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Metacognitive awareness, problem-based learning integrated science-environment-technology-society (SETS) toward creativity thinking

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Abstract

Metacognitive awareness plays a crucial role in enhancing creative thinking skills, enabling students to explore ideas and find solutions to problems. This study aims to describe students' metacognitive awareness and creative thinking skills after implementing problem-based learning integrated with science-environment-technology-society (SETS). The research was conducted at SMP Al-Huda Jatiagung. The sample was selected using purposive sampling, resulting in 26 students from class VII A as the experimental group and 37 students from class VII B as the control group. This study employed a quasi-experimental design with a non-equivalent control group design. Data collection was conducted through a metacognitive awareness questionnaire and a creative thinking skills test, analysed using an independent sample t-test. The research results show that the SETS integrated problem-based learning model has a significant effect on students' creative thinking abilities. Mapping of metacognitive awareness shows that students in the experimental class are at developed, high and excellent levels. Furthermore, analysis between metacognitive awareness and creative thinking ability descriptively shows that more than half of the students at the 'high' level consist of those in the medium and high creative thinking categories. Therefore, teachers are advised to actively identify problems around students and organize them systematically based on problem-based learning syntax in order to effectively achieve creative thinking skills and metacognitive awareness.

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Introduction

One effort that should be intensified in forming students into independent learners (self-regulated learners) is developing metacognitive awareness (Egok, 2016). Through their thinking, students can organize and decide that they are ready to assimilate new thoughts or knowledge. Students' low metacognitive awareness can be seen from their behaviour of being late for class, ignoring assignments, preferring to use social media when there are presentations, and only reading presentations without explaining (Aşıkcan & Saban, 2018). Meanwhile, students with good metacognitive awareness will be able to determine and decide on certain steps to discover knowledge independently through reflection activities (Aşıkcan & Saban, 2018). It is important to understand that learning independence is one of the supports for student learning success. Metacognitive awareness directly has a close relationship with

learning independence because it is related to careful regulation of cognitive processes in completing tasks (Wiono & Meriza, 2022).

Facts in class show that generally students will study when facing exams or given assignments by the teacher. Apart from that, there are still some students who complete their homework assignments at school by plagiarizing the results of their friends' work. This indirectly has an impact on the low cognitive learning outcomes of students in biology learning. Meanwhile, it is scientifically known that metacognitive awareness is a basic ability needed to develop problem solving skills as demanded by the 21st century (Lusiana et al., 2020). Considering the importance of metacognitive awareness in efforts to prepare Indonesia's golden generation, efforts to increase it need to be encouraged through classroom education.

As the aim of education is to strive for students to become independent learners, a set of steps are needed that are able to actively accommodate the development of students' thinking. Problem-based learning is the right model to be applied in forming independent, active, creative and solution-based learners (Sudjana & Wijayanti, 2018). The syntax consists of orienting the problem; organizing learning; investigate; displaying works; and ending with evaluating solutions (Arends, 2012) can lead students to be actively involved in solving problems. Learning outcomes will be more meaningful for students if the problems used as learning material come from the surrounding environment.

As an effort to design meaningful learning, the problem-based learning model will be integrated with the science, environment, technology and society (SETS) approach. This approach specifically seeks students to build knowledge based on the problems around them. Next, students are directed to formulate creative technology-based solutions based on the results of an analysis of the impact of the problem on society. Involving life phenomena in learning will hone students' creative abilities to develop better (Nurohmawati et al., 2023). So that the problem-based learning model integrated with the SETS approach can theoretically develop students' creative thinking patterns, especially in forming independent learners.

Environmental problems are an important issue raised in the Sustainable Development Goals (SDGs) efforts by the Indonesian government. One of the problems being addressed is environmental pollution in land and water ecosystems (Tan & Irawan, 2021). This is very reasonable, considering that Indonesia experiences a decline in water quality, forest area and an increase in the amount of waste every year (Sutadi et al., 2021). In this regard, the environmental problem that will be used as learning material in this research is the massive smoke resulting from burning fossil fuels from vehicle and factory fumes and waste in traditional markets. The location of the source of the problem is very familiar to students at SMPN Jati Agung, Lampung.

