

An Application of Problem-Solving Based Student Facilitating and Explaining Teaching Model to Improve Students' Metacognitive Ability

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Abstract: This research aims to reveal (1) the impact of implementing the student facilitating-and-explaining teaching model based on problem-solving on the improvement of students' metacognitive abilities, (2) the profile of metacognitive abilities, and (3) students' responses. This research is a quasi-experiment with a nonequivalent control group design. The sample was established using the simple random sampling technique, resulting in one control group and one experimental group. Research data were obtained from pretest and posttest scores of metacognitive abilities, the MAI self-assessment questionnaire, and students' response questionnaires. The t-test results show that the t_{count} is higher than t_{table} , indicating a significant difference between the post-test scores of the experimental and control groups. Additionally, the profile of students' metacognitive abilities before the learning process was mostly in the low and sufficient criteria, while after the implementation of the learning model, metacognitive abilities were mostly in the good criteria. The research findings were also supported by students' response questionnaire, with an 80.66% rating in the good category. In conclusion, the student facilitator and explaining model based on problem-solving have a significant impact on the improvement of students' metacognitive abilities.

Keywords: metacognition, problem-solving, student facilitator and explaining

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INTRODUCTION

The teaching-learning process is related to the development of skills needed to face future challenges such as 21st-century skills. According to the National Research Council (2014), 21st-century skills that are recommended to be developed in the learning process include adaptability, communication skills, problem-solving skills, self-development, and thinking skills. These skills are closely related to students' metacognition abilities in learning (Alt et al., 2022). This is reinforced by Permendikbud No. 20 of 2016 concerning Graduate Competency Standards for Primary and Secondary Education, which emphasizes the inclusion of metacognitive achievements as new aspects of knowledge that must be emphasized in learning.

According to (Alt et al., 2022), metacognitive ability is a high-level thinking ability where a person consciously thinks about knowledge and how to obtain it. Based on the results of research conducted by Sukarno & Widdah (2020), students' metacognition is still low which is indicated by the absence of management in students to plan what to do after getting homework. On the other hand, teachers also do not know and pay less attention to the introduction of metacognition in teaching so students do not understand how to use their metacognitive ability to solve problems (Clabough & Clabough, 2016). Indeed, metacognition plays a crucial role in the teaching and learning process because a sufficient understanding of cognitive processes is required for the development and selection of learning strategies. The proper selection of learning strategies allows students to use them effectively.

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However, the low level of metacognitive abilities serves as a trigger for the ineffectiveness of students' learning strategies (Uchinokura, 2020).

Pre-research observations conducted by researchers at SMP Negeri 32 Semarang found that the metacognitive ability of most grade VIII students [was^[A1]] still relatively low. Students with good metacognitive ability only amounted to 35% of the total number of students in one class, namely 32. In other words, only 11 to 12 students had good metacognitive ability. The results of interviews with science subject teachers found that eight students in one class did not submit assignments. This proves that students have not realized the thinking process within themselves, and do not know what to solve, and how to solve it (metacognition level 1). One of the factors causing this is the use of metacognitive ability that has not been optimized by students.

Metacognitive ability is related to metacognitive awareness. Meanwhile, metacognitive awareness is interrelated with problem-solving skills. Abdullah et al (2021) states that metacognitive ability is related to the appropriate use of certain learning strategies. Learner learning strategies are activities carried out in the learning process that aim to achieve learning objectives effectively and efficiently. In this way, the low metacognitive ability of students can be improved by using a good learning process. One of them is using a cooperative learning model that is centered on students.

The cooperative learning model has many types that can be used in the learning process, one of which is the student facilitator and explaining type of cooperative learning model. According to Harefa (2021), the student facilitating-and-explaining teaching model can train students to convey their ideas to their friends. Some of the advantages of the student facilitating-and-explaining teaching model according to Wrahatnolo & Munoto (2018) include training students to become facilitators, the material presented being clearer and more concrete, its ability to increase the absorption of students, students being able to find out their ability to convey ideas, and students becoming motivated to explain the material well.

The student facilitating-and-explaining teaching model can be combined with the problem-solving method to make learning more active and interesting. The advantages of problem-solving-based learning are training students to deal with problems that arise spontaneously, and training students to be active, creative, and responsible (Kai et al., 2021).

Based on research conducted by Supeno et al (2023), the student facilitating-and-explaining teaching model assisted by Edmodo shows a positive effect on students' problem-solving skills during learning. The research conducted by Yang & Sianturi (2019) found that the application of the problem-solving learning model had a positive impact on the improvement of students' chemistry learning outcome and it could improve metacognitive ability while increasing students' activities. Based on the research conducted by Männistö et al (2020) only the effects of the student facilitator and the explaining the learning model on problem-solving skills or the impact of problem-solving on students' metacognitive ability have been examined. Specifically, these studies have not integrated all three variables simultaneously. However, as problem-solving is closely related to students' metacognitive ability, it is essential to integrate the student facilitating-and-explaining teaching model, and problem-solving components. This integration can enhance the effectiveness of improving students' low metacognitive ability.

Based on the potential of the innovative student facilitating-and-explaining teaching model with problem-solving methods that are interconnected with problem-solving skills and metacognitive abilities, as described earlier, and the need to enhance students' metacognitive abilities, the researcher needs to conduct a study to applying problem-solving-based student facilitating-and-explaining teaching model for improving students' metacognitive ability. The advantage of this model is that it increases activity, that students can find out their ability to convey ideas, and that it trains students to deal with a problem. Close problem-solving concerns students' metacognitive abilities, so it is deemed necessary that there be integration between the student facilitating-and-explaining teaching model and problem-solving in order to increase students' metacognitive abilities. [A2]This research aims to reveal (1) the impact of implementing the student facilitating-and-explaining teaching model based on problem-solving on the improvement of students' metacognitive abilities, (2) the profile of metacognitive abilities, and (3) students' responses to the application of this model.

