

The Influence of Game-Based Learning Media on Students' Motivation and Understanding of Programming

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Article Info	Abstract
Article history: Received: April 25, 2025 Accepted: June 2, 2025 Published: June 8, 2025 Keywords: Algorithms Gamification Learning motivation Merdeka Curriculum Programming This article is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License. © 2025 Journal of Mathematics, Science, and Computer Education	This study examines the impact of the SoloLearn online learning platform on students' motivation and understanding of programming in a high school context. The research instruments included a programming comprehension test (pre-test and post-test), a Likert-scale-based learning motivation questionnaire, and an observation sheet for student engagement. All instruments were validated by subject matter experts and tested for reliability, with the motivation questionnaire yielding a Cronbach's Alpha value of 0.927, indicating high internal consistency. The study employed a quasi-experimental design with a pretest-posttest approach involving experimental and control groups. The participants were 11th-grade students selected through purposive sampling. The findings revealed that the experimental group, which used SoloLearn, demonstrated significantly greater motivation and comprehension improvements than the control group. An independent samples t-test indicated a statistically significant difference in post-test scores between the groups, with a p-value of 0.000 and a mean difference of 23.78. These results suggest that SoloLearn is an effective educational tool for enhancing programming instruction and aligns well with the principles of the Merdeka Curriculum.
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INTRODUCTION

Amidst globalization and the rapid pace of technological advancement, integrating technology into education has become an essential strategy to meet the needs of 21st-century learning (Farisi, 2016; Isti'ana, 2024; Yilmaz, 2021). In programming education, a recurring problem is low student engagement and difficulty understanding abstract concepts such as algorithms and logic structures (Kresnadi et al., 2022; Medeiros et al., 2018; Qian & Lehman, 2017). Many students report boredom and confusion when dealing with traditional programming instruction methods that rely heavily on textbooks and passive lectures (Hung et al., 2020). These problems contribute to low motivation and learning outcomes in programming subjects. Although various digital tools have been introduced, a gap exists in effectively combining student engagement with deep conceptual understanding. Most existing platforms emphasize gamification or instructional delivery but rarely integrate both elements in a structured learning experience tailored to high school students.

This study addresses that gap by investigating the integration of the SoloLearn platform, which provides a gamified, project-based, and community-driven learning environment.

Unlike general programming tools or passive e-learning platforms, SoloLearn is interactive and mobile-based, making it highly accessible and aligned with students' digital habits. Furthermore, while prior studies have discussed the advantages of gamification in learning (Amalia et al., 2023a; Javadikasgari et al., 2018), few have empirically measured the impact of SoloLearn on both motivation and programming comprehension in the specific context of Indonesian high school students under the Merdeka Curriculum. By filling this research gap, the study aims to provide empirical evidence for the effectiveness of using mobile gamified learning platforms to enhance programming education at the high school level.

Technology-based learning has been proven to enhance a more interactive and contextual learning experience. Research by Abiyyu et al. (2024) suggests that digital learning platforms enhance students' understanding of programming concepts by promoting exploratory learning and hands-on experience (Abiyyu & Efendi, 2024). However, a major challenge in implementing technology in education is ensuring that students are interested in using the platform and gaining a deep understanding of the concepts being taught (Putri, 2019). Therefore, a learning method is needed to boost learning motivation and strengthen students' comprehension of the subject matter (Krathwohl et al., 1964).

In line with this, the Merdeka Curriculum at the senior high school level provides more flexibility in developing adaptive and responsive learning models in accordance with technological advancements (Bahroni & Zulkarnain, 2024). One method that can be implemented is game-based learning (GBL), which integrates game elements into the learning process (Firdianika et al., 2023). This instructional model has effectively enhanced student engagement and motivation when dealing with abstract concepts (Maulana, 2025). SoloLearn, a technology-driven application developed to support programming comprehension through interactive tasks and project-based learning, is an example of a platform that aligns with this approach. In this context, full support from all relevant stakeholders—including schools, teachers, and the government—is necessary to ensure that technology integration in programming education at the senior high school level runs optimally (Amalia et al., 2023b; Nouri et al., 2019). By integrating findings from these studies, the Merdeka Curriculum at the senior high school level can effectively improve students' understanding of basic programming and prepare them to meet the increasing technological demands of the job market.

