approach that effectively supports this process is Project-Based Learning (PjBL), which involves students in authentic projects that facilitate the application of knowledge and the development of technical skills [14]. Prior research has demonstrated that PjBL enhances student engagement and learning outcomes in STEAM education [15], improves critical and creative thinking skills through Ethno-STEM-based projects [16], and positively influences STEM learning outcomes through authentic project experiences [17]. Moreover, PjBL has been shown to significantly improve academic achievement when supported by appropriate pedagogical design and motivational strategies [14].

The integration of PjBL with gamification has emerged as an innovative strategy to further increase student motivation and engagement. Gamification incorporates game elements such as points, badges, and challenges into non-game learning contexts, thereby creating more interactive learning experiences. Studies have reported that gamified PjBL enhances student participation and deepens understanding of learning materials [18]. Similarly, research findings indicate that gamified PjBL strengthens 21st-century skills, including collaboration, communication, and problem-solving, while fostering responsibility and learner autonomy [19]. In the context of Informatics education, PjBL has been shown to positively influence conceptual understanding and critical thinking skills; however, previous studies primarily focused on senior high school students and did not specifically examine software operation skills [20]. Likewise, other studies revealed that PjBL is more effective than conventional Problem-Based Learning in increasing student engagement at the junior high school level, yet these studies did not integrate gamification elements [21].

Although gamification has been widely recognized for its effectiveness in enhancing motivation, engagement, and learning outcomes [22], [23], the role of self-efficacy has not been sufficiently explored. Existing research has shown that gamification elements such as leaderboards, badges, and rewards in PjBL improve motivation and academic achievement, but self-efficacy was not examined as a contributing factor [23]. Other studies found that leaderboard-based gamification can strengthen students' self-efficacy and motivate them to achieve learning targets in PjBL; however, these studies did not analyze how increased self-efficacy directly affects learning outcomes [24]. Consequently, a research gap remains regarding learning models that simultaneously improve learning outcomes and strengthen students' self-efficacy in software operation skills. To date, limited empirical research has examined the interaction between gamified PjBL and self-efficacy in the development of psychomotor-based technological skills among junior high school students, underscoring the need for further investigation in this area.

Based on this context, Informatics learning requires the development of technical software operation skills that extend beyond cognitive understanding alone. Although PjBL has been proven effective in enhancing learning outcomes and student engagement [20], [21], its implementation still faces challenges in fostering learners' confidence in completing software-based tasks. Conversely, gamification has been shown to increase learning motivation and self-efficacy [23], [24]. Nevertheless, only a limited number of studies have examined how the combined integration of PjBL, gamification, and learners' self-efficacy influences learning outcomes in Informatics education, particularly in relation to software operation skills.

This study seeks to explain the influence of gamified PjBL learning strategies and self-efficacy on software operation skills in Informatics. This research is expected to contribute to the development of learning strategies in Informatics, particularly in improving software operation skills in junior high school students. By examining the interaction between gamified PjBL and self-efficacy, this study aims to identify how these two variables strengthen learners' ability to use the software effectively.

2. LITERATURE REVIEW

Project-Based Learning

Project-Based Learning (PjBL) has developed as a learning model that shifts conventional teacher-centered instruction toward a learner-centered approach [25]. This model employs authentic projects as the primary learning medium to facilitate meaningful and contextual learning experiences, enabling students to construct knowledge through real-world tasks [16] actively, [20].

Gamification in Learning

Gamification refers to the application of game elements in non-game contexts to enhance learners' motivation, engagement, and overall learning experience [18], [9]. In educational settings, gamification is commonly defined as the integration of game mechanics such as points, badges, progressively increasing challenges, immediate feedback, and leaderboards to support and stimulate the learning process [19]. Self-Determination Theory (SDT) states that individual motivation is influenced by the fulfillment of three basic psychological needs: autonomy, competence, and relatedness [30].

Self-efficacy in Learning

Self-efficacy is a concept rooted in cognitive theory, originally developed by Albert Bandura, that emphasizes individuals' beliefs about their own capabilities [10]. In an educational context, self-efficacy refers to learners' subjective judgments regarding their capacity to successfully perform academic tasks at a certain level of performance [1]. More specifically, self-efficacy concerns the evaluation of one's ability to carry out particular tasks rather than a general assessment of overall self-worth or self-concept [12].

