

The Effect of Project-Based Learning on Students' Self-Regulated Learning

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Abstract

This study examines the effect of Project-Based Learning (PjBL) implementation on students' self-regulated Learning in mathematics learning. This study involved two classes of VIII-grade students at SMP Negeri 5 Bandung using a quasi-experimental design with a Nonequivalent Pretest-Posttest Control Group Design. One class acted as an experimental class applying PjBL, while the control class used conventional learning with a scientific approach. Data were collected through a pretest and posttest and an attitude scale questionnaire, then processed using Mann-Whitney U nonparametric statistical test. According to the data, the average N-gain of self-regulated learning in the PjBL class was 0.23, significantly higher than the conventional class's 0.16. In conclusion, PjBL is more effective in increasing students' self-regulated learning than conventional learning methods. Based on these findings, it is recommended that PjBL can be implemented in the curriculum to support the development of students' self-regulated learning.

Keywords: math, project-based learning, self-regulated learning

Introduction

Self-Regulated Learning (SRL) refers to individuals' ability to control themselves in achieving learning goals. SRL encompasses three main stages: planning, execution, and evaluation, all of which aim to achieve learning goals independently (Zimmerman, 2008). In this context, students are considered independent if they can complete the learning process without relying on others (Saragih, 2018). Regulated Learning significantly impacts academic success, as students who can manage their learning tend to better understand concepts, which in turn leads to more optimal learning outcomes. This is because students do not only rely on external instructions but can also overcome difficulties independently (Putra, 2016).

The importance of SRL for students cannot be overlooked, given its significant impact on learning outcomes and personal development. Saragih's (2018) research shows that SRL positively influences students' learning outcomes, whereas students with high SRL tend to have better learning results. High SRL improves academic performance and prepares students to face real-world challenges. On the other hand, students with low SRL tend to be less confident, irresponsible, and struggle with problem-solving. They are more dependent on others and less able to make decisions independently (Saragih, 2018). They also struggle with time management, have a limited understanding of effective learning strategies, and tend to plagiarize others' work while avoiding responsibility (Supanti & Hartutik, 2018).

Based on these findings, it can be concluded that having good SRL is crucial for students to achieve optimal learning outcomes and overcome challenges in learning.

However, despite its importance, the level of SRL among students in Indonesia is still relatively low. Research by Laksana and Hadijah (2019) shows that students' SRL scores fall into the "adequate" category. In addition, another study found that the average SRL in mathematics learning is in the "low" category in indicators such as setting learning goals, viewing difficulties as challenges, seeking relevant resources, establishing learning strategies, and evaluating learning outcomes (Wulandari, 2022).

One factor contributing to the low level of SRL is the conventional teaching model. In conventional learning, students tend to be passive receivers of information rather than active participants who set goals, plan strategies, and self-evaluate (Zaida et al., 2024). Such learning limits students' opportunities to manage their learning process, such as setting goals, monitoring progress, and reflecting on learning outcomes.

Theoretically, the Project-Based Learning (PjBL) model aligns with the principles of SRL. PjBL is student-centered, provides opportunities for exploring and developing academic and cognitive skills, and prepares students to contribute to solving real-world problems in society (Insyasiska et al., 2017). This model requires active student involvement in the learning process, which can enhance their SRL. Putra's (2016) research shows that PjBL is more effective in improving students' SRL. This is supported by Tran & Tran (2020), who state that PjBL is an excellent method for initiating SRL-based learning. Furthermore, other studies also show that implementing PjBL improves SRL and enhances students' creativity and critical thinking skills (Dwiputri & Pujiastuti, 2022; Kuncahyono & Zutiasari, 2022).

Therefore, this study aims to explore the impact of PjBL on changes in students' SRL. The PjBL indicators in this study were developed based on Zimmerman's (2008) framework, which includes the forethought dimension with indicators such as task analysis by setting goals, task analysis by planning strategies, self-efficacy beliefs, and self-efficacy beliefs related to task orientation, the performance dimension with indicators such as self-control in self-instruction, effort and focus on tasks, self-control in task-solving strategies, adequate observation of metacognitive monitoring, adequate observation of self-notes, and adequate observation of self-experimentation; and the self-reflection dimension with indicators such as self-consideration in self-evaluation, self-consideration in causal attribution, self-reaction

in self-satisfaction (reward), self-reaction in self-satisfaction (punishment), and self-reaction in adaptive/defensive behaviors.