SoloLearn, as an online learning platform specifically focused on programming, offers various features that can support the learning process. Utilizing platforms like SoloLearn in an educational setting is an effective innovation for enhancing students' understanding of basic programming (Putra et al., 2022). The following section outlines several features of SoloLearn and how their implementation can improve basic programming education. SoloLearn provides features such as quizzes, coding challenges, and a learning community that enables user interaction, thus enhancing a more enjoyable and effective learning experience. (Mandias et al., 2017).

While numerous studies have underscored the advantages of GBL in various educational settings, research specifically focused on the impact of the SoloLearn platform on enhancing students' motivation and programming comprehension remains scarce. Given this gap, the present study explores how the SoloLearn platform influences student motivation and understanding within an Algorithm and Programming course (Anitha & Kavitha, 2020; Hunter et al., 2013). By employing a one-group pretest-posttest experimental design, this study aims to generate empirical data that will provide insights into SoloLearn's effectiveness as a learning tool. Furthermore, it offers actionable recommendations for educators on integrating this technology into programming instruction to improve student engagement and learning outcomes.

METHODS

This study employed a quantitative approach using a quasi-experimental design with a nonequivalent control group. The participants were 68 eleventh-grade students from a public senior high school, divided equally into experimental and control groups. The experimental group received learning through the SoloLearn platform, while the control group followed conventional teaching methods. Data were collected using three main instruments: (1) a pre-test and post-test to measure students' understanding of programming concepts, (2) a motivation questionnaire to assess students' learning motivation, and (3) observation sheets to document student engagement during lessons. Three experts reviewed the instruments to ensure content validity. The motivation questionnaire showed high reliability with a Cronbach's alpha score 0.927. Sixty-eight students participated in this research and were allocated to either an experimental class (n=34) or a control class (n=34). Purposive sampling was utilized to select participants based on predefined criteria, specifically their academic history and the availability of suitable devices for SoloLearn access. The experimental group was exposed to a treatment involving SoloLearn-integrated learning. In the control group, students received programming instruction through conventional classroom methods without the integration of digital tools. The nonequivalent control group design underpinning this study is depicted in Table 1.

Table 1 Nonequivalent control group design

Group	Pre-test	Treatment (X)	Post-test
Experimental	A1	X	A2
Control	A3	-	A4

Information:

- A1 : Pretest on programming & motivation
- A2 : Posttest on programming & motivation
- A3 : Pretest on programming & motivation
- A4 : Posttest on programming & motivation
- X : Learning with SoloLearn

This research design allows for comparing students' learning outcomes between the experimental and control groups, helping to determine the impact of using the SoloLearn platform in programming education. The SoloLearn learning intervention was implemented over four weeks with eight sessions, each lasting 90 minutes. The implementation of SoloLearn in learning was carried out in three main stages. The treatment flow is shown in Figure 1.

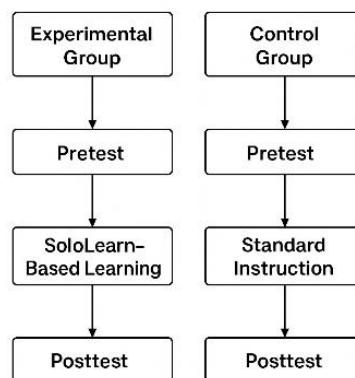


Figure 1 Treatment flow

The research instruments included pre-test and post-test assessments, a learning motivation questionnaire, and an observation sheet for student activities. The pre-test and post-test were used to measure students' understanding before and after the intervention, while the Likert-scale-based learning motivation questionnaire assessed changes in students' motivation toward programming after using SoloLearn. Additionally, observation sheets were used to record student engagement and interactions during the learning process. All research instruments were tested for validity to ensure each measurement tool accurately assessed the intended variables. Content validity testing was conducted using the expert judgment method, in which three experts in educational technology and programming instruction evaluated the instruments based on their alignment with research objectives, clarity of question items, and relevance to the variables of student motivation and understanding. Feedback from experts was used to refine the instruments before they were applied in field trials.