Software Operation in Learning

Previous research has identified several fundamental reasons why software mastery is essential for junior high school students. Software competence prepares learners to meet future workforce demands, where basic digital skills and the ability to operate various software applications are increasingly required [3]. In addition, software functions as a supportive learning tool across multiple subjects by enabling more interactive and comprehensive exploration of concepts in mathematics, science, and the arts [3]. Furthermore, software use contributes to the development of higher-order thinking skills, as it requires not only procedural compliance but also problem-solving, critical thinking, and creativity in practical application [3].

Psychological distress refers to a negative emotional condition characterized by symptoms of depression, anxiety, and stress that may disrupt an individual's daily functioning [14]. This condition can arise from several factors, including personality traits such as neuroticism, which increase vulnerability to emotional disturbances [4]. The use of maladaptive coping strategies, particularly avoidance behaviors, has also been shown to intensify psychological distress [15]. Additional contributing factors include physical health conditions [6], interpersonal relationship conflicts [17], economic circumstances [8], exposure to life stressors [9], experiences of discrimination and stigma [10], and limited access to adequate health care services [21].

Based on the theoretical review and findings from previous studies, this research proposes the hypothesis that there is a significant negative relationship between spiritual well-being and psychological distress among university students in Indonesia. The higher the students' spiritual well-being, the lower their psychological distress. In addition, this study also examines the contribution of the components of psychological distress, namely depression, anxiety, and stress, to spiritual well-being. Accordingly, an additional hypothesis is formulated that depression, anxiety, and stress each play a significant role in influencing psychological distress among university students in Indonesia.

Research Instruments

The research instruments included a self-efficacy questionnaire and a software operation skills assessment rubric. The self-efficacy questionnaire was developed based on Bandura's theory, which includes the dimensions of level, strength, and generality [27]. Modified with a five-level Likert scale; of the 30 statement items, 25 items were declared valid and classified into high and low self-efficacy categories based on criteria [28], [29]. Software operation skills were measured using a project assessment rubric that included 18 psychomotor indicators, all of which were deemed valid. Validity and reliability tests were conducted using IBM SPSS Statistics version 27, with Cronbach's Alpha results of 0.878 for the self-efficacy instrument and 0.871 for the skills instrument. Both instruments were deemed valid, reliable, and suitable for use in research.

3. METHOD

Research Design

This study employed a quasi-experimental Posttest-only with Control Group Design with a 2x2 factorial design. This was based on the condition that the researcher could not randomly assign experimental classes, meaning the researcher had to accept classes determined by the school. Therefore, this research design determined subjects based on class conditions. In this design, there were two groups of subjects: one receiving the treatment and the other serving as a control group. Both groups received a posttest [16]. This study aimed to explain the effects of gamified PjBL and learner self-efficacy on students' software operation skills in Informatics at the junior high school level, as well as the differences in self-efficacy on these skills. These differences were observed by comparing self-efficacy scores between the experimental class receiving PjBL and the gamified learning condition. This study sampled two classes with different learning styles: a class using gamified PjBL learning as the experimental class, and a class using non-gamified PjBL learning as the control class. The research design is shown below.

A	X	O_1
B		O_2

Description:

X : Learning Strategy

A : Experimental Group

B : Control Group

O1 : Experimental Class Posttest

O2 : Control Class Posttest

This research design was modified using a factorial design due to the presence of moderator variables. In this study, the independent variable (PjBL-Gamification) influences the dependent variable (software operating ability), and the moderator variable (Self-efficacy) moderates this relationship.

Research Subjects

A population is defined as a group of objects or subjects that possess specific characteristics determined by the researcher for observation and for drawing conclusions based on measurement results [12]. Based on this definition, the population in this study consisted of subjects within a particular group who met the research problem's criteria. Accordingly, the population of this research comprised first-grade students of SMP Negeri 1 Tana Tidung in the 2025/2026 academic year.

