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The Effect of Problem-Based Learning Model on Students’ Mathematical Literacy

(Ojose, 2011). Following this, Stacey & Turner (2015) defined mathematical literacy as the capacity to use mathematical material (concepts, facts, methods, and instruments) in daily life.

The seven components of mathematical literacy are communication, mathematizing, representation, reasoning and argument, designing problem-solving techniques, using symbols, formal and technical language, and operations, and employing mathematical tools. To be mathematically literate, individuals must possess all of these skills to vary degrees, as well as confidence in their ability to utilize mathematics and comfort with quantitative concepts (OECD, 2019).

Mathematical literacy starts from realistic problems, categorized into context and content. The process of mathematical literacy begins with the identification of genuine problems and their formulation based on the underlying concept and intrinsic link. After getting a suitable mathematical form of the problem, the following stage is to apply certain mathematical techniques to produce mathematical results and then interpret those results back into the original difficulties (Oktiningrum & Hartono, 2016).

Literacy questions in the PISA study require reasoning and problem-solving skills that emphasize various problems and situations in everyday life. The ability tested in PISA comprises process components: understanding and solving problems, reasoning, and communication (Khikmiyah & Midjan, 2017). According to PISA results in 2018, Indonesia ranks 72 out of 78 countries in mathematical literacy. It concludes that students' mathematical literacy is still deficient in Indonesia. It indicates that Indonesian students' mathematical literacy needs to be improved.

Based on the interview results with one of the mathematics teachers at SMP Negeri 3 Medan, it was stated that students still lacked understanding of story problems, were less precise in identifying the information contained in the questions, and had difficulty in making mathematical models. Students' abilities in problem-solving and mathematical calculations are not maximal.

In addition, based on observations, learning mathematics in the classroom does not explore students' mathematical literacy skills but only transfers knowledge. The problem given to students is also not much different from the example of the teacher's explanation, so students are less creative in solving high-level problems. Therefore, student learning outcomes, especially mathematical literacy skills, are challenging to achieve optimally.

Based on these two things, there are some students' abilities that are still low. These abilities are the basic abilities of mathematical literacy. In addition, the learning process does not support improving students' mathematical literacy skills. So it can be concluded that the mathematical literacy ability of students at SMP Negeri 3 Medan is still low.

Mathematical literacy is influenced by several factors, such as personal, environmental, and instructional factors. Instructional factors include intensity, quality, and teaching methods. Teachers' teaching methods positively impact the achievement of students' mathematical literacy, so it can be said that teachers play an essential role in student learning outcomes and mathematical literacy (Masdiansyah & Rahmawati, 2014). Therefore, the teacher's teaching method must be able to improve students' mathematical literacy. One way to improve students' mathematical literacy is to innovate learning models; the learning process has to focus on students' learning process and the stages of problem-solving (Nasrulloh & Nurlia, 2021).
According to Wardono et al. (2018), one effort to improve students' mathematical literacy is to innovate the learning of mathematics and develop the instrument of learning assessment. Innovation in learning mathematics is done by choosing the learning method according to the material and characteristics of students. One mathematics learning that can positively impact students' literacy is Problem-Based Learning.

In line with Masjaya & Wardono (2018), mathematics learning for students must be designed in such a way as to provide good opportunities for students to train, develop, and improve mathematical literacy skills as an essential part of improving future outcomes. One of the learning models that can improve students' mathematical literacy skills is a problem-based learning model. Astuti (2018) stated that one of the recommended learning models in the Kurikulum 2013 is Problem Based Learning. Problem-Based learning trains students to solve real problems that are open and unstructured to develop problem-solving skills and, at the same time, build students' new knowledge.

The problem-based learning model helps students get information already in their minds and devise their basic and complex knowledge (Malmia et al., 2019). Problem-based learning provides students with the knowledge and enhances their problem-solving, critical and creative thinking, lifelong learning, communication skills, teamwork, flexibility, and self-evaluation (Anazifa & Dju'kri, 2017).

The problem-Based Learning model has been proven to improve several variables of mathematical ability, namely: creative thinking ability, mathematical representation ability, mathematical communication ability, and mathematical understanding ability (Rinaldi & Afriansyah, 2019). Problem-based learning as a paradigm of education that cultivates problem-solving skills is very conducive to the development of mathematical literacy. Students' capacity to gain mathematical literacy is measured by their ability to solve everyday issues that frequently arise (Fery et al., 2017). According to Junianto & Wijaya (2019), Problem-Based Learning impacts mathematical learning and improves students' understanding and skills to use concepts in daily life. Understanding and skills to use the concept in daily life are one of the mathematical literacy aspects, namely, mathematizing and formulating situations mathematically.

In line with that, Rattanatumma (2016) also stated that PBL improves students' mathematics learning achievement and problem-solving abilities. Problem-solving abilities contain three of seven components in mathematical literacy: mathematizing, representation, reasoning, and argument devising strategies for problem-solving.

Wardono et al. (2016) also stated that PBL could encourage creative thinking, mathematical competence, and tolerance. Mathematizing, developing problem-solving strategies, reasoning, argumentation, and communicating are key mathematical literacy skills that should be incorporated into creative thinking. The relationship between Problem Based Learning (PBL) and mathematical literacy is because mathematical literacy can improve the mathematical competencies of students and the fundamental capabilities in mathematical literacy.