RESULTS AND DISCUSSION

The data consisted of students' pre-test and post-test scores from both the experimental and control groups. The following are the results of SPSS 26 data processing on pre-test scores are listed in Table 2.

Table 2 Pre-test and post-test value data processing results

Statistics	Pretest		Posstest	
	Experiment	Control	Experiment	Control
Mean	74.5588	48.39	85.0882	57.86
Maximum	88.00	85	96	90
Minimum	45	45	60	50
Standart Deviasi	10.68897	11.26792	9.00292	8.71908

Table 2 shows that the pre-test and post-test data analysis revealed significant differences in score improvement between the experimental and control groups. Before the intervention, the experimental group had a higher average pre-test score (74.56) than the control group (48.39). After the treatment, the experimental group's average score increased to 85.09, while the control group also showed improvement, though their average score only reached 57.86. Additionally, analysis of the maximum and minimum scores indicates that the highest score in the experimental group rose from 88 in the pre-test to 96 in the post-test, whereas the top score in the control group increased more modestly from 85 to 90. These findings suggest that the intervention in the experimental group was more effective in improving learning outcomes. From the perspective of standard deviation, the experimental group's variability decreased from 10.69 in the pre-test to 9.00 in the post-test, signifying that the improvements in understanding were more uniformly distributed. In contrast, the control group's standard deviation remained relatively high (11.27 in the pre-test and 8.72 in the post-test), indicating that the scores in the control group remained broad. Overall, these results indicate that the treatment given to the experimental group positively improved participants' understanding, as reflected in the more significant increase in average scores compared to the control group and a more evenly distributed score variation.

Assumption Testing for Data Analysis

Statistical analysis for this study was performed utilizing established formulas and the Statistical Product and Service Solution (SPSS) software, version 26. This process encompassed data normality and homogeneity assessments alongside hypothesis testing, as detailed below. Regarding normality assessment, the objective was to ascertain whether the data from each group exhibited a normal distribution. The data subjected to this analysis

included the pre-test and post-test scores obtained from both the control and experimental groups. Given that the sample size for each group was below 30, the Shapiro-Wilk test was employed to evaluate normality. The decision criterion for this test stipulated that a significance level (p-value) of 0.05 or greater indicated that the data could be considered normally distributed. Conversely, a significance level below 0.05 suggested a deviation from a normal distribution. The results of the normality test are shown in Table 3.

Table 3 Normality test results

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest-Exp	0.136	34	0.114	0.893	34	0.072
Posttest-Exp	0.173	34	0.052	0.905	34	0.065
Pretest-Control	0.139	34	0.093	0.938	34	0.054
Posttest-Control	0.133	34	0.131	0.940	34	0.063

The findings from the normality tests, as detailed in Table 3 and conducted using both the Kolmogorov-Smirnov and Shapiro-Wilk methods, revealed varying significance levels for the pre-test and post-test data across the experimental and control groups. Specifically, the Kolmogorov-Smirnov test yielded the following significance values: 0.114 for the experimental group's pre-test, 0.052 for their post-test, 0.093 for the control group's pre-test, and 0.131 for their post-test. When evaluated against a significance threshold of $\alpha = 0.05$, all data sets exhibited values exceeding this criterion, except the experimental group's post-test (0.052), which was marginally above the cutoff. Similarly, the Shapiro-Wilk test demonstrated significance values of 0.072 for the experimental pre-test, 0.065 for the experimental post-test, 0.054 for the control pre-test, and 0.063 for the control post-test. Given that all these values were greater than 0.05, the data were deemed to satisfy the normality assumption. In summary, the normality assessments generally indicated a normal data distribution, although the experimental group's post-test in the Kolmogorov-Smirnov test approached the significance level. With the normality assumption met, parametric statistical analyses, such as independent and paired t-tests, were deemed appropriate for further study.