This study employed a non-probability sampling technique, which is a sampling method that does not provide equal opportunities for all population members to be selected as research samples [3]. Two groups were involved in this research: an experimental class and a control class. Class VIIIA, consisting of 24 students, served as the experimental group and received Project-Based Learning integrated with gamification, while Class VIIIB, also consisting of 24 students, functioned as the control group and received Project-Based Learning without gamification. Thus, the total number of participants involved in this study was 48 students.

4. RESULTS AND DISCUSSION

Normality Test

According to Montgomery [4], the normality test in two-way ANOVA is conducted using standardized residuals, which represent the difference between the observed values and those predicted by the statistical model. If the residuals are not normal, the normality assumption of two-way ANOVA is not met. The Shapiro-Wilk decision-making process uses significance values. A significance value > α at the 5% level indicates that the data used are normally distributed, as seen in Table 1.

Table 1. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Hasil	.072	48	.200*	.980	48	.571

The results of the normality test in Table 1 using the Shapiro-Wilk method show a significance value of 0.571, exceeding the α value (0.05). It can be concluded that the data are normally distributed, thus meeting the assumption of normality.

Homogeneity Test

This homogeneity test is conducted as a prerequisite to ensure that the basic assumptions of two-way ANOVA are met and the analysis results can be interpreted correctly. The homogeneity test is shown in Table 2. The basis for the decision is that if the significance value exceeds the α value (0.05), the data are homogeneous. The homogeneity test uses Levene's Test of Equality of Error Variances.

Table 2. Results of the Homogeneity Test

		Levene Statistic	**df1**	**df2**	**Sig.**
Learning outcomes	Based on Mean	1.745	3	44	.172
	Based on Median	1.199	3	44	.321
	Based on Median and with adjusted df	1.199	3	32.753	.325
	Based on trimmed mean	1.687	3	44	.183

a. Dependent variable: Hasil Belajar
b. Design: Intercept + Strategi + SE + Strategi * SE

Based on Table 2, the results of Levene's test show a mean of 1.745 with a significance level of 0.172, a median of 1.199 with a significance level of 0.321, a median and adjusted df of 1.199 with a significance level of 0.325, and a trimmed mean of 1.687

with a significance level of 0.183. Therefore, it can be concluded that the data variance is homogeneous. Therefore, the assumption of homogeneity of variance is met.

The normality and homogeneity tests have met the basic assumptions. Therefore, the hypothesis testing can be conducted.

Hypothesis Testing

The hypothesis testing in this study was conducted using a two-way ANOVA (Analysis of Variance) technique to identify the interaction effect between two independent variables: learning strategy (PjBL-gamification and PjBL-non-gamification) and self-efficacy level (high and low) on software operating ability. The analysis was conducted at the 5% significance level (α = 0.05) to test whether there are significant differences in software operating ability by learning strategy type and self-efficacy level, and whether there is an interaction between the two independent variables that jointly influence student learning outcomes. The research hypothesis is accepted or rejected as shown in the table.

Table 3. Hypothesis Test Results

Tests of Between-Subjects Effects

Dependent Variable: Hasil Belajar

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3221.021[a]	3	1073.674	21.413	.000
Intercept	165872.905	1	165872.905	3308.092	.000
Strategi	376.912	1	376.912	7.517	.009
SE	2468.111	1	2468.111	49.223	.000
Strategi * SE	181.704	1	181.704	3.624	.064
Error	2206.229	44	50.142		
Total	258598.000	48			
Corrected Total	5427.250	47			

a. R Squared = ,593 (Adjusted R Squared = ,566)

The results of the two-way ANOVA test in Table 3 show that the corrected model has a sig. <0.05 value of 0.000, an F value of 21.413, and an R-squared value of 0.593, explaining 59.3% of the variance in learning outcomes. Therefore, it can be concluded that the overall model is significant, meaning the combination of strategy, SE, and interaction significantly contributes to student learning outcomes. The following conclusions can be drawn based on the sig. values obtained in Table 3.

1. The effect of learning strategies on students' software operating skills. Based on the two-way ANOVA analysis data in Table 3 above, the F value is 7.517 with a sig. 0.009 <0.05. Therefore, H0 is rejected, and H1 is accepted. Therefore, it can be concluded that there are differences between students who use PjBL with gamification and those who use PjBL without gamification.
2. The effect of self-efficacy (SE) on students' software operating skills. Based on the two-way ANOVA analysis data in Table 3 above, the F-value was 49.223 with a significance value of 0.000 <0.05. Therefore, H0 is rejected, and H1 is accepted. Therefore, it can be

concluded that there is a difference in students' software operating skills between students with high and low self-efficacy.

