



Self-regulated Learning for High School Students in Biology Lessons through the Problem-Based Learning Model

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Abstract: The ability to acquire knowledge and skills through systematic and deliberate monitoring of one's behavior is not evenly distributed among each student. Quantitative research using quasi-experimental methods aims to find the effect of PBL on self-regulated learning, the effect of PBL on self-regulated learning based on gender, and to identify self-regulated learning for high school students based on indicators. The research design was a Posttest Only Control-Group Design carried out on Class XI students at a high school in Palu City with a population of 7 classes. Self-regulated learning data were obtained through questionnaires that were distributed to the experimental and control classes after learning was complete. Data were analyzed using an independent t-test and analysis of each indicator of self-regulated learning using the percentage formula. The study finds that self-evaluation is the most important indicator of self-regulated learning and that learning using the PBL model has a significant impact on student self-regulated learning based on gender and in comparison to conventional learning. It is recommended to apply the PBL model to learning in schools in Indonesia in particular to increase the ability of each student to carry out independent learning.

Keywords: PBL models, self-regulated learning

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INTRODUCTION

The rapid development of technology causes self-regulated learning to be a positive behavior that students need to achieve their academic goals. Self-managed learning is characterized as the capacity to actuate, control, and direct oneself proactively to obtain information and abilities that include profound, persuasive, and mental viewpoints deliberately (Zimmerman & Schunk., 1989), and is a simple interactive process that is carried out intentionally, automatic and habitual involving cognitive self-regulation and motivation (Boekaerts, 1997). Student learning quality is significantly linked to self-regulation (Sadi & Uyar, 2013), learning achievement (Leite et al., 2022; Xu et al., 2023), affects literacy skills (Gabriel et al., 2020), is a significant predictor of students' mindset development (Bai & Wang, 2020), is a moderate predictor of the use of metacognitive learning strategies and motivation (Vrieling et al., 2012), predicts academic adjustments related to planning learning efficiency and monitors learning progress and behavior in learning situations (Cazan, 2012). Self-regulated learning involves metacognitive awareness in terms of controlling, maintaining, or manipulating planning, monitoring, and evaluating beliefs about motivation, persistence, effort, involvement, fun, interest, and other emotional aspects (Bakhtiar & Hadwin, 2021). As a result of their ability to demonstrate lower levels of test anxiety and neuroticism, higher scores in extraversion, awareness, sociability, and openness to experiences, students with high self-regulated learning always develop better personalities (Dörrenbächer & Perels, 2016), have intrinsic pleasure and motivation related to social relations in groups of learners (Pfost et al., 2022). In addition, they can show their ability to express ideas and high curiosity, carry out tasks independently, be active in organizations, commit to completing tasks, be responsible for their actions, work together with friends, and have an optimistic attitude (Wangid, 2013).

Each student possesses unique self-regulation learning abilities. Educational psychology students with high and low achievement differed in the components of self-regulated learning, particularly cognitive, metacognitive, and motivational aspects (DiFrancesca et al., 2016). In several aspects of self-regulated learning, the group of students with high self-regulation stands out, particularly in how they regulate their own personal processes, behavior, and environment (Abdelhalim, 2022), they tend to learn more material and have the highest level of material mastery orientation for the longer time (Abar & Loken, 2010) and score higher than groups of students with moderate or low self-regulation in their learning (Ali & Hanna, 2021). Then again, understudies with lower levels of self-managed learning and scholarly commitment are displayed to have character qualities of transparency, uprightness, extraversion, mindfulness, the benevolence of change, and low scholastic inclusion (Mahama et al., 2022). Self-regulated learning is not an innate characteristic of every person. Therefore this ability tends to be unstable and has the potential to change (Li et al., 2020) which is influenced by internal and external factors for each student including motivation (Leidinger & Perels, 2012; Vavropa et al.,

2012), learning readiness (Lin & Dai, 2022), learning characteristics (Lu & Wang, 2022; Russell et al., 2020), metacognitive skills (Rivers et al., 2021), social interaction (Alvi & Gillies, 2015; Liu, 2017), and expectations of parental behavior (Ellis & Helaire, 2022). This situation is a reflection that students need guidance to encourage and awaken their abilities in setting goals, planning, implementing, and reflectively improving and adapting their learning (Hadwin, 2021), developing their study skills, finding appropriate learning strategies, and managing their learning effectively. Implementing interactive active learning that is fun and highlights real problems has the potential to trigger self-regulated learning capabilities. Learning like this is the character of the problem-based learning model (PBL).