Several research findings show that problem-based learning has a significant influence on students' creative thinking abilities (Suharno et al., 2022). The results of other research conclude that the application of learning using the SETS approach has a significant influence on students' creative thinking abilities (Lekman, 2020; Nurohmawati et al., 2023). Meanwhile, it is known that metacognitive awareness has a significant influence on students' higher-order thinking skills in integrated discovery learning on environmental issues (Wiono & Meriza, 2022). Based on the research results above, the focus of this research is the

application of the problem-based learning model with the SETS approach to students' creative thinking abilities on the subject matter of environmental change. This integration is expected to increase the effectiveness of learning in honing the creativity of the younger generation regarding environmental issues.

Method

This research is a quasi-experiment using a non-equivalent control group design. The consideration is that the research subjects are students who are in a group in the form of class 7 of Al-Huda Middle School, totalling 199 students. The research sample of 63 students was determined using purposive sampling because of consideration of which subjects were most representative of the population. The research sample consisted of an experimental class and a control class, both of which were given a pre-test at the start of learning. The experimental class applies the SETS integrated problem-based learning model while the control class applies learning strategies as implemented by the teacher. Both classes at the end of the lesson were given a post-test. In detail, the research design is shown in **Table 1**.

Table 1. Non Equivalent Control Group Design

Group	Pre-test	Treatment	Post-test
Experiment Class	Y_1	X_1	Y_2
Control Class	Y_1	X_0	Y_2

Information:

Y_1 : pre-test

Y_2 : post-test

X_1 : learning applies SETS integrated problem-based learning.

X_0 : conventional learning

The independent variable in this research is the SETS integrated problem-based learning model. Meanwhile, the dependent variable is creative thinking skills. Meanwhile, students' metacognitive awareness will be captured using the metacognitive awareness questionnaire developed by (Schraw & Dennison, 1994 in Bogdanović et al., 2015) and the results will be mapped and analysed descriptively.

The instruments used to collect research data were metacognition awareness questionnaires and creative thinking skills tests. The metacognition awareness questionnaire consists of 52 positive statements. The aspects measured in the questionnaire are knowledge of cognition and cognitive regulation. Cognitive knowledge includes indicators of declarative, procedural and conditional knowledge. Declarative knowledge refers to a person's ability to know something for real, while procedural knowledge is the ability to do something, while conditional knowledge is the ability to determine the right time when a particular strategy is applied (Anderson & Krathwohl, 2010). Furthermore, indicators of cognitive regulation include planning, information management strategies, monitoring of understanding improvement, and evaluation strategies. Each statement is answered by applying the Guttman

scale, namely choosing 'yes or no' (Sugiyono, 2017). Mapping the level of metacognitive awareness refers to Schraw (1998) which is presented in **Table 2**.

Table 2. Metacognitive Awareness Levels

Score Interval	Level	Term	Description
0 – 18	0	Undeveloped	Not yet lead to cognition.
19 – 36	1	At-risk	Seems to have no awareness of thinking as a process.
37 – 54	2	Poor	Unable to separate what he thinks from how he thinks.
55 – 72	3	Developed	Can be helped towards self-thinking awareness if stimulated or supported.
73 – 90	4	High	Aware of his thinking and can distinguish the input stages of self-elaboration and the output of his mind.
91 – 100	5	Excellent	Able to use metacognitive skills regularly to regulate their thinking and learning processes. Aware of many kinds of thinking possibilities, able to use them fluently and reflect on their thought processes.

The next instrument is a test sheet describing creative thinking abilities which was developed based on the Munandar, (2014) benchmark which includes indicators of fluency, elaboration, flexibility and originality. The derivatives of these indicators in the form of student learning behaviour are presented in Table 3.

Table 3. Creative Thinking Ability Behaviour

Indicator	Behaviour
Fluency	generate lots of ideas/answers
Elaboration	have new ideas detailing certain details
Flexibility	generate ideas, answers or questions from different points of view provide a different direction of thinking
Originality	provide a variety of answers that are unusual, different from the others and rarely given provide a variety of different directions of thought

The research began by mapping the level of metacognitive awareness of students in the experimental and control groups using a questionnaire developed by Schraw & Dennison, (1994). Next, students in both groups were asked to complete a pre-test of creative thinking skills adopted from Munandar, (2014). The experimental class then applied a problem-based learning syntax consisting of 5 stages (Arends, 2012) and the control class underwent conventional learning. Sequentially, the five syntaxes are problem orientation; organizing learning; guiding investigations; presenting work; and evaluating the problem solving process. The application of this syntax is based on the Science, Environment, Society and

Technology (SETS) approach. The research procedures carried out follow the flow chart as in **Figure 1**.

