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The Influence of the Problem-Based Learning Model on Metacognitive Knowledge and Science Learning Outcomes

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Abstract: Metacognitive knowledge refers to what is known about memory function and the strengths and weaknesses of one's own cognition. This research aims to describe the influence of the problem-based learning model on the metacognitive knowledge and learning outcomes of class IX junior high school students. The research was carried out on Class IX students of Palu City Middle School, the entire population of Class IX consisted of three classes with a total of 45 students. Two classes were used as samples determined based on purposive sampling. Metacognitive knowledge data was obtained through questionnaires and learning outcome data through essay and multiple choice tests. Data analysis used an independent t-test with the help of SPPS version 25.0. The results showed that metacognitive knowledge with conventional learning was significantly lower than the PBL class with a gain of $t(25) = 9.289$, $p < 0.000$ and learning outcomes in the conventional class were significantly lower than the PBL class with a gain of $t(25) = 4.520$, $p < 0.000$. The conclusion of this research is that there is an influence of the problem-based learning model on the metacognitive knowledge and learning outcomes of class IX SMP students.

Keywords: Learning outcomes; Metacognitive knowledge; Problem-based learning models

Introduction

Thinking about what is currently being thought known as metacognitive is a unique activity that has long been discussed, especially in the world of education. Metacognitive knowledge refers to what individuals know about their cognition (Schraw, 2016) namely explicit knowledge about how memory functions and knowledge about their cognitive strengths and weaknesses without involving conscious factors (Perfect & Schwartz, 2002). Metacognitive knowledge helps students improve and control their thinking and learning (Smith et al., 2017), helps find learning strategies (Cer, 2019; Gul & Shehzad, 2012), improves their performance (Cannon et al., 2021; Sato & Lam, 2021), helps understand cognitive processes and how to manage learning activities, helps assess and carry out evaluations, provides feedback about one's performance, and helps the adaptation process and application of existing knowledge to solve new problems in certain situations (Devikaa & Singh, 2019). In addition, metacognition triggers increased self-confidence (Kisac & Budak, 2014; Kleitman & Gibson, 2011; Negretti, 2021) and learning motivation (Hüseyin, 2016) so that it can contribute to learning outcomes (Veenman & Verheij, 2003) because it is higher metacognitive knowledge, the higher student learning outcomes (Hoseinzadeh & Shoghi, 2013). On the other hand, learning outcomes are used as a means of knowing the success achieved by students (Lile & Bran, 2014), to report student progress and make decisions about teaching (Jimaa, 2011), becoming an effective and powerful tool for improving learning (Kubik et al., 2021) and serves as a guide for teachers to guide students (Hailikari et al., 2022).

Students who have good metacognitive knowledge have high motivation to learn (Urban et al., 2021), can choose problem-solving strategies (Montague & Bos, 1990), and have the skills to plan, use, and monitor an effective learning approach and

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method (Özçakmak, 2021) as well as engaging less in self-harming behavior (Kleitman & Gibson, 2011). In addition, students who have good learning outcomes have good interest in learning, motivation and self-efficacy, low levels of anxiety, have time to study outside of school (You et al., 2021), and can control their time effectively (Adams & Blair, 2019), able to form study habits by arranging study schedules and not delaying study time (Goda et al., 2015), serious and enthusiastic in learning (Azhary et al., 2020), and high curiosity (Singh & Manjaly, 2022).

Metacognitive knowledge and learning outcomes greatly influence students' academic success which can be reviewed through academic behavior and cognitive learning outcomes (Chamorro-Premuzic & Furnham, 2003). Empirical evidence through research conducted has consistently reported that the metacognitive knowledge of prospective teachers is at a moderate level (Demirel et al., 2015), differs based on gender (Abdelrahman, 2020; Liliana & Laviniab, 2011) and differs based on educational strata (Repo et al., 2017; Siswati & Corebima, 2017). On the other hand, the learning outcomes achieved by students are high in mathematics (Hossain & Tarmizi, 2011; Mohamed Elsayed, 2022; Pouyamanesh & Firoozeh, 2013), Physical Science (Chandra & Watters, 2012; Kuhna & Müller, 2014), Biological Science (Dorfner et al., 2018; Ing et al., 2020), and English lessons (Ninsiana et al., 2022), while the learning outcomes are lower for female students compared to male students (Lavrijsen & Verschueren, 2020), and low learning, occurs in mathematics lessons (Beatty et al., 2021; Maruyama, 2022; Phelps & Price, 2016). Different metacognitive knowledge and unequal student learning outcomes in all subjects at all levels of education are phenomena that cannot be avoided. This hole is exceptionally stressing and an issue since it can possibly happen in different subjects, particularly science subjects, which were tracked down in class IX understudies in one of the middle schools in Palu City.