Method

This research is a type of quasi-experimental study involving two class groups. It aims to examine the effect of Project-Based Learning (PjBL) on changes in students' SRL. Both class groups received a scientific approach; however, the distinguishing factor is that in the experimental class, students also received instruction through the PjBL approach, while in the control class, students only received conventional instruction using the scientific approach.

The population in this study consisted of eighth-grade students in the 2023/2024 academic year at SMP Negeri 5 Bandung, with the topic taught being statistics. Two classes were randomly selected from the available courses as samples. Then, a random draw was conducted to determine the treatment assigned to each class. Students in the experimental and control classes were divided into three groups based on Initial Mathematical Ability (IMA): high, medium, and low IMA groups. This grouping was based on Daily Assessment (DA) scores from prerequisite material in the odd semester, which had been confirmed with the mathematics teacher of the selected classes. The research design was quasi-experimental with the Nonequivalent Pretest-Posttest Control Group Design model.

Table 1. The Nonequivalent Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experiment	O	X	O
control	O	-	O

Source: (Lestari, & Yudhanegara, 2018)

The Initial Mathematical Ability (IMA) scores of the population classes were tested for normality and homogeneity to determine the sample classes for this study. The IMA data of the population class students were obtained from the results of daily assessments on the statistics material. Data processing was done using statistical tests on the pretest and posttest results and attitude scale questionnaires from the experimental and control classes. The N-gain data were processed using IBM SPSS 27 for Windows. The N-gain or normalized gain was obtained by comparing the difference between the posttest and pretest scores to the difference in the Ideal Maximum Score (IMS). The N-gain value was calculated using the following formula.

$$N - \text{gain} = \frac{\text{skor posttest} - \text{skor pretest}}{\text{IMS} - \text{skor pretest}}$$

The calculation results of the N-Gain were then interpreted using the following classification:

Table 2. N-Gain Classification

Magnitude of N-Gain (g)	Classification
$g > 0,70$	High
$0,30 < g \leq 0,70$	Medium
$g \leq 0,30$	Low

Results and Discussion

Descriptive Analysis of Changes in Students' Self-Regulated Learning

The pre-response was used to measure students' self-regulated learning before the treatment, and the post-response was used to measure students' self-regulated learning after receiving the treatment. The pre-and post-response data were used to calculate the self-regulated learning scale's normalized gain (N-gain). The average N-gain obtained reflects the changes in students' self-regulated learning. The descriptive statistics of the changes in students' self-regulated learning in both classes are presented in Table 3.

Table 3. Descriptive Statistics of Self-Regulated Learning Scale

Data obtained		Project Based Learning	Conventional Learning
N		34	34
Pre-response	\bar{X}	67.51	64.39
	s	15.05	13.99
Post-response	\bar{X}	73.78	70.08
	s	13.92	13.71
N-gain	\bar{X}	0.23	0.16
	s	0.16	0.16
Ideal Maximum Score = 100			

Table 3 shows that the average pre-response score in the project-based learning class and the conventional class differs, namely 67.51 for the project-based learning class and 64.39 for the conventional class. Likewise, in terms of standard deviation, both classes have

different standard deviations, with 15.05 for the project-based learning class and 13.99 for the conventional class. This indicates that the pre-response scores in the project-based learning class were more varied than those in the conventional class. In addition, the average post-response scores also show that the project-based learning class achieved higher results than the conventional class. The average post-response score in the project-based learning class was 73.78, while the average in the conventional class was 70.08. About the N-gain, the data in Table 3 show that the project-based learning class experienced greater improvement compared to the conventional class, as the project-based learning class had an average N-gain of 0.23. In contrast, the conventional class had an average N-gain of 0.16, with both averages falling into the low category. This descriptive statistic indicates that the change in students' self-regulated learning in the project-based learning class was better than in the conventional class.

Inferential Analysis of Changes in Students' Self-Regulated Learning

Before determining the inferential test to be used, a normality test was conducted using IBM SPSS 27 for Windows at a significance level of 0.05 with the following hypotheses:

H_0 : The N-gain data of the self-regulated learning scale for students in the PjBL and conventional classes are normally distributed.