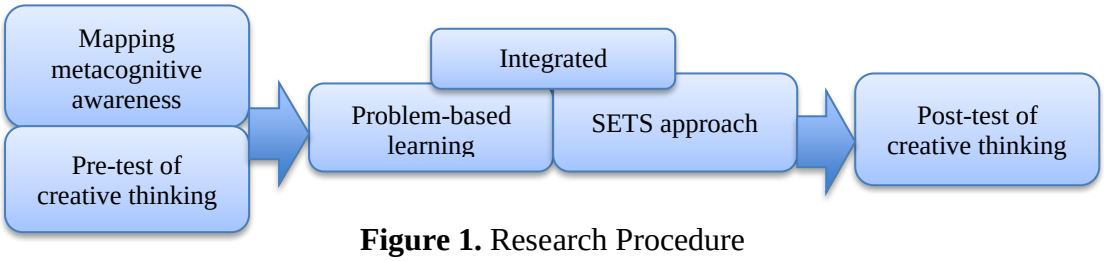

Figure 1. Research Procedure

Data from the metacognitive awareness questionnaire were mapped and linked descriptively with students' creative thinking skills scores. Meanwhile, data in the form of pre-test and post-test scores were analyzed to determine normalized gain. Determining normalized gain applies the formula:

$$N - Gain = \frac{posttest\ scores - pretest\ scores}{maximum\ score - pretest\ scores}$$

The n-gain score will then be interpreted based on the criteria as in Table 4.

Table 4. N-gain Score Criteria (Hake, 1998)

n-gain score	**Interpretation**
0,7 ≤ g ≤ 1	high
0,3 ≤ g < 0,7	medium
0,0 < g < 0,3	low
0	no increase occurred
g < 0	there was a decline

The interpretation of the effect size results will be analyzed based on the criteria outlined in Table 5.

Table 5. Cohen's d Score Criteria (Lovakov, 2021)

Effect size	**Interpretation**
0 < d < 0,2	small
0,2 < d < 0,8	medium
d > 0,8	large

Results and Discussion

Problem-based learning in this research refers to the syntax developed by (Arends, 2012) in Learning to Teach. Learning begins by orienting students to the problem by observing photos of piles of rubbish at the market near the school location. Next, students' learning activities are organized by the teacher by guiding them to analysis and formulate problems from the images given on worksheets. The next step is to ask students to collect information to solve the problem that has been previously formulated. Students who have

prepared a solution to the problem that was formulated at the beginning of the lesson are asked to explain it to all students in the class. At the same time, the teacher provides feedback questions to explore the preparation process and the effectiveness of the resulting solution.

The SETS approach is applied as an effort to ensure that all student activities in problem-based learning lead to solving problems that really exist around them. Students are guided through worksheets to recognize and analysis problems followed by formulating and communicating problem solutions. Based on these activities, students are given a pre-test and post-test to see changes in creative thinking skills before and after being given treatment. The results of the analysis of pre-test and post-test scores are shown in **Table 6**.

Table 6. Statistical Test Results on Pre-test and Post-test Scores

	Class	**x̄ ± Sd**	**Normality**	**Homogeneity**	***t-Test***	***Effect size***	**Interpretation**
Pretest	E	25 ± 7,03	*Sig.* 0,11 > 0,05	*Sig.* 0,13 > 0,05			
	K	20 ± 9.18	*Sig.* 0,18 > 0,05				
Posttest	E	71,92 ± 8,84	*Sig.* 0,07 > 0,05	*Sig.* 0,01 < 0,05	*Sig.* 0,00 < 0,05	2,044	large
	K	40,06 ± 15,47	*Sig.* 0,33 > 0,05				
N-gain	E	0,63 ± 0,11	*Sig.* 0,38 > 0,05	*Sig.* 0,00 < 0,05			
	K	0,24 ± 0,19	*Sig.* 0,64 > 0,05				

The information in **Table 6** shows that each pre-test and post-test score from the experimental and control classes is normally distributed. This can be seen from every sig. > 0.05. Furthermore, after going through homogeneity testing, it was seen that the research sample came from a homogeneous population. Where in Table 5 shows a sig. < 0.05. Based on the results of the normality and homogeneity tests, it was continued with the t test with a sig.< 0.05. The effect size test results indicate a large effectiveness interpretation with a value of 2.044, which means the independent variable has a significant influence on the dependent variable. The conclusion that can be drawn is that the SETS integrated problem-based learning model has a significant influence on students' creative thinking skills.