Having confirmed the data's normality, a Pearson product-moment correlation analysis was conducted. This specific correlational method was chosen because the data met the assumption of a normal distribution. As Sugiyono (2016) outlined, interpreting the resulting correlation coefficient involves determining the strength of the association (Sugiyono, 2016). The present study yielded a correlation coefficient 0.793, indicating a robust relationship. This conclusion is drawn from its classification within the strong correlation range and its statistical significance below the 0.05 threshold. The correlation results of SoloLearn and motivation are shown in Table 4.

Table 4 Correlations SoloLearn and motivation

		SoloLearn	Motivation
SoloLearn	Pearson Correlation	1	0.793**
	Sig. (2-tailed)		0.000
	N	33	33
Motivation	Pearson Correlation	0.793**	
	Sig. (2-tailed)	0.000	
	N	33	

The Pearson correlation test results (Table 4) indicated a strong and statistically significant link between SoloLearn use and student motivation, with a correlation coefficient (r) of 0.793, signifying a substantial positive correlation. This suggests that increased and more frequent usage of SoloLearn is linked to higher motivation levels in

programming education. Additionally, the significance value (p) was 0.000, well below the 0.01 threshold, confirming that the relationship between SoloLearn usage and student motivation is highly significant at the 99% confidence level.

The significant improvement in the experimental group's learning outcomes can be attributed to the interactive and gamified nature of the SoloLearn platform. Unlike conventional instruction, SoloLearn offers immediate feedback, code practice modules, and motivational elements such as badges and leaderboards, which promote active engagement and sustained interest (Naufal Rahmandita et al., 2017; Putra et al., 2022). These features are aligned with the principles of GBL, which emphasize that students learn more effectively when the learning process is enjoyable and goal-oriented (Djatkika & Praherdhiono, 2024). As a result, the null hypothesis (H_0), which posits no relationship between SoloLearn use and student motivation, is rejected, while the alternative hypothesis (H_1), which asserts a significant relationship, is supported.

Hypothesis test:

The findings of this study, obtained through a quasi-experimental design with a nonequivalent control group, demonstrate that using SoloLearn as an instructional intervention significantly improved students' understanding and motivation in programming. Applying a pretest-posttest approach made it possible to compare the learning gains between students who experienced gamified, project-based learning and those who received traditional instruction. The results of statistical analyses, including paired and independent t-tests and Pearson correlation, provide strong empirical support for the effectiveness of SoloLearn in enhancing student outcomes. This test is conducted to determine whether the hypothesis is accepted or rejected. The criteria for making decisions on this independent sample t-test are that if the significance value (2-tailed) is <0.05 , it is rejected and accepted. If the significance value (2-tailed) is > 0.05 , it is accepted and rejected. The results of the independent sample t-test are shown in Table 5.

Table 5 Independent sample t-test

		Levene's Test for Equality of Variance		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2- tailed)	Mean Difference	Std. Error Difference
Programming Comperhension	Equal variances assumed	0.489	0.487	22.49	70	0.000	23.78333	1.057
	Equal variances not assumed			22.49	69.5	0.000	23.78333	1.057

Results of Independent Sample T-Test

The results of the independent sample t-test analysis show a significant difference in programming comprehension between the experimental group (using SoloLearn) and the control group (conventional instruction), with a p-value of $0.000 < 0.05$ and a mean difference of 23.78. This suggests that integrating SoloLearn significantly enhances students' understanding of programming concepts. The interactive features, gamification elements, and real-time coding feedback in SoloLearn likely foster a more engaging and effective learning environment than traditional teaching methods.