Many factors influence differences in students' metacognitive knowledge, including the learning strategies and approaches used by teachers in the classroom (Khurram, 2023; Matook et al., 2023; Werdiningsih et al., 2022), the role of emotions and academic motivation (Acosta-Gonzaga & Ramirez-Arellano, 2021) as well as interactions between friends (Ouyang et al., 2022). On the other hand, high and low student learning outcomes are influenced by self-confidence and metacognitive abilities (Roebers et al., 2014), personality factors (Neuenschwander et al., 2013), intrinsic goals (Cai et al., 2019), prior knowledge (Byrnes et al., 2019; Cutumisu et al., 2020; Liu et al., 2014), interactions between friends (Hendriks et al., 2011), family social characteristics (Bouiri et al., 2022), teacher support and academic self-efficacy (Ginns et al., 2018; Tach & Farkas, 2006) as well as enjoyable learning (Burke & Williams, 2008; Giannakos, 2013; Gillies, 2004; Lee et al., 2005; Li et al., 2023). Thus, learning is a key factor that influences metacognitive knowledge problems and student learning outcomes so organizing the learning process becomes the main solution that needs to be implemented.

The issue of increasing students' metacognitive knowledge and cognitive learning outcomes through the learning process has been widely discussed. Metacognitive knowledge can be improved through the learning process (Altıok et al., 2019; Clark et al., 2023; Gurung et al., 2022; Khellab et al., 2022; Mafarja et al., 2023; Mohd Nasim, 2022; Ramadhanti & Yanda, 2021; Samuel & Okonkwo, 2021) which can provide freedom and support for students to explore and expand knowledge (Cotterall & Murray, 2009) because metacognitive knowledge develops along with increasing experience and psychological knowledge (Cho, 2023) as well as students' intellectual abilities (Veenman & Spaans, 2005). Likewise, learning outcomes can be improved through the learning process (Chen et al., 2023; Sailer et al., 2021; Tong et al., 2022; Wardoyo et al., 2021; Wei et al., 2023; Zheng et al., 2020), because the application of appropriate learning models can facilitate student involvement in building their learning environment (Rahimi et al., 2015), as well as the use of innovative learning media (Han & Shin, 2016; Orús et al., 2016; Shieh, 2012), collaborative effects (Reychav & Wu, 2015) and student behavior in learning also influence their learning outcomes (Bosch et al., 2021). Thusly, executing an intelligent learning model can possibly work on the metacognitive information and learning results of class IX understudies in one of the middle schools in Palu City science subjects.

Intelligent learning can be introduced by educators by carrying out imaginative learning models that can work on the nature of instructing and learning (Singh et al., 2021), have the greatest influence on increasing student success and experience (Minhas et al., 2021), encourage students to form a positive learning attitude, finding good learning strategies and cultivating students' innovative spirit (Xu, 2022) increasing class engagement so that they become more active learners and improving academic self-concept (Elsayed Abdelhalim et al., 2020). The issue based-learning model, abridged as PBL, is a creative learning model that is intelligent and understudy focused.

The adequacy of PBL in learning has been widely reported, including PBL tends to work in teams and this situation allows students to evaluate their understanding, share, and exchange thoughts and

communicate with other classmates (Bayat & Tarmizi, 2012; Shamdas et al., 2023), PBL is superior for long-term knowledge retention (Yew & Goh, 2016), improving students' ability to think critically (Seibert, 2021) think creatively (Ersoy & Başer, 2014), improve learning outcomes (Astuti et al., 2017; Promentilla et al., 2017; Zuhrotunnisa & Ngabekti, 2020), problem-solving abilities (Shamdas, 2023b) and increasing students' understanding of the concepts studied (Gorghiu et al., 2015). Apart from that, PBL can also increase metacognitive knowledge (Diekema et al., 2011; Gholami et al., 2016; Sutarto et al., 2022), increase self-regulated learning (Shamdas, 2023c), awareness of metacognitive learning and critical thinking skills (Shamdas, 2023a), self-efficacy and cognitive learning outcomes (Shamdas, 2023d).