The results of the analysis above show that syntax in problem-based learning is proven to support the development of students' creative thinking skills. Through this syntax, students are trained to hone their creativity in formulating solutions to problems presented at the beginning of learning (Suharno et al., 2022). Apart from that, implementing the steps in problem-based learning also trains students in searching and finding appropriate references to develop a solution (Raehan et al., 2020). Students are seen taking full advantage of the use of devices and textbooks when discussing how to develop the best solution. Indirectly, this activity will accustom students to become independent learners, where they are able to choose

and determine independently what is needed to solve everyday problems (Egok, 2016). In addition, there is an information gathering stage that allows students to exchange ideas in a natural and collaborative atmosphere (Arends, 2012).

Table 7. Average n-gain Score for Each Creative Thinking Indicator

Indicators of Creative Thinking	Experimental Class	Control Class
Fluency	0,62	0,33
Flexibility	0,59	0,18
Originality	0,71	0,14
Elaboration	0,36	0,3

The results of the analysis of creative thinking skills scores are then mapped based on four indicators, namely fluency, flexibility, originality and elaboration (Munandar, 2014). Based on the information in table 7, it can be seen that the biggest change in scores in the experimental class occurred in the originality indicator, namely 0.71 which is in the high category. Meanwhile, the lowest increase in score occurred in the elaboration indicator, namely 0.36, which means moderate. Meanwhile, in the control class, the increasing score only reached the medium category, namely on the fluency and elaboration indicators (0.33 and 0.30). The data above directly concludes that students in the experimental class experienced a higher increase in creative thinking skills than the control class. This means that the implementation of SETS integrated problem-based learning has a real effect on students' creative thinking skills.

The results of observations in the experimental class learning showed that students developed fluency skills by generating ideas related to the impact of people who continuously breathe air with an AQI (Air Quality Index) of 168. Students were able to generate the idea that the person in question would experience respiratory system disorders such as asthma, coughing, and sore throat (Figure 2). It is strongly suspected that this achievement is related to the discussion activities carried out by students in developing ideas for solutions. By itself, discussions will hone students' abilities in providing relevant responses fluently based on the main problem. This finding is in line with the conclusion of the study which states that the activity of exchanging ideas can influence students' creative and critical thinking skills by correcting each other's statements (Wiono & Meriza, 2023). In addition, a person's fluency in responding to questions is a sign that the fluency indicator has developed (Munandar, 2014).

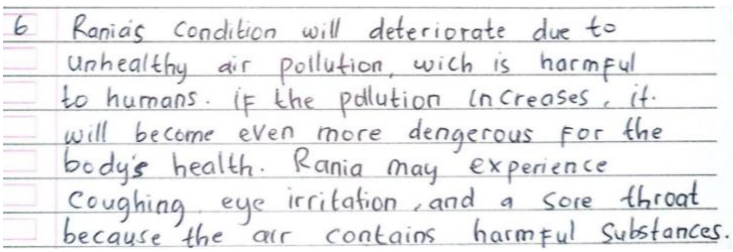
6 Rania's condition will deteriorate due to unhealthy air pollution, wich is harmful to humans. if the pollution increases, it will become even more dengerous for the body's health. Rania may experience coughing, eye irritation, and a sore throat because the air contains harmful substances.

Figure 2. Student Ideas for Fluency Indicators

Furthermore, the flexibility indicator appears when students generate ideas related to examples of cases where schools issue policies for school traders who are not allowed to use plastic. The answers produced by students meet the flexibility criteria because they use several different points of view (**Figure 3**). This is also related to the problem solving stages in the learning process. Students' habit of analyzing, searching for and determining the right answer will train their speed when faced with many alternative answers available (Trijaya, 2020).

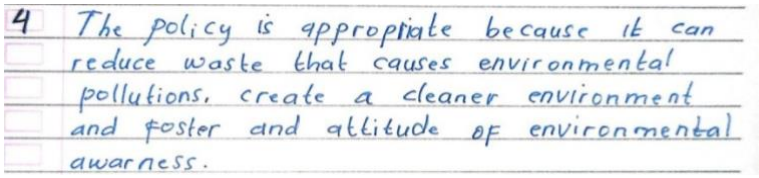

Figure 3. Student Ideas for Flexibility Indicators

The development of the originality indicator appears when students are able to come up with answers related to the noisy atmosphere caused by motor vehicle exhaust (**Figure 4**). Students indicate appropriate answers that are appropriate to local conditions. The use of problems that really exist and are close to students' lives is able to direct them to imagine solving problems and in accordance with the resources available in that place (Kalsum et al., 2019). Continuously, this behaviour will support the formation of strong creative thinking skills in students.