RESEARCH METHOD

The research was conducted at SMP Negeri 32 Semarang in the second semester of the academic year 2022/2023. The population comprised all eighth-grade classes at SMP Negeri 32 Semarang. The sample was established using the simple random sampling technique. This technique is applicable when the population is considered homogeneous, therefore a homogeneity test was conducted initially. The results of the homogeneity test, based on the Final Semester Assessment scores, indicated that the population was homogeneous. Following confirmation of the homogeneity of the population, two sample groups were selected: class VIII B served as the experimental group, while class VIII A served as the control group. In the experimental group, students received treatment with the problem-solving-based student facilitating-and-explaining teaching model. Conversely, in the control group, students received treatment with the learning model employed by the science teacher in that class, namely the direct instruction model.

This study was experimental research. The research design used was a quasi-experiment with a nonequivalent control group design. The research design is shown in Figure 1 (Creswell, 2014).

Experiment	O1	X	O2
Control	O3	Y	O4

Figure 1. The Research Design

Where: Q1 = metacognitive ability in the experimental group before treatment, O2 = metacognitive ability in the experimental group after treatment, O3 = metacognitive ability in the control group before treatment, O4= metacognitive ability in the control group after treatment, X = treatment using problem-solving-based student facilitating-and-explaining teaching model, and Y = treatment using direct instruction model.

In this research, the data collection used a test of metacognitive abilities as well as an MAI self-assessment questionnaire and student response questionnaire to the problem-solving-based student facilitating-and-explaining teaching model. The type of data and data collection methods can be seen in Table 1.

Table 1. The Type of Data and Data Collection Methods

Data Type	Data Collection Methods	Instrument	Time
The impact of implementing the problem-solving-based student facilitator and explaining model on the increase of students' metacognitive abilities	Test	Metacognitive ability test questions	Before and after treatment
Profile of students' metacognitive abilities	Questionnaire	MAI metacognitive ability test and self-assessment questionnaire questions	Before and after treatment
Student responses to the learning model applied	Questionnaire	Student response questionnaire sheet	After treatment

The test used was a pretest and posttest question instrument regarding vibration, wave, and sound material. The metacognitive ability test consists of 20 open-ended multiple-choice questions that have been validated by five experts. These questions were developed referring to indicators of metacognitive ability according to Haryani (2012) and also indicators of competency achievement in vibration, wave, and sound materials.

The questionnaires used were the MAI self-assessment questionnaire and the student response questionnaire. The MAI self-assessment questionnaire (Metacognitive Awareness Inventory) is a questionnaire to measure students' metacognitive abilities developed by Schraw & Dennison (1994). The MAI self-assessment questionnaire consists of 52 statements covering all aspects of metacognitive abilities. The students responded to 20 statements with four answer choices, namely "strongly agree", "agree", "disagree", and "strongly disagree". These instruments have been declared valid by experts and can be used to collect research data.

The impact of implementing the problem-solving-based student facilitating-and-explaining teaching model on the improvement of students' metacognitive abilities can be seen from the t-test and N-gain values. Data were analyzed using Microsoft Excel with parametric statistical tests of normality, homogeneity, and t-test. To determine the significance of the research results, a comparison of t_{count} and t_{table} was carried out. If $t_{count} \geq t_{table}$ with $dk = (n1 + n2) - 2$ and a significance level of 5%, then H_1 was accepted, indicating a significant difference between the post-test scores of the experimental and control groups.

N-Gain was used to find out how much the students' metacognitive abilities had increased by paying attention to the pre-test and post-test scores. The calculation of N-Gain is shown as follows:

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

The criteria of N-Gain are shown in Table 2 by Meltzer (2002).

Table 2. Criteria of N-Gain

Score	Criteria
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Moderate
$g < 0.3$	Low

Students' metacognitive profiles can be assessed using the results of the Metacognitive Awareness Inventory (MAI) test questions and self-assessments, which include metacognitive indicators. Analysis of metacognitive ability scores was conducted by calculating the percentage achievement for each indicator. The percentage of success was obtained using the following formula:

$$P = \frac{score}{score\ max} \times 100\%$$

This formula allows for a quantitative evaluation of students' metacognitive abilities based on their performance on the MAI test questions and self-assessments. The criteria for the level of achievement of metacognitive indicators are categorized as shown in Table 3 by Song, J. H., Loyal, S., & Lond (2021).

Table 3. Criteria for Achievement of Metacognition Indicators

Percentage	Criteria
$80\% < P \leq 100\%$	Very Good
$60\% < P \leq 80\%$	Good
$40\% < P \leq 60\%$	Sufficient
$20\% < P \leq 40\%$	Poor
$0\% \leq P \leq 20\%$	Very Poor

The analysis of students' responses was carried out by calculating the total scores obtained on the questionnaire sheet that has been filled in by students using the percentage formula as above. Student response criteria can be seen in Table 4 by Arikunto (2018).