PBL learning has been implemented in schools in Palu, Central Sulawesi, but there have been no reports regarding the effect of the problem-based learning model on metacognitive knowledge and science learning outcomes, especially for class IX junior high school students in Palu City. This research is important to carry out because it has been widely reported that metacognitive knowledge and science learning outcomes among secondary school students in Indonesia are still low (Beatty et al., 2021; Fauzi & Sa'diyah, 2019; Isfiani & Ekanara, 2022; Keliat et al., 2021; Kusaeri & Ridho, 2019). The results of this research can be used as information about how to improve metacognitive knowledge and learning outcomes through real problems in students' living environments by applying the PBL learning model. Apart from that, the findings obtained can be used as a basis for research development in science learning. The results can also be used by teachers in designing learning that can arouse student interest and academic achievement. Therefore, this research aim to describe the influence of the problem-based learning model on metacognitive knowledge and science learning outcomes in class IX junior high school students.

Method

This exploration utilizes a quantitative methodology with Posttest Just Control Plan. This plan includes understudies being haphazardly partitioned into gatherings and treatment is simply given to the trial bunch yet the two gatherings are given a posttest while the quantitative methodology is a bunch of develops or factors, framed into a recommendation or speculation that decides the connection between factors (Creswell, 2014). The free factor in this exploration is the issue based learning model and the reliant variable is metacognitive information and understudy learning results.

The examination was completed on Class IX understudies in one of the middle schools in Palu City. The populace is all Class IX adding up to 3 classes with a sum of 45 understudies. The example utilized two classes adding up to 30 understudies, specifically class IX-A adding up to 15 understudies treated with the issue based-learning model, and class IX-B likewise adding up to 15 understudies as the control class. The sample was determined using purposive sampling considering that the number of students in the two classes was the same and the student's academic abilities were also relatively the same (data source, Class IX science teacher).

Learning utilizes the Issue Based Gaining model by applying the language structure embraced from Arends (2012). Toward the finish of the learning series, understudies are given a mental learning results test and a metacognitive information survey. The mental learning results test contains HOTS questions comprising of 10 numerous decision questions and 2 article questions. The metacognitive information survey contains articulations created and changed from metacognitive information pointers by Gregory et al. (1994). All instruments were approved inside by two senior speakers who are specialists in instructive assessment at the Science Training Study Program, FKIP, Tadulako College, Indonesia. The aftereffects of the examination show that the HOTS inquiries for mental learning results and all assertions for the poll instrument are remembered for the substantial measures.

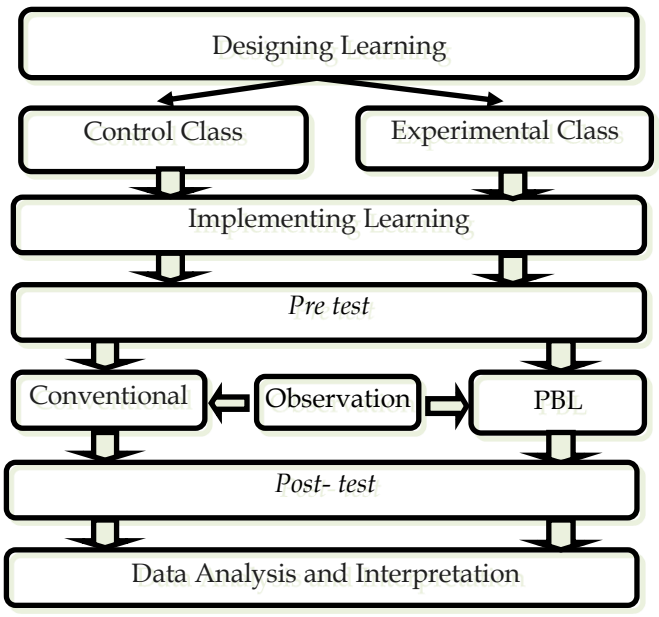

Figure 1. Research flow

Information investigation utilized an autonomous t-test to test the impact of the issue put together learning model with respect to metacognitive information and learning results since this test was utilized for tests with two distinct medicines (Sugiyono, 2013). An assumption test is carried out first on the data to be tested through a normality test to determine normally distributed data and a variance homogeneity test for uniformity of data variance. All data analysis uses SPPS version 25.0. The research process flow is shown in Figure 1.