3. The effect of the interaction between the PjBL-gamification learning strategy and self-efficacy on students' software operating skills. Based on the two-way ANOVA analysis data in Table 3 above, the F-value was 3.624 with a significance value of 0.064 <0.05. Therefore, H0 is accepted, and H1 is rejected. Therefore, it can be concluded that there is no interaction between the PjBL-gamification learning strategy and students' self-efficacy on students' software operating skills.

The relationship between the results of the hypothesis test between variables in this study can be seen in Figure 1 below:

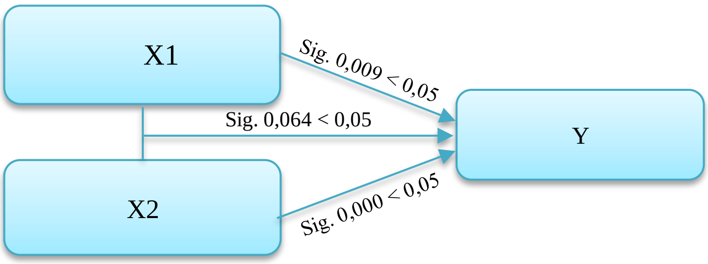

Figure 1. Relationship between PjBL, Gamification, Self-efficacy, and Software Operational Skills

The interaction plot between learning strategies and self-efficacy on learning outcomes is shown in Figure 2.

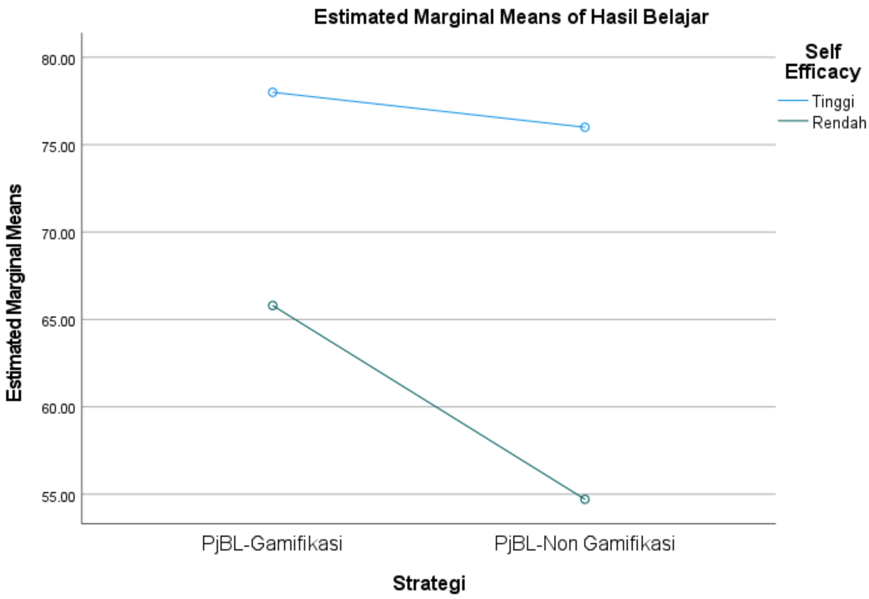

Figure 2. Interaction Plots

Figure 2 above shows a clear interaction pattern, although the interaction effect is not statistically significant (p = .064). Visually, the benefits of the PjBL-gamification strategy are significantly greater for learners with low self-efficacy than for learners with high self-efficacy. For the low self-efficacy group, implementing PjBL-gamification drastically improved learning outcomes (from approximately 55 to 66), while for the high self-efficacy group, the difference between the two strategies was relatively small (from approximately 76 to 78). This indicates that gamification serves as a highly effective counterbalance or motivator for learners who lack confidence in their learning abilities, helping them achieve significantly better results than when using learning strategies without game elements. Although statistical tests have not yet confirmed this interaction as strictly significant, this consistent and practically meaningful pattern deserves to be an important consideration in learning strategies, especially to support learners with low self-efficacy so they do not fall behind.