Table 4. Student Response Criteria

Percentage	Criteria
$81.25\% < P \leq 100\%$	Very Good
$62.50\% < P \leq 81.25\%$	Good
$43.75\% < P \leq 62.50\%$	Sufficient
$25\% \leq P \leq 43.75\%$	Poor

FINDINGS AND DISCUSSION

The Impact of Problem-Solving-Based [A3] Student Facilitating-and-Explaining Teaching Model on the Improvement of Students' Metacognitive Ability

The impact of applying the student facilitating-and-explaining teaching model on problem-solving was analyzed through the compilation of metacognitive ability test scores based on students' metacognitive ability indicators. The results of the analysis revealed that the average metacognitive ability score of students in the experimental group was higher than that of the control group. The results of the pretest and posttest data analysis of students' metacognitive abilities, based on the questions, yielded an average value of 37 for the experimental group and 36 for the control group. Following treatment in both the experimental and control groups, the average posttest value increased to 69 in the experimental group and 54 in the control group.

The pretest and posttest scores on metacognitive ability were then analyzed for normality to determine whether the data were normally distributed or not. This analysis was necessary to determine the appropriate type of data analysis for the next steps. The results of the normality test can be seen in Table 5.

Table 5. Normality Test of Pretest and Posttest Data

Data	Group	X^2_{count}	X^2_{table}	Criteria
Pretest	Experiment	7.30	11.07	Normal
	Control	8.09		Normal
Posttest	Experiment	3.23	11.07	Normal
	Control	8.52		Normal

Table 5 shows the normality test of the pretest and post-test data obtained by $X^2_{count} < X^2_{table}$, so the data are declared normally distributed. The results of the normality test analysis confirmed that the pretest and posttest data were normally distributed, enabling further analysis with parametric statistics, namely the related t-test. The t-test-related test is used to determine whether or not there is a significant difference in the application of the problem-solving-based student facilitating-and-explaining teaching model. Significant differences can be seen by determining the result t_{count} which are compared with t_{table} , then determined by the test criteria that H_0 is accepted if $t_{count} < t_{table}$ which means there is no significant difference, and H_1 is accepted if $t_{count} \geq t_{table}$ which means there is a significant difference in the resulting data. The results of the related t-test can be seen in Table 6.

Table 6. Results of Related T-test

Group	Average	t_{count}	t_{table}	Description
Experiment	69	5.00	2.00	There is a significant difference
Control	54			

Table 6 shows that there is a significant difference in the application of the problem-solving-based student facilitating-and-explaining teaching model for improving students' metacognition abilities after treatment because the results of $t_{count} > t_{table}$. The impact of this learning model's application is discernible due to the marked observed disparity between the experimental and control groups. This disparity stems from the differing treatments administered to the two groups: while the experimental group engaged in learning activities utilizing the problem-solving-based student facilitating-and-explaining teaching model, the control group followed direct instruction of the learning model. [A4]

According to (Suyatno, 2009) in his book entitled *Menjelajah Pembelajaran Inovatif*, the syntax of the student facilitating-and-explaining teaching model consists of 1) competency information, 2) presentation of material, 3) students developing and explaining to other students, 4) conclusion and evaluation, and 5) reflection. The student facilitating-and-explaining teaching model combined with problem-solving make learning activities in the experimental group more active and can facilitate students to improve their metacognitive ability. The problem-solving steps listed on the experimental group worksheet used in this study refer to Polya. G. (1973) which consists of understanding the problem, making a plan, implementing the plan, and checking back. The enthusiasm and active participation of students in the implementation of the student facilitating-and-explaining teaching

model are marked as a form of understanding of the discussed learning material (Hajar, S., & Sukma, 2020).

The average pretest and posttest scores in the experimental and control groups increased, indicating an improvement in metacognitive abilities after the implementation of the model. The improvement of students' metacognitive ability can be analyzed using N-Gain. The result of improvement in metacognitive abilities in the experimental group is classified as moderate, while that in the control group is classified as low, as shown in Table 7. [A5]

Table 7. [A6] N-Gain of Metacognitive ability

Group	Average		N-Gain	Criteria
	Pretest	Posttest		
Experiment	37	69	0.52	Moderate
Control	36	54	0.29	Low

The improvement in metacognitive abilities in the experimental group is higher compared to that in the control group, as shown in Table 7 [A7]. The *n*-gain value for the experimental group is 0.52, indicating a moderate criterion, while for the control group, it was 0.29, indicating a low criterion. The improvement of students' metacognitive abilities was also measured using *n*-gain, which was analyzed for each indicator. The indicators of metacognitive abilities in the test questions refer to the indicators of metacognition according to Haryani (2012). The results of the *n*-gain analysis for each indicator can be seen in Figure 2. [A8]

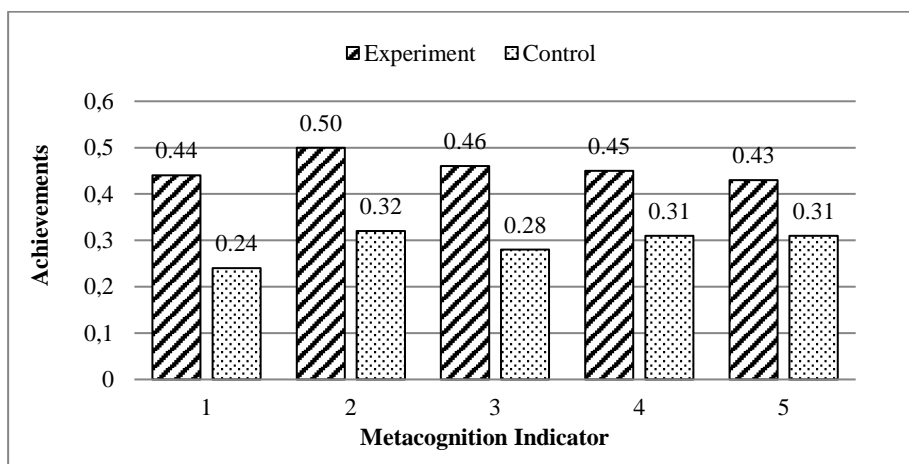


Figure 2 [A9]. Average N-Gain of Each Indicator

Description of metacognition indicators:

Level 1: Being aware of the thinking process and being able to describe it

Level 2: Developing recognition of thinking strategies

Level 3: Reflecting evaluatively on procedures

Level 4: Transferring experience, knowledge, and procedures to other contexts

Level 5: Connecting conceptual understanding with procedural experience

A complete explanation of the *n*-gain for each indicator of metacognitive ability is shown in Figure 2.