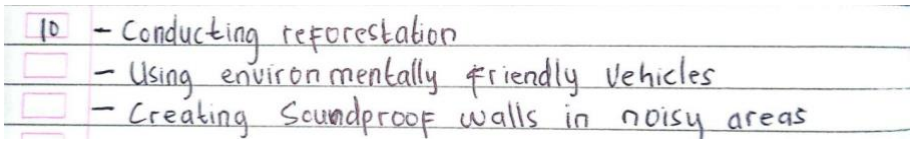

Figure 4. Student Ideas for Originality Indicators

Lastly, elaboration is characterized by someone being able to develop, add, detail and expand an idea. Students in this indicator are able to come up with detailed answers about the condition of cloudy water when given chlorine (**Figure 5**). This achievement is thought to be because there is a stage of detailing each group member's proposal when developing ideas for solving the problems presented (Lekman, 2020).

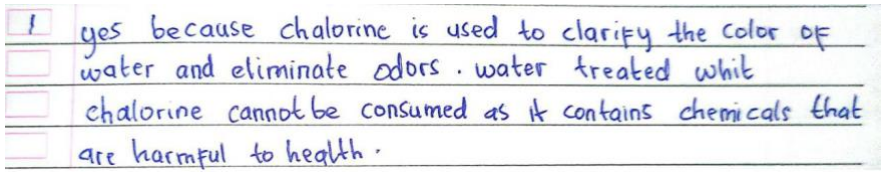

Figure 5. Student Ideas for Elaboration Indicators

Furthermore, the mapping results for each indicator of students' metacognitive awareness level in the experimental class are shown in Table 8. Based on the data in Table 8, it can be seen that overall students' metacognitive awareness shows a mean score of 3.90

rounded to 4, which means it is at a high level. It is no different when looking in more detail, where the indicators of knowledge about cognition and regulation of cognition, if rounded up, also get a score of 4 (3.86 and 3.95). Based on these data it can be concluded that all students are in a state of awareness of their thinking and can distinguish the input stages of self-elaboration and the output of their thoughts (Schraw & Dennison, 1994).

Table 8. Mapping Levels of Metacognitive Awareness Based on Indicators

Indicator	Average	Level
Knowledge about cognition	3,86	High
Procedural knowledge	3,84	High
Declarative knowledge	3,78	High
Conditional knowledge	3,97	High
Regulation of cognition	3,95	High
Information management strategies	3,69	High
Planning	4,10	High
Comprehension monitoring	3,89	High
Debugging strategies	3,98	High
Evaluation	4,08	High
Total	3,90	High

As stated by Moore (Lusiana et al., 2020) knowledge about cognition is a person's awareness of what he really knows, while regulation of cognition is related to how a person regulates his cognitive activities effectively. Referring to this definition, the 'high' level of metacognitive awareness is thought to be strongly related to student activities in learning, especially on syntax, problem orientation, learning organization and evaluating problem solving. These three syntaxes are closely related to metacognitive activities in solving problems formulated by Cohors-Fresenborg & Kaune, namely planning, monitoring and assessing (Sudjana & Wijayanti, 2018; Nurohmawati et al., 2023). The support of appropriate learning activities makes it possible to achieve learning goals quickly, in this case metacognitive awareness and creative thinking.

Meanwhile, the percentage of experimental class students with n-gain creative thinking scores at the metacognitive awareness level is presented in Figure 6. Each bar in the diagram depicts the percentage of students with a certain level of metacognitive awareness (developing, high, very good). Meanwhile, different colours on each bar indicate the percentage of students with a certain n-gain score category for creative thinking skills (moderate, high). Figure 7 informs that experimental class students are at varying levels of metacognitive awareness and creative thinking skills. The levels of metacognitive awareness found are developing, high, and very good, while the creative thinking categories are "moderate" and "high". It can be seen that as many as 69% of students are at the "high" level of metacognitive awareness where the group consists of students with n-gain scores for "moderate" (50%) and "high" (19%) creative thinking skills. At least, students are in the very good category and overall (12%) they are at the moderate n-gain level. The middle position is

a group of students with a developed level of metacognitive awareness which also consists of students with medium (15%) and high (4%) n-gain. This finding also supports the results of previous studies (Wiono & Dewi, 2023) which concluded that students at the junior high school level are already able to manage their thinking processes and are aware of the possibility of other ways of thinking.