These findings are consistent with prior studies highlighting the advantages of mobile and gamified learning platforms in computer science education. For instance, Vakaliuk et

al. (2023) demonstrated that using mobile-based programming applications significantly improves students' learning outcomes and engagement ([Vakaliuk et al., 2023](#)). Similarly, [Putra et al. \(2022\)](#) found that gamification-based collaborative learning features within SoloLearn effectively increase students' motivation and facilitate deeper conceptual understanding. The results also support the self-determination theory ([Ahlqvist, 2021.](#)), which posits that learning environments that promote autonomy, competence, and relatedness tend to enhance intrinsic motivation, leading to better academic achievement. Therefore, SoloLearn can be considered not only a supplementary digital tool but also a transformative instructional approach that aligns with the demands of 21st-century education and the goals of the Merdeka Curriculum.

Correlation Analysis and Motivation Factors

Additionally, the Pearson correlation test results reveal a strong and significant correlation between using SoloLearn and students' motivation in learning programming ($r = 0.793$, $p < 0.001$). This indicates that higher engagement with SoloLearn is associated with higher student motivation. These findings support previous research by Inie (2023), which concluded that gamification-based and interactive learning technologies enhance students' motivation by providing a more engaging, adaptive, and personalized learning experience. Furthermore, a study by Wibisono (2024) found that mobile-based programming applications such as SoloLearn provide a flexible and hands-on learning experience, significantly enhancing student motivation and engagement in understanding programming concepts. Increased motivation in learning is also linked to better academic performance, as supported by Vakaliuk (2023) in the framework of Self-Determination Theory ([Ahlqvist, 2021](#)). This theory emphasizes that autonomy in learning plays a crucial role in fostering intrinsic motivation, ultimately leading to better learning outcomes.

Implications and Future Research Directions

The findings of this study reinforce the evidence that integrating technology in programming education not only enhances conceptual understanding but also contributes to increased student motivation. These results imply that technology-based learning methods, such as the implementation of SoloLearn, can be an effective strategy in supporting programming education, particularly in improving conceptual comprehension and learning motivation. Future research should explore other factors that may influence the effectiveness of technology-based learning in programming education, such as students' learning styles, cognitive factors, and social interactions in online learning environments.

CONCLUSION

Based on the results of this study, integrating the SoloLearn platform into programming instruction has a significant and positive effect on students' learning outcomes. The experimental group, which was taught using SoloLearn, showed greater improvement in programming comprehension and motivation than the control group receiving conventional instruction. This conclusion is supported by statistical evidence from the independent sample t-test, which revealed a significant difference in post-test scores ($p = 0.000$), with a mean difference of 23.78 points. The effectiveness of SoloLearn can be attributed to its interactive, gamified, and self-paced learning environment, which promotes student engagement and active learning. These features align with current pedagogical approaches, such as game-based learning and self-determination theory, which emphasize the importance of motivation, autonomy, and contextual learning in improving academic performance. Therefore, this study recommends that educators and policymakers consider integrating mobile and gamification-based platforms like SoloLearn into programming

curricula, particularly in the context of the Merdeka Curriculum, to enhance students' 21st-century skills. Future research may explore the long-term impact of such platforms, variations across different learning styles, and their application in other technical subjects.

CONFLICTS OF INTEREST

There is no conflict of interest during this research.

AUTHOR CONTRIBUTIONS STATEMENT

The first authors primarily conducted the research and conceptualized the research design developed the theoretical framework, formulated the research questions, and collected quantitative data through in-depth interviews and observations. The first author also conducted thematic analysis, coding, and interpretation of findings, as well as the initial drafting of the manuscript.

The second and third authors contributed to refining the methodology, provided critical feedback on data interpretation, and were involved in the review process, editing the manuscript, providing supervision and academic guidance throughout the research process, and ensuring the validity and coherence of the final version. All authors have read and approved the final manuscript.

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