1. *Being Aware of Thinking Processes and Being Able to Describe Them*

In this indicator, the experimental group experienced a higher increase because the learning process utilizing the problem-solving-based student facilitating-and-explaining teaching model incorporates steps designed to enhance students' level 1 metacognition. The information conveyed by the teacher regarding competencies can effectively train learners' metacognitive ability at level 1 sublevel 1, which involves articulating the goals to be achieved. Through this initial stage, students become aware of the benefits and objectives to be attained following the learning process. According to Jin & Kim (2021), the essence of metacognitive ability lies in recognizing the necessity to comprehend the objectives and engage in critical thinking during learning. Moreover, the succinct

presentation of material by the teacher during this stage contributes to heightened awareness of students' thought processes. This activity fosters learners' awareness to contemplate the material they are about to engage with, further promoting metacognitive development.

Level 1 metacognition indicators can also experience an increase due to the stage of development and explanation to other students. During this phase, students engage in understanding and identifying problems within the problem-solving-based student worksheet. This process contributes to the enhancement of level 1 metacognitive abilities. By working through problem-solving-based worksheets, students become adept at recognizing the information presented within the problem, thereby gaining a clear understanding of what needs to be solved and how to approach it.

2. *Developing recognition of thinking strategies*

The increase in this indicator in the experimental group is higher due to the inclusion of a stage where students develop and explain concepts to their peers. Within the experimental group setting, students engage in refining their thinking strategies to effectively process and convey information to their classmates. Research suggests that learners who possess awareness of their metacognitive abilities tend to think more effectively and strategically compared to those who lack such awareness (Uchinokura, 2020). This suggests that the opportunity for students to engage in collaborative learning activities, such as explaining concepts to others, contributes significantly to the development of their metacognitive skills, ultimately resulting in greater improvement in this indicator within the experimental group.

Level 2 metacognitive abilities can also experience growth through problem-solving-based worksheets, particularly in the step involving creating a plan. The teacher presents problems related to the learning material on optical devices; then, students conduct investigations as scientists would. Students conduct their investigations according to the activities outlined in the student worksheets that have been developed. The activities in the student worksheets are designed based on beneficial problems to develop skills in identifying variables, formulating hypotheses, designing experiments, conducting experiments, designing data tables, analyzing data, and concluding (Alt et al., 2022). The process of devising a plan contributes to the enhancement of metacognitive abilities as it entails monitoring the progression of thoughts and strategizing to ensure the formulation of an effective plan (Schwchow et al., 2022).

3. *Reflecting evaluatively on procedures*

The increase in the experimental group is higher because the problem-solving-based student facilitating-and-explaining teaching model incorporates discussions during the problem-solving process within the problem-solving-based worksheet. Although discussions also occurred in the control group while working on worksheets, the tasks were simpler as they were based on direct instructions.

In the experimental group, discussions during the problem-solving process train students in data compilation, interpretation, and overcoming obstacles in problem-solving. These discussions involve each group analyzing information and data from experiments. The students' proficiency in interpreting data is evident in their ability to interpret scientific evidence by organizing experimental data in tabular form (Warliyah et al., 2023). According to Heeg & Avraamidou (2023), discussion is a high-level thinking skill essential for helping individuals solve the problems they encounter.

The inference and evaluation stages within the problem-solving process can further develop level 3 metacognition indicators. Students with strong metacognitive skills can effectively plan, monitor, and evaluate their learning activities (Alt et al., 2022). Additionally, the reflection stage in learning activities contributes to the enhancement of level 3 metacognition. (Hettithanthri et al., 2023) state that components such as reflecting and monitoring thinking support the development of metacognitive abilities.

4. *Transferring experience, knowledge, and procedures to other contexts*

The increase in this indicator in the experimental class was higher due to the discussion activities, which engaged students in problem-solving and facilitated the transfer of experience, knowledge, and procedures to other contexts or various problems. Through discussions aimed at finding solutions to problems and applying them to problem-solving-based LKPD sheets, students applied their understanding of vibration, wave, and sound material to specific situations. The discussion technique effectively supports knowledge transfer within the learning process (Hansson et al., 2020).

During the implementation phase of the plan found in the problem-solving-based student worksheet, students' abilities can also be enhanced in transferring experiences, knowledge, and

procedural skills to different contexts. The presence of experimental activities or practical work can improve students' science process skills such as observation, measurement, analysis, and hypothesis-making (Warliyah et al., 2023). Different contexts or various problems found in the problem-solving-based student worksheet encourage students to use different operations to solve the same problem, use the same operations or procedures for other problems, develop procedures for the same problem, and apply understanding to a situation. Uchinokura (2020), as cited in (Abdullah et al., 2021), highlights the relationship between metacognitive ability and learning transfer, emphasizing the ability to apply acquired knowledge in different situations.