Result and Discussion

The outcomes and conversation in regards to the impact of the issue put together learning model with respect to metacognitive information and learning results in science examples are introduced beneath.

The Influence of Problem-Based Learning Models on Metacognitive Knowledge

The impact of the issue put together learning model with respect to the metacognitive information on Class IX SMP understudies in Palu City is shown by the consequences of information examination which shows the presumption test results introduced in Tables 1 and 2 and the aftereffects of the autonomous t-test examination introduced in Table 3.

Table 1. Results of Data Normality Analysis

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Metacognitive knowledge	Control	.120	14	.200*	.946	14	.503
	Experiment	.232	13	.055	.908	13	.170

*. This is a lower bound of the genuine importance.
a. Lilliefors Significance Correction

Table 2. Results of Homogeneity of Variance Analysis and Descriptive Statistical Analysis

		Levene's test for equality of variances		Group statistics				
		F	Sig.	Class	N	Mean	Std. deviation	Std. error mean
Metacognitive knowledge	Equal variances assumed	1.482	.235	Control	14	105.50	3.006	0.803
				Experiment	13	119.46	4.683	1.298

The aftereffects of the Kolmogorov-Smirnov and Shapiro-Wilk tests in Table 1 illuminate that the metacognitive information in the trial class that applied the PBL model was [D(13)=0.232, p=0.055] and [W(13)=0.908, p=0.170] and regular learning in the control class [D(14)=0.120, p=0.200] and [W(14)=0.946, p=0.503] was normally distributed.

The consequences of Levene's test in Table 2 show that the difference of metacognitive information for the exploratory class and control class is homogeneous [F(1,25) = 1.482, p = 0.235].

Table 3. Results of Independent t-Test Analysis

Independent Samples Test							
	t-test for equality of means						
	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence interval of the difference lower	upper
Metacognitive knowledge	-9.28	25	.000	-13.9615	1.503	-17.05	-10.86
	-9.14	20.209	.000	-13.9615	1.527	-17.14	-10.77

The results of the analysis using the unpaired t-test (Table 3) were that metacognitive knowledge in the control class with conventional learning (M = 105.50, SD = 3.006) was significantly lower than in the experimental class that applied the PBL learning model (M = 119.46, SD = 4.683), t(25) =9.289, p < 0.000. The results obtained show that the problem-based learning model influences the metacognitive knowledge of class IX students in science subjects. Real problems in students' environments are not something they are unfamiliar with so they are appropriate as references for orienting students' thinking skills to problems related to the material developed in learning. Phenomena that occur in real life are presented in a PBL syntax through video displays that can attract students' attention to listen seriously. This present circumstance is additionally upheld by the educator's spryness in posing animating inquiries that can animate understudies to ponder the occasions that happen in the video show and associate them to the issue that will be talked about. In this way, students are triggered to revive their memories about the knowledge they already have and think about its connection to the problems that will be discussed in this lesson. This kind of learning process is supported by findings that have been reported that PBL can increase students' metacognitive knowledge (Herlanti et al., 2017) because students in PBL gain knowledge little by little but gain a lot of knowledge and remember it for a longer time (Dochy et al., 2003).

Apart from that, there is a significant positive effect on students' meta-cognitive awareness after undergoing PBL intervention (Tarmizi & Bayat, 2010), PBL influences cognitive engagement in increasing conceptual understanding (Loyens et al., 2015), PBL is effective in motivating students to use their metacognition to thinking when working on authentic problems (Diekema et al., 2011), and PBL is successful in influencing students' metacognition which makes them skilled in problem-solving (Carriger, 2016; Liu & Liu, 2020).