H_1 : The N-gain data of the self-regulated learning scale for students in the PjBL and conventional classes are not normally distributed.

The testing criterion is to accept H_0 if Sig. > 0.05 and reject H_0 otherwise. The results of the normality test on the N-gain data of the self-regulated learning scale are presented in Table 5 below.

Table 5. Normality Test of Self-Regulated Learning Scale N-Gain Data

Class	Shapiro-Wilk		
	Statistic	df	Sig.
Project Based Learning	.894	34	.003
Conventional Learning	.847	34	.000

Based on Table 5, the conventional class obtained a Sig. Value of $0.000 < 0.05$, and the PjBL class obtained a Sig. Value of $0.003 < 0.05$. Since both classes have significance values less than 0.05, this leads to the rejection of H_0 . This means that the self-

regulated learning (SRL) change in data distribution in both the PjBL and conventional classes is not normal. Therefore, a homogeneity test is not required.

As the students' N-gain data are not normally distributed, the statistical test used to examine the difference in the average N-gain between the two classes is a nonparametric test, namely the Mann-Whitney U test. The research hypothesis for this test is formulated as follows:

Hypothesis

“The change in self-regulated learning of students who received Project-Based Learning is significantly better than that of students who received conventional learning.”

The statistical hypotheses are as follows:

$$H_0 : \mu_{sre} \leq \mu_{srk}$$

$$H_1 : \mu_{sre} > \mu_{srk}$$

Description:

μ_{sre} : The average change in SRL of students who received PjBL

μ_{srk} : The average change in SRL of students who received conventional learning

Using a significance level of 0.05, the testing criterion is: if the significance value is greater than or equal to 0.05, then H_0 is accepted; otherwise, H_0 is rejected. The Mann-Whitney U test calculation results can be seen in Table 6 below.

Table 6. Mann-Whitney U Test Results. N-gain SRL Data

	N-gain SRL
Mann-Whitney U	391.000
Wilcoxon W	986.000
Z	-2.296
Asymp. Sig. (2-tailed)	.022

The statistical test in Table 6 obtained a significance value of 0.022. Since this study used a one-tailed test, the significance value was divided by two, resulting in $\frac{1}{2}$ sig. (2 – tailed) = 0,011 < α = 0,05, thus H_0 is rejected. It can be concluded that the average change in self-regulated learning (SRL) of students who received Project-Based Learning (PjBL) is significantly better than that of students who received conventional learning.

Both the experimental class and the control class used the scientific approach. However, in the experimental class, students were taught through a project-based approach, while in the control class, students were only taught using the scientific approach. In self-

regulated learning (SRL), the scientific approach can enhance thinking, performance control, and self-reflection. During the observing activity, students are trained to analyze tasks and self-efficacy by setting goals and creating problem-solving strategies. Many studies show that learning strategies and goal-setting help students learn (Zimmerman, 2008). In the questioning activity, students are also trained to have sufficient self-control and observation. Students will likely be able to hypothesize and develop strategies to complete tasks and instruct themselves to implement those strategies to solve problems. While sufficient observation refers to self-recording, self-experimentation, and metacognitive monitoring, self-control refers to applying chosen strategies (Zimmerman, 2008).

Furthermore, students are trained to enhance their self-control and observation in the information-seeking activity involving problem-solving strategies. In the reasoning activity, students work collaboratively in groups based on sources of information and their initial thoughts, which can foster self-judgment and self-reaction. Therefore, this approach can improve thinking, performance control, and self-reflection within SRL.

The hypothesis test results show that students in the PjBL class have a significantly higher average change in SRL than students in the conventional learning class. The average SRL change of students in the PjBL class is 0.23, while students in the conventional learning class have an average change of 0.16. This condition indicates that project-based learning helps students improve their independence. This aligns with the idea that the project-based learning approach can enhance the SRL of junior high school students.