5. *Connecting conceptual understanding with procedural experience*

The increase in the experimental group was higher due to the stage of implementing the plan and documenting the results on the problem-solving-based worksheet completed by students. At this stage, implementing the problem-solving plan and documenting the outcomes on the problem-solving-based worksheet could enhance level 5 metacognitive ability. The inclusion of a rechecking stage conducted at the final step to review all problem-solving procedures undertaken could also contribute to the improvement of level 5 metacognitive ability. During this stage, students re-monitor the problem-solving methods utilized, analyzing their efficiency and effectiveness. According to (Uchinokura, 2020), learners' metacognitive skills can be reinforced through activities such as re-monitoring, re-planning, self-reflection, and re-evaluating their learning processes. All steps involved in the problem-solving process undertaken by learners represent characteristics of metacognition (Tsai et al., 2021).

Profile of Metacognitive Ability of Learners Before and After Applying the Problem-solving-Based Student Facilitating-and-explaining Teaching Model

The profile of metacognitive ability is measured before and after the application of the student facilitating-and-explaining teaching model based on problem-solving. The profile of students' metacognitive ability is determined from their responses to the metacognitive ability test questions and the MAI self-assessment questionnaire. The metacognitive profile is based on the achievement of metacognitive indicators adapted from Haryani (2012) and Schraw & Dennison (1994).

A comparison of the profile of students' metacognitive abilities at level 1 indicators, such as realizing the thinking process and being able to describe it, both before and after applying the problem-solving-based student facilitating-and-explaining teaching model, can be seen in Figure 3.

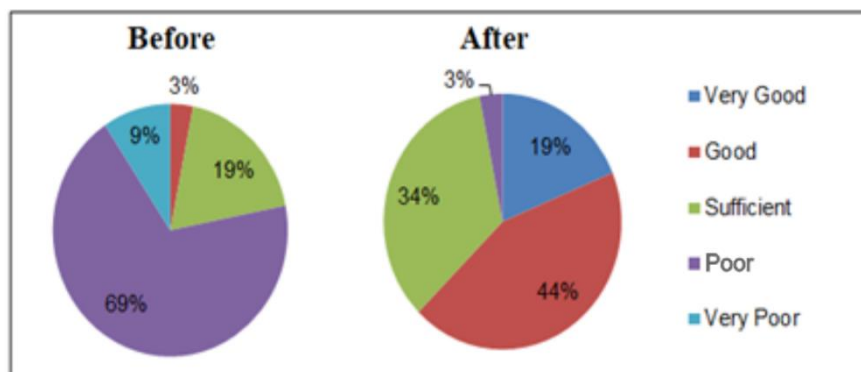


Figure 3. Comparison of Indicator Profile 1

Figure 3 shows that the profile of level 1 indicators in students after treatment is better than that before treatment whereas after being treated students with good and very good metacognitive ability are more than before treatment. The application of the problem-solving-based student facilitating-and-explaining teaching model supports the profile of metacognitive ability, especially at level 1 indicators, to be better. This level 1 indicator is represented by sublevel 4, namely identifying information, and sublevel 5, namely choosing the operation or procedure used. The stage of understanding the problem in the problem-solving-based worksheet in this learning activity leads students to be able to identify information on the problems presented. Students actively analyze existing problems with their friends in the group. The planning stage can also facilitate them to look for references from various relevant sources to determine the right operation or procedure to use so that they realize the thought process in solving a problem and realize that solving problems requires a lot of references.

The percentage profile of metacognitive ability in indicator 1 before being given treatment is shown in Figure 3. Most students are in the insufficient criteria. They can only realize the thinking process in themselves but they cannot describe it well. This means that students have been able to identify the information they get but have not been able to choose the right procedure or operation to solve a problem. This is indicated by the answers of the students who are still wrong in writing the problem-solving procedure on the pretest question.

A comparison of the profile of students' metacognition abilities on level 2 indicators of developing recognition of thinking strategies both before and after treatment can be seen in Figure 4.^[A10]

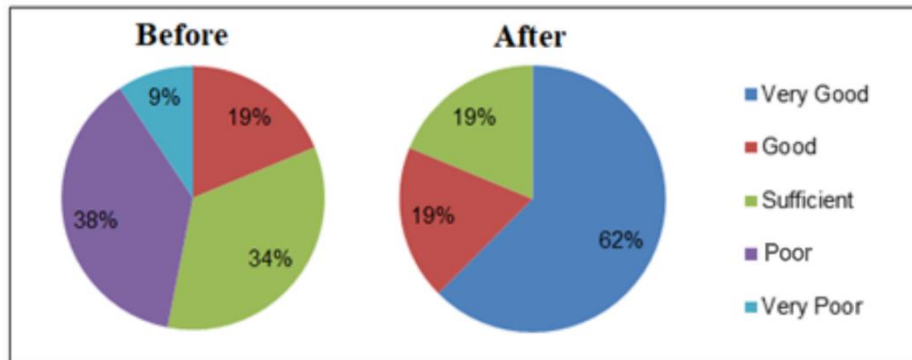


Figure 4. Comparison of Indicator Profile 2

The indicator that represents level 2 is sublevel 2 elaborating information from various sources. Figure 4 shows that the percentage of students after treatment on level 2 indicators with good and very good criteria is more than that before treatment. The profile of level 2 metacognitive ability after treatment is better than that before treatment due to the problem-solving-based student facilitating-and-explaining teaching model applied in learning. The stage of developing and explaining to other students in this learning trains students to develop what they understand and develop their thinking strategies to be able to explain the material well to their groupmates. Their enthusiasm to become learning facilitators can prove that the development of their thinking strategies is going well.^[A11]