The Influence of Problem-Based Learning Models on Learning Outcomes

The impact of the issue put together learning model with respect to the learning results of Class IX SMP understudies in Palu City is shown by the consequences of information examination which shows the presumption test results introduced in Tables 4 and 5 and the aftereffects of the autonomous t-test examination introduced in Table 6.

Table 4. Results of Data Normality Analysis

Tests of normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Learning outcomes	Control	.176	14	.200*	.888	14	.075
	Experi-ment	.193	13	.200*	.875	13	.061

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The consequences of the Kolmogorov-Smirnov and Shapiro-Wilk tests in Table 4 illuminate that the learning results information in the exploratory class that applied the PBL model were [D(13) = 0.193, p = 0.200] and [W(13) = 0.875, p = 0.061] and regular learning in the control [D(14) = 0.176, p = 0.200] and [W(14) = 0.888, p = 0.075] was normally distributed.

Table 5. Results of Homogeneity of Variance Analysis and Results of Descriptive Statistics Analysis

		Levene's test for equality of variances		Group statistics				
		F	Sig.	Class	N	Mean	Std. deviation	Std. error mean
Learning outcomes	Equal variances assumed	.337	.567	Control	14	11.50	1.091	.2918
				Experiment	13	13.46	1.163	.3225

The aftereffects of Levene's test in Table 5 demonstrate that the difference in learning results information for the trial class and control class is homogeneous [F(1,25) = 0.337, p = 0.567].

Table 6. Results of Independent t-Test Analysis

Independent samples test							
	t-test for equality of means						
	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence interval of the difference lower	upper
Learning outcomes	-4.520	25	.000	-1.96154	.43393	-2.855	-1.067
	-4.509	24.520	.000	-1.96154	.43498	-2.858	-1.064

The consequences of the examination utilizing the unpaired t-test (Table 6) show that learning results in the control class with customary learning (M = 11.50, SD = 1.091) were significantly lower than the experimental class which applied the PBL learning model (M = 13.46, SD = 1.163), t (25) =4.520, p < 0.000. The results obtained mean that the problem-based learning model has a positive influence on science learning outcomes for class IX students. Student activities in Syntax three in terms of exploring the material as widely as possible through various available sources and discussing it with a group of friends are a valuable opportunity for students to obtain a lot of information related to the problem being studied. Apart from that, exclusive attention from the teacher by visiting each group and providing direct guidance to groups experiencing difficulties is the best opportunity for students to consult on the difficulties they encounter in the problem-solving process. Exploring the material in-depth and intensive discussions with a group of friends under the supervision and assistance of the teacher can make it easier for students to understand the concepts being studied. Not only that, the concepts that have been understood are strengthened again in the four PBL syntaxes, namely when the results of discussions with small groups are presented in front of the class and receive responses from other groups and clarification and reinforcement from the teacher. This way of learning causes the meaning of the concepts being studied to become more unequivocal, thus having a better effect on learning outcomes. This finding is supported by previous research results which indicate that PBL improves student learning outcomes (Baturay & Bay, 2010; Fidan & Tuncel, 2019; Niwa et al., 2016), improves critical thinking skills (Sharma et al., 2023),

cognitive abilities (Al-Kloub et al., 2014; Loppies & Badrujaman, 2021) and improving learning achievement, problem-solving abilities and class interactions (Alrahlah, 2016; Aslan, 2021; Tarmizi & Bayat, 2012). In addition, PBL has an effect on cognitive learning outcomes (Hanipah et al., 2018; Mulyanto et al., 2018; Permatasari et al., 2019) and physics learning outcomes in the cognitive, affective and psychomotor domains (Susilawati & Doyan, 2023).

Conclusion

The aftereffects of the examination show that there is an impact of the issue put together learning model with respect to metacognitive information and there is an impact of the issue put together learning model with respect to the learning results of class IX SMP understudies in science subjects.

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Author Contributions

Conceptualization, G.S. ; methodology, A.S.; validation, A.H. ; investigation, R.F ; writing—review and editing, G.S.; A.H.; A.B.; and R.F. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The creators proclaim no irreconcilable situation.

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