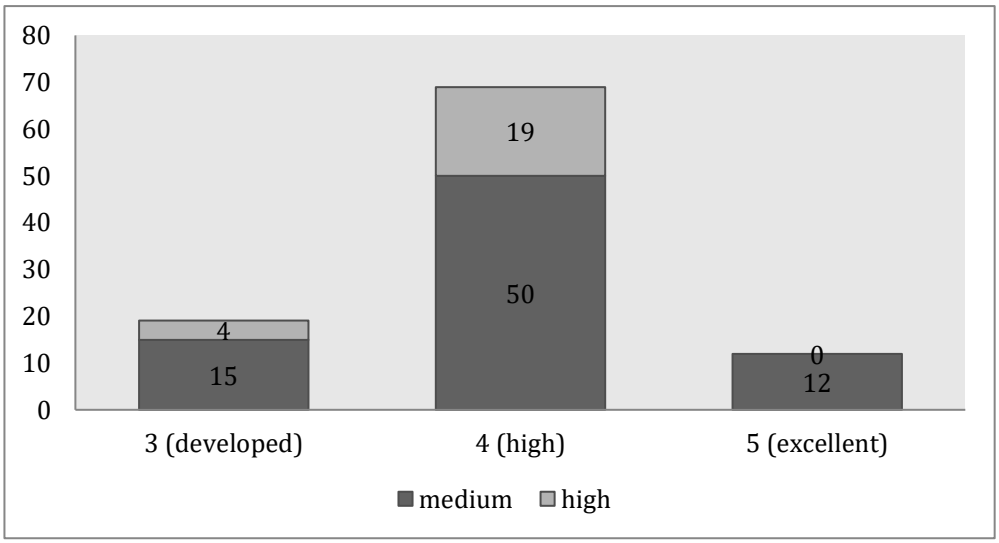

Figure 6. Distribution of Metacognition Awareness of Creative Thinking Skills

Problem solving activities are closely related to the use of metacognitive abilities. Especially in biology subjects, metacognition is really needed when students carry out investigations in observing living creatures (Damopolii et al., 2020). Students with a good level of metacognitive awareness are characterized by the emergence of behaviour in the form of the ability to determine appropriate and effective learning strategies to achieve learning goals (Nawawi et al., 2021; Wiono & Meriza, 2022). Based on the information in Figure 7, it can be seen that more than half of the students who were at the 'high' level of metacognitive awareness experienced a significant increase in creative thinking scores (n-gain). This means that students in the class are aware of their thinking and are able to differentiate the stages of elaboration and output of their thinking (Schraw & Dennison, 1994). The connection with creative thinking skills is the formation of awareness to improve the output of one's thinking to become a new, better output. This also has an impact on students' ability to identify their deficiencies carefully and determine appropriate strategies to correct these deficiencies.

The results of this study have significant implications for teaching practices. By understanding the critical role of metacognitive awareness in enhancing students' creative thinking skills, it is essential to create a learning environment that fosters exploration, inquiry, and reflection on their learning processes. Teachers should also provide constructive and specific feedback so that students can understand their strengths and weaknesses and develop effective learning strategies.

Conclusion

It can be seen, based on the analysis above, that the syntax in problem-based learning which is integrated with the SETS approach is able to have a significant influence on the development of students' creative thinking skills at Al-Huda Middle School. Apart from that, looking at the research data, it was revealed that students with metacognitive awareness at the 'high' level experienced the highest changes in behaviour between the 'developed' and 'excellent' levels. The results of this research show that environmental problems that are close to students' lives, when packaged systematically using a problem-based learning model, will be able to develop students' creativity in developing the best solutions. Analysis of the level of metacognitive awareness also shows that students' ability to recognize learning difficulties will direct them to determine the appropriate improvement strategy to choose.

Credit Authorship Contribution Statement

Wisnu Juli Wiono: Coordinator Conceptualization, Methodology, Software, Visualization, Formal analysis, Writing – original draft, Writing – review & editing. **Ismi Rakhmawati**: Director Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Dewi Sinta Rahayu**: Executor Conceptualization, Formal analysis, Resources, & Project administration.

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