A comparison of the profile of students' metacognition abilities on level 3 indicators of reflecting on procedures evaluatively both before and after treatment can be seen in Figure 5.^[A12]

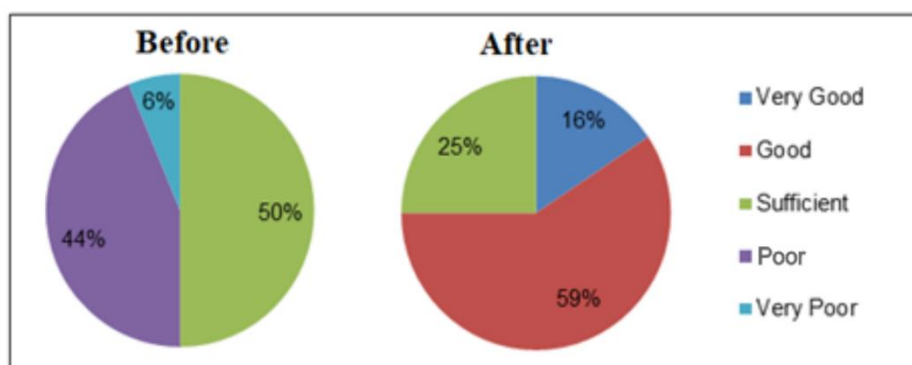


Figure 5. Comparison of Indicator Profile 3

The third indicator of metacognitive ability is reflecting on procedures evaluatively. Sublevels that represent level 3 indicators are compiling and interpreting data (sublevel 2) and evaluating the procedures used (sublevel 3). Figure 5 shows that the percentage of students after treatment on level 3 indicators with good and very good criteria is more than that before treatment. Before being given treatment, students could not compile and interpret data properly and could not evaluate the procedures used in solving problems. The application of the problem-solving-based student facilitating-and-explaining teaching model has an impact on the metacognitive abilities of students on the indicator of evaluatively reflecting on procedures. The evaluation and reflection stage in problem-solving-based

student facilitation and explaining learning enables students to evaluate the problem-solving procedures that have been carried out and enable them to monitor how the learning process is. Gholam (2019) state that reflection and monitoring thinking can support the development of metacognitive ability.^[A13]

The comparison of the profile of students' metacognition abilities at level 4 indicators transferring experience, knowledge, and procedural in other contexts both before and after treatment can be seen in Figure 6.^[A14]

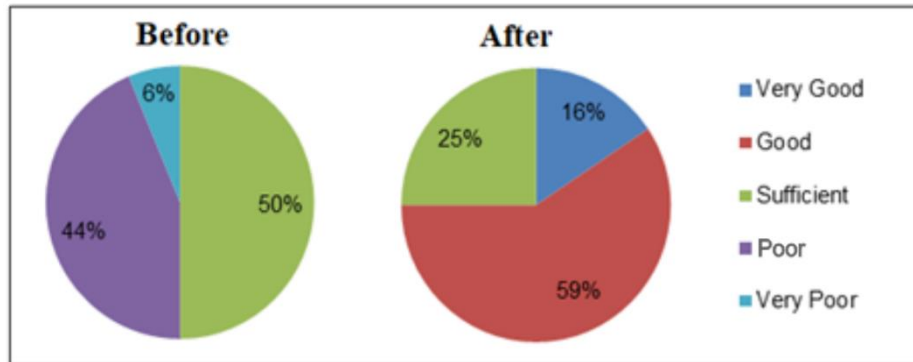


Figure 6. Comparison of Indicator Profile 4

The fourth indicator of metacognitive ability is transferring experience, knowledge, and procedures in other contexts. After the application of the problem-solving-based student facilitator and explaining model, the percentage of the number of students at level 4 indicators with good and very good criteria is greater than that before the application of the learning model as can be seen in Figure 6. This shows that the application of the problem-solving-based student facilitating-and-explaining teaching model has an impact on students' metacognitive ability on level 4 indicators. Indicators that represent level 4 include using the same operation or procedure for other problems (sublevel 2) and applying understanding to a situation (sublevel 4). Based on the research that has been done, students can work in the same way on several different problems. This is because the questions contained in the posttest have almost the same type of problem as the practice questions and quiz questions during learning. In addition, students can apply their understanding to certain situations according to the problems. Wrahatnolo & Munoto (2018) state that students' understanding will increase in line with the increase in higher metacognitive abilities.^[A15]

A comparison of the profile of students' metacognitive abilities at level 5 indicators connecting conceptual understanding with procedural experience both before and after treatment can be seen in Figure 7.^[A16]

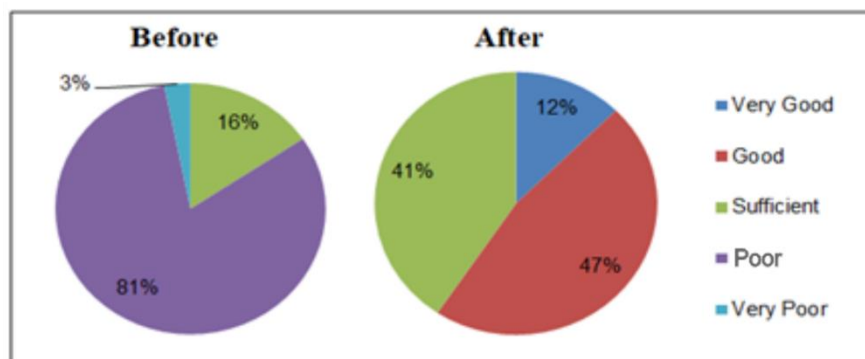


Figure 7. Comparison of Indicator Profile 5

The fifth indicator of metacognitive ability is the ability to connect conceptual understanding with procedural experience. The indicator representing level 5 involves linking observation data with discussion (sublevel 1) and analyzing the efficiency and effectiveness of procedures (sublevel 2). Figure 7 shows that the percentage of students after treatment on level 5 indicators with good and very good criteria is higher compared to that before treatment. Students who meet this level 5 metacognitive indicator have high learning outcomes. Jin & Kim (2021) state in their research that students with high

metacognitive abilities also have high learning outcomes. This achievement is obtained because students can link the data found in the problems to solve an issue.^[A17]