PBL can be relied upon to support self-regulated learning because the PBL syntax directs students to work together in groups conducting investigations, using a lot of time to explore, observe, and evaluate their learning so that it has the opportunity to train students to become more independent learners (Erdogan & Senemoglu, 2014), skilled in time planning and self-monitoring which can affect the efficiency of managing study time (Ge et al., 2022; Hurk, 2016). PBL also provides opportunities for students to improve communication skills (Shamdas et al., 2023), and master a lot of knowledge with longer retention (Dochy et al., 2003). On the other hand, PBL has had a significant impact on learning processes and outcomes. Several studies have shown that PBL can increase students' cognitive knowledge, comprehension of the problem-solving process, and self-regulation skills in grade 8 students in two Australian schools (Loneragan et al., 2022), higher post-test scores achieved by students in Turkey's higher education institutions (Baturay & Bay, 2010), higher achievement of physics course teacher candidates at Dokuz University Eylül, Faculty of Education Buca (Celika et al., 2011), and enhance the cognitive learning outcomes of SMP Bina Insani Semarang, Indonesia, class VII students (Hanipah et al., 2018). In addition, PBL has a significant impact on student achievement by influencing motivation, learning styles, ways of thinking, learning difficulties, and learning skills (Almulla, 2019).

PBL is one of the innovative learning models that has been familiarly applied in many schools in Palu, Central Sulawesi, especially at the high school level, and has been widely reported on its effectiveness on learning outcomes and processes. However, there is a lack of concentrated data on Self-Regulated Learning for High School Students in Biology Lessons. Consequently, this research is significant because the aftereffects of this exploration can give logical data about the advantages of the PBL learning model in supporting understudies' capacities to do autonomous learning in Science illustrations. The obtained results can also serve as a foundation for future learning biology development research. The outcomes can likewise be involved by educators in planning Science examples that can construct understudies' abilities in dealing with their acquiring all the more actually. Using indicators, this study sought to determine the impact of PBL on self-regulated learning, gender-based impact, and self-regulated learning among high school students.

METHODS

This type of quasi-experimental research with a quantitative approach used the Posttest Only Control-Group Design. This design was used to control for the confounding effects of the pretest, and only the experimental group was given the treatment while the control was not subjected to the experiment, but both were given the posttest (Creswell, 2014). The autonomous variable in this study was the issue-based learning model and the reliant variable was self-managed learning. The problem-based learning (PBL) model was used in the experimental class, while conventional learning was used in the control class. This study was located in one of the high schools in Palu City, Central Sulawesi. The research population was class XI which was divided into seven classes and two classes were selected as samples. Purposive sampling was used to select the sample because the cognitive abilities of the students in both classes were similar (data source: documents from the school). Self-regulated learning data was obtained through a questionnaire that was distributed to all experimental and control class students after the learning series was completed. The questionnaire containing 15 statement items was developed from the indicators used by Barnard-brak et al. (2010). Before use, the questionnaire was validated internally by two senior lecturers who are experts in educational evaluation at the Biology Education Study Program, FKIP Tadulako University, Indonesia. The results of the analysis showed that the 15 statement items in the questionnaire instrument were valid criteria. In addition, the Likert scale, which ranges from strongly disagree to strongly agree, was used for all of the questionnaire's items. On the other hand, the self-regulated learning data from both the experimental and control classes were examined with an independent t-test. This measurable test was utilized for test examination with two distinct medicines (Sugiyono, 2013). A normal distribution test of the data was performed using the normality test and homogeneity test of variance to ensure that the data variants were uniform before analysis. SPSS 25.0 was used for the data analysis. On the other hand, the data were processed using the percentage formula, which was the total score divided by the maximum score multiplied by one hundred percent, to determine the percentage of self-regulated learning indicators.

RESULT AND DISCUSSION

A description of the effect on self-regulated learning, a description of the effect on self-regulated learning based on gender, and a description of self-regulated learning based on indicators make up the order in which the PBL learning model's results and discussion are presented.

The Effect of The PBL Model on Self-Regulated Learning

Biology self-regulation is significantly enhanced by the PBL model for high school students. The results of the independent t-test, descriptive statistical analysis, and data normality analysis are presented in Table 1. Table 2 contains the aftereffects of the free t-test examination.