Discussion

The Effect of Gamified PjBL and Non-Gamified PjBL on Students' Software Operation Skills

The results of this study indicate that the Project-Based Learning (PjBL) strategy, when integrated with gamification, has a significant effect on improving students' software operation skills compared to PjBL without gamification. This finding is supported by the Two-Way ANOVA test, which yielded a p-value of $0.009 < 0.05$, leading to the rejection of H_0. Descriptively, the average score of the experimental group (Gamified PjBL) reached 75.46, while the control group (Non-Gamified PjBL) achieved an average score of only 69.79. These findings confirm that gamification elements such as points, badges, levels, and leaderboards play an important role in strengthening students' motivation, engagement, and persistence throughout the project-based learning process. Therefore, the significant difference in learning outcomes between the Gamified PjBL and Non-Gamified PjBL groups is due to the integration of gamification elements, which enhance students' motivation, active involvement, and perseverance in completing project tasks that require software operation skills.

These findings are supported by previous studies indicating that Gamified Project-Based Learning consistently enhances learning experiences, subjective interest, content knowledge, and learning outcomes, particularly in technical and digital skill contexts [18]. In addition, integrating gamification into Project-Based Learning has been shown to significantly improve student engagement, learning motivation, and academic achievement across diverse educational settings, reflecting the universal nature of motivational psychological principles [15]. In the context of Informatics learning, gamification elements transform technical tasks, such as using Microsoft Word, Excel, and PowerPoint, into enjoyable missions or challenges, thereby reducing perceived cognitive load and increasing a sense of achievement. As a result, students become more persistent in completing complex technical projects.

This approach is aligned with the principles of Self-Determination Theory (SDT), which emphasize that the fulfillment of basic psychological needs, autonomy, competence, and relatedness can be achieved through well-designed gamification structures [16]. Furthermore, gamification accelerates the trial-and-error learning process by providing immediate feedback. When students receive points or badges immediately after completing subtasks successfully, such as creating charts in Excel or inserting images in Word, they can evaluate their performance and correct mistakes without fear of failure. Real-time feedback in a gamified learning context has been shown not only to reinforce learning but also to gradually enhance learners' self-confidence [17]. In this study, students were frequently observed experimenting more freely, exploring new software features, and sharing technical tips with peers, indicating that a gamified learning environment supports active exploration.

However, the effectiveness of gamification depends heavily on its pedagogical design. When gamification focuses solely on extrinsic incentives, such as leaderboards without meaningful learning contexts, its impact may be short-term or even counterproductive for students with low self-efficacy [8]. In this study, gamification elements were systematically integrated at every stage of the Project-Based Learning process, from planning and implementation to presentation, ensuring rewards were tied to the development of authentic skills rather than mere participation. This design ensures that gamification functions not merely as a decorative element but as a pedagogically grounded strategy grounded in contemporary learning theory. The learning outcomes achieved through the application of gamification elements are presented in Appendix 13.

Practically, Informatics learning at the junior high school level can be developed by adopting the Gamified PjBL model as an innovative alternative to address low levels of software mastery. As identified in the research background, where 67–79% of students had not met the Minimum Learning Achievement Criteria (KKTP), this strategy offers a contextual, enjoyable, collaborative, and effective solution for building digital competence. This model is also aligned with the spirit of the *Merdeka Curriculum*, which promotes meaningful, differentiated, and project-based learning.

The Effect of Self-Efficacy on Students' Software Operation Skills

The findings of this study demonstrate that self-efficacy has a highly significant effect on students' software operation skills ($p < 0.001$), thereby rejecting H_0. Students with high self-efficacy achieved an average score of 77.06, far exceeding those with low self-efficacy, who scored an average of 59.33. This substantial difference indicates that self-confidence is not merely a supporting psychological factor, but a primary predictor of success in technical skill development. Students with high self-efficacy tend to be more proactive, less likely to give up when encountering errors, and more willing to explore software features independently. Thus, the significant influence of self-efficacy on software operation skills stems from students' confidence directly affecting their persistence, willingness to experiment, and problem-solving strategies when facing technical tasks.