Overall, the profile of students' metacognitive abilities in each indicator is getting better than it is before treatment. The following are the results of the analysis of the comparison of students' metacognitive ability profiles both before and after treatment which can be seen in Figure 8.^[A18]

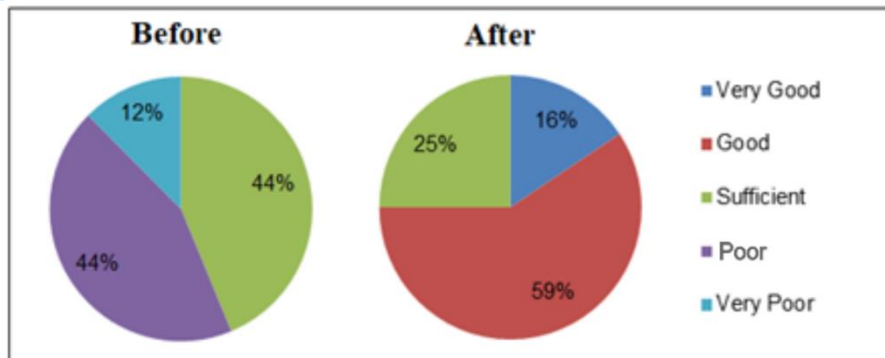


Figure 8. Comparison of Metacognitive Ability Profile

Based on Figure 8, the profile of metacognitive abilities of students in the experimental group before the implementation of the student facilitating-and-explaining teaching model based on problem-solving mostly fell into the poor and sufficient categories. Whereas the profile of metacognitive abilities of students in the experimental group after the implementation of the student facilitating-and-explaining teaching model based on problem-solving mostly fell into the good category. Therefore, this research can be considered successful because it has met the criteria for research success.^[A19]

The profile of students' metacognitive abilities both before and after treatment of the problem-solving-based student facilitating-and-explaining teaching model on vibration, wave, and sound material is also analyzed based on the MAI self-assessment questionnaire. The result of the analysis of each metacognition indicator based on the MAI self-assessment questionnaire both before and after treatment is presented in Figure 9.

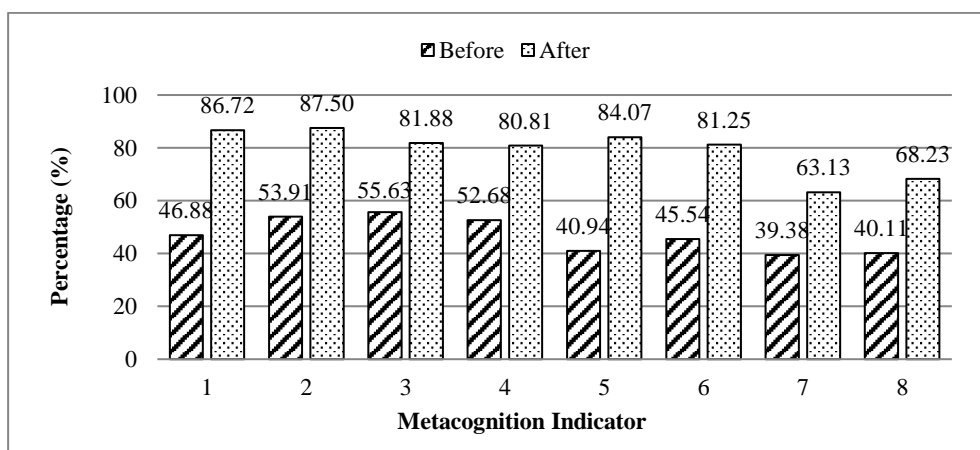


Figure 9^[A20]. Proportion of Achievement of Each Metacognition Indicator Based on the MAI Self-Assessment Questionnaire

Description of metacognition indicators:

Indicator 1: Declarative knowledge

Indicator 2: Procedural knowledge

Indicator 3: Conditional knowledge

Indicator 4: Planning

Indicator 5: Information processing strategy

Indicator 6: Comprehension monitoring

Indicator 7: Improvement strategy

Indicator 8: Evaluation

The profile of level 1 metacognitive ability indicators is supported by the results of the MAI self-assessment questionnaire which shows that the achievement of planning indicators after treatment is better than that before treatment as can be seen in Figure 9. The achievement of planning indicators before treatment is in the sufficient criteria and that after treatment is in the excellent criteria. Based on these results, before being given treatment using the problem-solving-based student facilitating-and-explaining teaching model, students felt they had sufficient ability to plan learning activities, while after the treatment the ability to plan their learning activities increased to be very good. Planning indicators are seen during learning activities when students in groups plan a way to solve the problems presented in the problem-solving-based worksheet. This planning activity can be said to be a form of awareness for students about the learning process on their own.