After receiving the treatment, the research results show that implementing PjBL provides a significant opportunity for students to construct their knowledge, which supports the development of students' self-regulated learning (SRL). This aligns with the findings of Windyaningsiwi et al. (2025), who found that PjBL effectively enhances SRL at various educational levels, significantly improving self-management abilities, creative thinking, and learning outcomes, mainly when supported by a conducive learning environment. In this model, students do not simply receive information passively; instead, they actively engage in completing projects they choose themselves. This process enables students to plan, monitor, and evaluate their learning independently, which is the core of SRL. Through PjBL, students can organize and oversee the progress of their projects, ultimately improving their self-management skills in learning.

One of the main aspects of PjBL is collaborative work within groups. In this setting, students learn to cooperate, share ideas, and plan steps together to achieve the project's goals.

This collaboration enhances their cognitive skills in completing tasks and strengthens self-regulated learning (SRL) as students learn to manage time, resources, and responsibilities to ensure the project is completed. Research by Blackmore et al. (2021) shows that group activities in PjBL allow students to be more actively involved in planning, strategy implementation, and evaluating their work outcomes.

In addition, PjBL teaches students to design and carry out their projects independently, from setting goals to evaluating results. For example, in a mathematics project, students formulate the objectives they want to achieve, develop problem-solving strategies, and periodically assess their progress. This view is supported by Zimmerman (2008), who states that key elements of SRL, such as goal setting, strategy use, and self-evaluation, can be learned through social modeling from parents, teachers, and peers. Students with good SRL rely on their personal abilities and seek support from others to enhance their learning. Social support contributes positively to learning outcomes, directly and through improving SRL, and is a protective factor that helps students cope with academic stress (Martínez-López et al., 2024).

Thus, PjBL encourages students to develop initiative, perseverance, and skills in various learning methods. This finding is supported by research from Chung (2021), which shows that PjBL improves students' self-regulated learning (SRL), especially in mathematics education. Students understand mathematical concepts in project-based learning and develop critical thinking, creativity, and collaborative skills. The SRL developed through PjBL equips students with essential tools to become independent learners who can overcome various learning challenges in the future, both in further education and in their professional lives.

Although conventional learning with a scientific approach can improve self-regulated learning (SRL), its impact is not as strong as that of PjBL. Conventional learning often limits students' interaction with the material and predetermined methods, so students are not free to take initiative in planning and managing their learning. Although there are group activities, opportunities to develop SRL in depth are limited, such as in information-gathering activities where students only follow instructions without independently designing problem-solving strategies. In line with this, Ekantini et al. (2023) and Sudirman et al. (2017) state that PjBL is significantly more effective in improving students' SRL than conventional learning at the elementary and secondary school levels.

Therefore, teaching good self-regulated learning (SRL) in the classroom is very important. One effective way to achieve this is by implementing Project-Based Learning (PjBL). PjBL provides students with a comprehensive framework to learn how to manage their learning, from planning to self-evaluation. Unlike conventional learning, PjBL offers more opportunities for students to develop their self-regulation comprehensively by integrating learning autonomy, opportunities for collaboration, and more regulated learning planning.

Conclusion and Suggestion

The research results show that students who use project-based learning exhibit a significantly greater improvement in self-regulated learning than students using conventional learning. The PjBL class had an average N-gain of 0.23, while the conventional class had only 0.16. The conventional class had lower pretest and posttest scores than the class using PjBL. This indicates that PjBL helps students become more independent in their learning. According to the Mann-Whitney U test, the difference in the average change in self-regulated learning between the two classes is significant; the significance value is 0.022, and when divided by two for the one-tailed test, it becomes $0.011 < 0.05$. Despite both classes using the scientific approach, only the class employing PjBL showed a significant increase in self-regulated learning. PjBL helps students become more independent by assisting them in planning, implementing, and evaluating their projects. Previous studies have shown that PjBL can improve students' self-regulated learning. These findings are consistent with those of Blackmore et al. (2021), Chung (2021), and Zimmerman (2008).

However, this study has several limitations. First, the sample used was limited to students from a single school, which may restrict the generalizability of the findings to a broader population. Second, this study only measured changes in students' self-regulated learning within the context of mathematics, so it is not certain whether the same results would apply to other subjects. Therefore, it is recommended that future research expand the sample to include more schools and subjects to obtain a more comprehensive understanding of the effects of PjBL on SRL. Additionally, further studies could explore other factors that may influence the effectiveness of PjBL, such as social support, teachers' skills in implementing PjBL, and conducive learning environment factors.

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