Table 1. Results of Data Normality Analysis and Descriptive Statistics

Tests of Normality/Kolmogorov-Smirnov				Group Statistics			
SRL/Class	Statistic	df	Sig.	N	Mean	Std. Deviation	Std. Error Mean
Experiment	.089	32	.200	32	50.3750	5.00161	.88417
Control	.149	28	.116	28	32.1786	2.24522	.42431

The results of the Kolmogorov-Smirnov test inform that self-regulated learning data in the experimental class that applies the PBL model [$D(32) = 0.089$, $p = 0.200$] and conventional learning [$D(28) = 0.149$, $p = 0.116$] are normally distributed. Table 2 shows that self-regulated learning is significantly lower in the control class using conventional learning ($M = 32.17$, $SD = 2,24$) than in the class using the PBL learning model ($M = 50.37$, $SD = 5,00$), $t(58) = 17.732$, $p = 0.000$).

Table 2. Independent t-Test Analysis Results

SRL	df	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	58	17.737	.000	18.19643	1.02592	16.14284	20.25002
Equal variances not assumed	44.229	18.554	.000	18.19643	.98071	16.22023	20.17263

The outcomes acquired imply that oneself-regulated learning of high school understudies in Science subjects is altogether affected by picking up utilizing the PBL model. One of the characteristics of the PBL model, which is learning that always brings up real-world issues, lends credence to this finding. This authentic problem is designed in the form of a case study or phenomenon so that it attracts students' attention and a learning process like this can stimulate students' reasoning power which has the potential to trigger them to become active because they examine familiar problems experienced in their environment. In addition, the first PBL syntax, namely student orientation to problems, is the first step in learning that provides the widest possible opportunity for each student to identify problems in video presentations and ppt about phenomena or cases that contain problems related to the material being taught. Individually students are triggered to be able to convey the problems they find through the results of their observations. Students are activated to think critically to find important parts that contain problems and express them openly. In this situation, students are awakened by the will and curiosity to find out through their abilities which triggers them to think actively. Indirectly this situation has challenged students to build and maximize their willingness to learn independently. According to Zimmerman (2001), independent learning is the ability of students to manage their learning through personal initiative, persistence, and proactive adaptive skills that can be acquired through social learning like modeling, guidance, and feedback from peers, coaches, and teachers or open behavior like choosing, modifying, or building a favorable personal environment or seeking other social support. This finding is supported by the opinion that independent learning is the ability of students to manage their learning. Innovative learning models have been shown in several studies to improve self-regulated learning throughout the learning process (Devolder et al., 2012; Nguyen & Ikedat, 2015; Stefanou et al., 2013). Additionally, the PBL model was found to be effective for student academic achievement and self-regulated learning (English & Kitsantas, 2013; Fitriani, 2018; Yaniawati et al., 2019).

The Effect of The PBL Model on Self-Regulated Learning Based on Gender

The PBL model essentially affects oneself controlled learning of male and female understudies in Science examples. Table 3 contains the descriptive statistics and data normality analysis results, while Table 4 contains the independent t-test analysis results. The self-regulated learning data for male students ($D(10) = 0.254$, $p = 0.066$) and female students ($D(22) = 0.095$, $p = 0.200$) were found to be normally distributed by the

Kolmogorov-Smirnov test. Table 4 shows that male students' self-regulated learning is significantly lower than that of female students ($M = 51.12$, $SD = 5.124$), $t(30) = 2.856$, $p = 0.008$, according to the analysis performed with the unpaired t-test.

Table 3. Results of Data Normality Analysis and Descriptive Statistics

Tests of Normality/Kolmogorov-Smirnov				Group Statistics			
SRL/Gender	Statistic	df	Sig.	N	Mean	Std. Deviation	Std. Error Mean
Man	.254	10	.066	10	45.6000	6.04060	1.91021
Woman	.096	22	.200	22	51.5000	5.12464	1.09258

Table 4. Independent t-Test Analysis Results

SRL	df	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	30	-2.856	.008	-5.90000	2.06547	-10.11826	-1.68174
Equal variances not assumed	15.157	-2.681	.017	-5.90000	2.20059	-10.58623	-1.21377

According to the findings, the PBL model significantly influences male and female students' self-regulated learning in Biology subjects. This finding is supported by the syntax of the three PBL models, namely assisting individual and group investigations, meaning that the teacher allows students to make observations and find appropriate information about anything related to the problem and alternative solutions. In this activity, students explore alternative solutions to each problem. Male and female students independently explore and explore the widest possible range of information related to alternative solutions to the problems being studied followed by elaborating their findings in their discussion groups. Cooperation and collaboration of male and female students produce alternative solutions to problems even though the participation of female students outperforms male students in this study. This finding is in line with the results of relevant research which reported that female students outperformed male students in several academic activities and achievements (Ehrtmann & Wolter, 2018; Hakkarainen & Palonen, 2003; Mierdel & Bogner, 2019; Robertson, 2012; Tsay et al., 2018).