These findings are consistent with previous research showing that increased self-efficacy is strongly associated with improved practical skills, particularly when learning environments provide immediate feedback and opportunities for gradual mastery [21]. This perspective aligns with Bandura's theory, which emphasizes mastery experiences as the primary source of self-efficacy development [10]. In digital learning contexts, students with high self-efficacy tend to perceive technical errors such as incorrect Excel formulas or formatting issues in documents as manageable challenges rather than threats to their competence. Similarly, studies have demonstrated that learners with high technological self-efficacy exhibit stronger achievement motivation and more adaptive learning strategies in project-based learning environments, especially in rural contexts with limited infrastructure [5]. This finding is highly relevant to the present study, which further highlights the critical psychological role of self-efficacy in determining technical performance, even under constrained computer facilities.

The results also align with research emphasizing the importance of peer modeling in digital learning environments [11]. This helps explain observations noted in the research background: students with lower ability levels tended to show hesitation and a heavy reliance on teacher assistance. Low self-efficacy often leads to heightened technical anxiety, which inhibits exploration and independent practice. Prior studies have indicated that high self-efficacy plays a significant role in reducing digital anxiety, thereby making learners more receptive to technology-based instruction [22]. Moreover, evidence suggests that students with strong self-efficacy consistently achieve better learning outcomes despite the complexity of instructional materials and technical demands [13]. In this study, learners with low self-efficacy were more likely to withdraw quickly from problem-solving efforts and seek help before attempting alternative solutions independently.

Therefore, efforts to enhance digital competence should not be limited to providing facilities or technical training, but should also include psychological interventions to strengthen self-efficacy. Informatics teachers need to design learning activities that provide gradual success experiences, deliver positive feedback, and create a safe learning environment free of negative judgment. Such an approach will help students, especially those who initially lack confidence, develop the belief that they can master technology step by step.

The Interaction between Gamified PjBL and Self-Efficacy on Students' Software Operation Skills

The results of the study indicate that there is no interaction between the gamified PjBL learning strategy and students' self-efficacy levels on software operation skills ($p = 0.064 > 0.05$); therefore, H_1 is rejected. Although the statistical data are insufficient to confirm a scientifically significant interaction, the interaction graph in Figure 2 clearly illustrates how the two variables, learning strategy and self-efficacy, jointly influence learning outcomes.

Table 4. Mean Interaction between Learning Strategy and Self-Efficacy

Strategi * Self Efficacy Dependent Variable: Learning outcomes Strategy	Self Efficacy	Mean	Std. Error	95% Confidence Interval Lower Bound	 Upper Bound
PjBL- Gamification	High	78.000	1.625	74.726	81.274
	Low	65.800	3.167	59.418	72.182
PjBL-Non-Gamification	High	76.000	1.717	72.539	79.461
	Low	54.714	2.676	49.320	60.108

Based on the table above, the mean score for the Gamified PjBL strategy with high self-efficacy was 78.00, while the Gamified PjBL strategy with low self-efficacy achieved a mean score of 65.80. Meanwhile, the Non-Gamified PjBL strategy with high self-efficacy obtained a mean score of 76.00, and the Non-Gamified PjBL strategy with low self-efficacy recorded a mean score of 54.71. When examining the mean values across groups, students with low self-efficacy showed an increase from 54.71 under the Non-Gamified PjBL strategy to 65.80 under the Gamified PjBL strategy, representing an improvement of 11.09 points. In contrast, among students with high self-efficacy, the mean score increased from 76.00 to 78.00, reflecting an improvement of only 2 points. These results indicate that although the interaction was not statistically significant, gamification provides the greatest practical benefit for students with low self-efficacy. Gamification appears to compensate for deficits in motivation and self-confidence by providing structure, rapid feedback, and competitive elements that enhance engagement.

These findings are consistent with studies suggesting that integrating Project-Based Learning, gamification, and adaptive feedback systems can effectively strengthen students' self-efficacy [14]. Gamification has been emphasized as a "bridge" that enables learners with low confidence to build competence through progressive achievements, external validation, and constructive social comparison [20]. Similarly, previous research has reported that gamification elements, particularly leaderboards and badges, enhance self-efficacy by providing positive reinforcement and meaningful social comparison opportunities [24]. Furthermore, systematic reviews have indicated that Gamified Project-Based Learning is most effective when its design focuses on strengthening perceived competence, a core component of Self-Determination Theory [18]. Within project-based learning contexts, gamification structures such as levels and badges offer tangible indicators of learning progress, a feature especially beneficial for students with low self-efficacy, who often doubt their abilities. In this study, learners with low self-efficacy responded positively to the progressive gamification structure, as each level or badge earned provided external affirmation that gradually fostered internal confidence.