The profile of level 2 metacognitive ability indicators is supported by the results of the MAI self-assessment questionnaire which showed that the achievement of information processing strategy indicators after treatment was better than that before treatment as can be seen in Figure 9. Based on these results, before being given treatment using the problem-solving-based student facilitating-and-explaining teaching model, students felt they had sufficient ability to manage the information obtained, while after the learning model was applied, the ability to manage information became very good. This is due to the stage of developing and explaining back to other students which makes students develop what they know to explain back to their friends. In this activity, there is control in the management of thoughts and management of the knowledge they get.

The profile of level 3 metacognitive ability indicators is supported by the results of the MAI self-assessment questionnaire which shows that the achievement of understanding monitoring indicators, repair strategies, and evaluation after treatment is better than that before treatment as can be seen in Figure 9. The achievement of understanding monitoring indicators before treatment is in the sufficient criteria and after treatment is in the excellent criteria. Based on these results, before being given treatment using the problem-solving-based student facilitating-and-explaining teaching model, students feel they have sufficient ability to monitor their understanding, while after the learning model is applied, the ability to monitor understanding becomes very good. Monitoring indicators related to the monitoring process, students are involved in developing self-awareness skills about what is known during the learning process. This monitoring process involves monitoring and self-evaluation of the understanding and knowledge that students have while learning (Clabough & Clabough, 2016).

The profile of metacognitive ability indicators at levels 4 and 5 is supported by the results of the MAI self-assessment questionnaire, which showed that the achievement of declarative knowledge, procedural knowledge, and conditional knowledge indicators after the treatment was better than before the treatment, as can be seen in Figure 9. Students with a profile of metacognitive indicators at levels 4 and 5 with good and very good criteria have demonstrated excellent skills in analyzing and understanding information, as well as effectively allocating their study time optimally, and they do not encounter difficulties in solving given problems. This aligns with research conducted by Abdullah et al (2021), which states that one of the factors underlying the mastery of level 5 metacognitive skills is the motivation and experience of students in learning activities, as well as their ability for self-regulation. [A21]

Students' Response to the Application of the Problem-solving-Based Student facilitating-and-explaining Teaching Model

The results of the analysis of the student's response questionnaire in the research conducted at SMP Negeri 32 Semarang with 32 students in the experimental group who applied the problem-solving-based student facilitator and explained the learning model obtained an average of 80.66% with good criteria. The results of the analysis of the student's response questionnaire can be seen in Table 4.

Table 4. Results of The Student's [A22]Response Questionnaire

No.	Aspects	Percentage (%)	Criteria
1.	Students' responses to the applied learning model	79.93	Good
2.	Students' responses to problem-solving-based worksheet learning media used	82.81	Very Good
3.	Students' feelings when participating in learning activities	79.69	Good

No.	Aspects	Percentage (%)	Criteria
4.	Understanding of learning materials	80.08	Good
5.	Fostering students' metacognitive ability	80.80	Good
	Average	80.66	Good

The first aspect shows that the student facilitating-and-explaining teaching model can provide students with a good response. Silveira et al (2022) state that good communication skills will offer an interactive and effective environment and have an impact on the high intensity of discussions, deep understanding of learning, and a positive impact on students' metacognitive ability. The second aspect shows that the use of problem-solving-based worksheets in the student facilitating-and-explaining teaching model is given a very good response by students. This means that problem-solving-based worksheet succeeds in attracting students to learn and can train problem-solving well. This is in line with research conducted by Tsai et al (2021) which states that the existence of worksheets in the form of structured task sheets and in such an interesting way will motivate students when learning to improve problem-solving skills.

The third aspect shows that students feel happy with the student facilitating-and-explaining teaching model and feel interested in and enthusiastic about the problem-solving-based worksheet used. This is in line with research conducted by Fidai et al (2020) which states that students give a positive response to physics learning using Polya's problem-solving-based worksheet indicated by an increase in students' interest in learning and interest. The fourth aspect shows that students find it easy to understand vibration, wave, and sound material through learning with the student facilitating and explaining the teaching model and with problem-solving contained in the worksheet. This is in line with research conducted by McLure et al (2022) which states that the application of the student facilitating-and-explaining teaching model in science learning shows a significant effect on students' concept understanding. Other studies also state that worksheet learning media can increase learning activities and understanding of the concepts of students (Khair et al., 2021).

The fifth aspect is that students can organize and control their thinking process well and can be seen in the way they solve problems. This is in line with Chen et al research (2023) which states that the student facilitating-and-explaining teaching model assisted by Edmodo shows a positive effect on students' problem-solving skills. Research conducted by Lee et al (2022) found that the application of the problem-solving model had a positive impact on the improvement of students' chemistry learning outcomes and can improve metacognitive ability while increasing student activity. Another study by Uchinokura (2020) found that the prototype of reflective-integrative basic physics teaching materials based on problem-solving was effective in improving students' metacognitive ability. Therefore, this study concludes that the combination of the student facilitating-and-explaining teaching model with problem-solving is good for improving students' metacognitive ability on vibration, wave, and sound material.

CONCLUSION

The problem-solving-based student facilitating-and-explaining teaching model applied to vibration, wave, and sound material has a significant impact on the improvement of students' metacognitive ability. Before the application of the problem-solving-based student facilitating-and-explaining teaching model, the profile of students' metacognition abilities was mostly in the low and sufficient criteria, while after the application of the problem-solving-based student facilitating-and-explaining teaching model, most of them were in the good criteria. Students gave a good response to the application of the problem-solving-based student facilitator and explained the learning model on vibration, wave, and sound material. The researcher recommends that learning materials with the student facilitator and explaining model based on problem-solving can be further developed to yield even better results for implementation in future learning activities, aiming to enhance students' metacognitive abilities.

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