Self-Regulated Learning for High School Students Based on Indicators

High school understudies who were educated by applying PBL and customary models accomplished various rates for every mark of self-controlled learning. Fig. 1 depicts the obtained results.

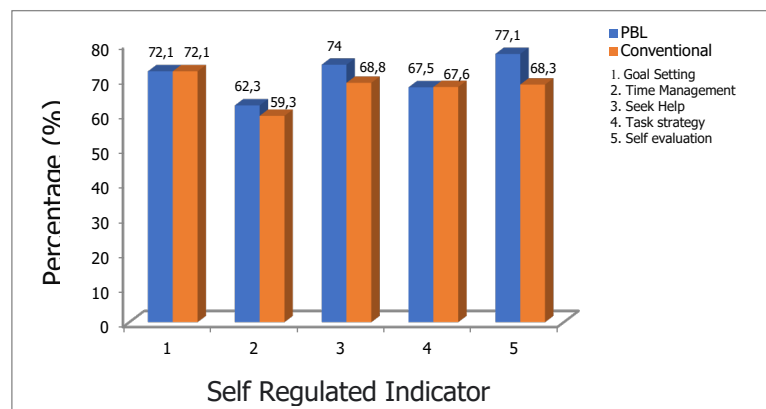


Figure 1. Percentage of Self-Regulated Learning Indicators

The research findings shown in Figure 1 are that students who are taught using the PBL model achieve a higher percentage of self-regulated learning indicators than conventional learning and the highest percentage is in the self-evaluation indicator. Students' skills in self-evaluation are strongly supported by the syntax of the five PBL models, namely analyzing and evaluating the problem-solving process. In analyzing activities, the teacher helps students carry out analysis and reflection on the inquiry process they are doing and students are guided to determine the correct solution to the problem being discussed. Students are allowed to think seriously, examine and reflect on the process of observing and finding solutions that have been carried out, and determine that the solution found is the right idea and best solves the problem under study. This situation can train and

accustom students to always do self-evaluations for a moment after carrying out activities and producing something. The findings of this study are in line with the results of relevant research which explains that in PBL, teachers always train and encourage students to reflect and evaluate the processes that occur in groups and the results obtained (Salari et al., 2018) because reflection is the best way to assess work that has been carried out (Shalini, 2021).

Another finding shown in Figure 1 is that the indicator of seeking help looks superior to other indicators of self-regulated learning in learning using the PBL model. Syntax 3 PBL is to assist individual and group investigations to facilitate students working collaboratively to search for as much information as possible about matters related to problems and alternative solutions. Students are trained to provide mutual assistance among group mates and explore the information needed via the internet. All students are actively involved in their groups according to their respective roles and occasionally there is communication or small discussion among them. Every student was very enthusiastic in this learning even though several groups needed the teacher's help with the problems they encountered. This finding is supported by the results of previous research which reported that learning that is rooted in authentic problems with many solutions allows students to collaborate and develop actively into independent learners (Laprise, 2018), helps students appreciate various perspectives, recognize elements, make non-rational decisions, be able to implement the plan, able to lead a team, resolve conflicts when faced with ethical confusion, can persuade others and communicate with many parties (Brownell & Jameson, 2004).

An indicator of self-regulated learning that also excels in learning using the PBL model is an indicator of goal setting. Syntax 1 PBL which starts this lesson begins to introduce students to the goals to be achieved throughout the learning process. Indirectly the teacher introduces students to how important it is to set goals before an activity is carried out. Gradually students are trained to examine each segment of the objectives that have been introduced through the problem orientation presented by the teacher. This finding is supported by the results of previous research which reported that PBL trains students to raise awareness and self-confidence to choose their study topics using available resources, set goals to achieve, and choose the most comfortable time to study (Phungsuk et al., 2017).

CONCLUSION

In this review, oneself directed learning of high school understudies through the use of the PBL model in Science examples was considered. When compared to conventional learning, the study reveals that applying the PBL model to learning has a significant impact on the self-regulated learning of high school students. Besides, advancing by applying the PBL model essentially affects oneself controlled learning of high school understudies in light of orientation. In addition, among the self-regulated learning indicators, the self-evaluation indicator achieves the highest percentage. The PBL model should be implemented in several Indonesian schools because the findings of this study may offer a practical solution to the learning issues that many teachers face. Further research that examines self-regulated learning and student motivation through the PBL model compared to other learning models also needs to be done. This research will be able to provide information about the advantages or disadvantages of PBL when compared to other learning models. In addition, studies that examine the effect of PBL on thinking skills also need to be carried out so that teachers can find out the benefits that can be obtained through implementing PBL in learning.

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