The lack of statistical significance in the interaction effect may be due to unequal group sizes, particularly the relatively small proportion of students with low self-efficacy, which reduced the analysis's statistical power. This condition aligns with the principles of Universal Design for Learning (UDL), which emphasize the use of diverse instructional strategies to accommodate heterogeneous learner characteristics within a single classroom [19]. The lack of statistical significance is most plausibly attributable to sample limitations, especially the limited number of students classified as having low self-efficacy, which accounted for only 12 of the 48 participants. Previous methodological literature has emphasized that statistical power in a two-way ANOVA is strongly affected by group size, and increasing the number of participants in smaller groups can substantially enhance the likelihood of detecting interaction effects [23]. Nevertheless, the practical significance of this pattern should not be disregarded, as it underscores the potential of gamification as an effective remedial instructional strategy for supporting learners with lower self-efficacy.

Thus, although the interaction effect was not statistically significant, these findings still provide important practical implications, indicating that Gamified PjBL has the potential to support students with low self-efficacy. Therefore, this strategy can be implemented in heterogeneous classroom contexts, while further studies with larger sample sizes are needed to examine the interaction effect more comprehensively.

Research Contributions

This study makes an important contribution to Informatics education by demonstrating that implementing Project-Based Learning (PjBL) integrated with gamification significantly improves junior high school students’ software operation skills compared to PjBL without gamification. As evidenced in the results and discussion, this improvement is reflected in increased student engagement and motivation, as well as consistent practice throughout the project. The findings also reinforce the role of self-efficacy as a key factor influencing students’ success in completing software-based technical tasks, as students with high self-efficacy were found to be more independent, persistent, and quicker to master application features.

Furthermore, the interaction between the PjBL Gamification strategy and students’ self-efficacy levels provides new insights that the effectiveness of Informatics learning methods is determined not only by pedagogical approaches but also by students’ psychological conditions. In practice, this research produces a learning model, implementation strategies for gamification, and software skill assessment instruments that Informatics teachers can directly apply to enhance technological literacy in line with the demands of the *Merdeka Curriculum*. The study also offers a theoretical contribution by strengthening the role of constructivist theory and self-efficacy in the context of digital psychomotor skills, thereby serving as a reference for curriculum development and future research.

5. CONCLUSION

This study indicates that the development of students’ software operation skills is shaped not only by instructional strategies but also by learners’ psychological readiness in perceiving their own abilities. Project-oriented learning enriched with gamification elements fosters a more structured, engaging, and supportive learning environment that encourages active participation in digital skill development. At the same time, students’ self-beliefs consistently influence their persistence, independence, and effectiveness in completing technology-based tasks that require continuous practice and problem-solving. The findings imply that junior high school Informatics instruction should be designed holistically by integrating pedagogical innovation with affective development. Gamified Project-Based Learning can serve as an inclusive instructional approach that accommodates diverse learner characteristics by offering clear learning goals, progressive challenges, and continuous feedback that sustain motivation. In parallel, strengthening self-efficacy should be considered an essential component of learning design, as students’ confidence functions as a foundational driver in building and maintaining digital competence.

Despite these contributions, the study is bound by its quasi-experimental design, a relatively limited sample size, and its focus on a single school context. The scope of the investigation was also confined to specific office software applications within a restricted instructional timeframe. These constraints limit the extent to which the findings can be generalized to broader educational settings, different learner populations, or other forms of digital technology. Future research is encouraged to involve more diverse samples, longer intervention periods, and a wider range of digital skills, including emerging and advanced technologies. Subsequent studies may also explore adaptive gamification designs tailored to individual learner profiles. Overall, this research contributes to the general public by emphasizing that improving digital literacy requires more than technological access; it demands well-designed learning strategies that cultivate motivation, self-confidence, and equitable development of digital skills among students.

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