Based on the background described above, the researcher was interested in conducting a study entitled "The Effect of Problem Based Learning Model on Student's Mathematical Literacy Ability at SMP Negeri 3 Medan". This study aims to determine the level of students'
The Effect of Problem-Based Learning Model on Students’ Mathematical Literacy

Mathematical literacy skills before and after the problem-based learning model is applied to students.

METHOD

This study performed a quantitative analysis utilizing a quasi-experimental one-group pretest-posttest design method (single group initial test-end test). This research was conducted in SMP Negeri 3 Medan. The respondents of this research were students in the second term of the academic year 2021/2022.

This study's population consists of seventh-grade SMP Negeri 3 Medan students. It is known that there are 11 study groups for class VII. The sample must be representative of the population. Every class VII study group at SMP Negeri 3 Medan has the same ability, so this study's sample consisted of students from Class VII-J of SMP Negeri 3 Medan since the sampling was conducted at random without respect to the stratification of the study group.

This study's research instrument consists of pre-test and post-test questions of mathematical literacy comprised of six essay questions. There are six kinds of selected contexts (levels 1 – 6). Each level has a different level of difficulty. Using the learning model, this instrument determines students' mathematical literacy skills before and after participating in mathematics learning. This essay test was given to students in class VII-J of SMP Negeri 3 Medan who acted as samples in this study.

The following is a grid of essay tests given to the research sample.

<table>
<thead>
<tr>
<th>No.</th>
<th>Basic Competencies</th>
<th>Mathematical Literacy Indicator</th>
<th>Level</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.9 Identify and analyze various situations related to social arithmetic (sales, purchases, discounts, profits, losses, single interest, percentage, gross, net, and tare)</td>
<td>1) Students can identify the information and questions given clearly; 2) Students Perform routine procedures to answer questions in a general context; and 3) Students can take action according to the given stimulus.</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4.9 Solve problems related to social arithmetic (sales, purchases, discounts, gains, losses, single interest, percentage, gross, net, and tare)</td>
<td>1) Students can interpret the problem and solve it with a formula; 2) Students can apply fundamental algorithms and execute elementary procedures or provisions; 3) Students can comprehend situations requiring straight conclusions; and 4) Students can interpret the obtained results.</td>
<td>II</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1) Students can use representations based on sources of information’</td>
<td>III</td>
<td>3</td>
</tr>
</tbody>
</table>
2) Students can apply simple problem-solving strategies;
3) Students can perform procedures that require sequential decisions; and
4) Students can communicate their results and reasoning.

1) Students can use representations to identify the given information;
2) Students can work effectively with implicit models in concrete but complex situations;
3) Students can develop skills in making assumptions according to context; and
4) Students can communicate results and actions.

1) Students can create models in complex situations, identifying information and limits and explaining assumptions accurately;
2) Students can use problem-solving strategies in complex situations;
3) Students can use their reasoning and mathematical skills to solve complex situations; and
4) Students can communicate the results of their interpretation and reasoning.

1) Students can identify various sources of information in complex problem situations;
2) Students can conceptualize, generalize, and use information in complex problem situations;
3) Students can perform mathematical reasoning accompanied by mastery of mathematical operation techniques to deal with complex situations; and
4) Students can formulate and communicate the results of their actions.
RESULTS AND DISCUSSION

In this case, hypothesis testing is done using an independent sample t-test. The paired sample t-test is a parametric test used. The research hypothesis is as follows:

1) $H_0: \mu_1 = \mu_2$ The Problem Based Learning Model does not affect Students’ Mathematical Literacy;

2) $H_1: \mu_1 \neq \mu_2$ There is an effect of the Problem Based Learning Model on Students’ Mathematical Literacy.

The basis for decision-making is if the $|t_{arithmetic}| > t_{table}$, then $H_0$ is rejected and $H_a$ is accepted. On the other hand, if the $|t_{arithmetic}| < t_{table}$, then $H_0$ is accepted and $H_a$ is rejected. In summary, the results of the independent sample t-test are shown in the following Table 2.

<table>
<thead>
<tr>
<th>Name</th>
<th>$\sum D$</th>
<th>$\sum D^2$</th>
<th>$s$</th>
<th>$t_{arithmetic}$</th>
<th>$t_{table}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest – Posttest</td>
<td>353</td>
<td>9910</td>
<td>11,778</td>
<td>8,444</td>
<td>2,13145</td>
</tr>
</tbody>
</table>

Based on the result of paired t-test in table 4.10, it was found that the $|t_{arithmetic}| > t_{table}$, then $H_0$ was rejected and $H_1$ was accepted. Thus, it is known that there is an effect of the Problem-Based Learning Model on students' mathematical literacy.

Research in the experimental class was carried out with a time allocation of 5 lessons with two hours for each lesson. In the first lesson, a pre-test was given to measure students' mathematical literacy. The second lesson to the fourth lesson was the implementation stage, students used a problem-based learning model while studying, and in the fifth lesson, a post-test was conducted to measure students' mathematical literacy after being given intervention.

Based on the calculation result on the pre-test data, the average score of the student was 49, and on the post-test data, the mean score was 72. Before evaluating the hypothesis, the normality test was conducted; the pre-test and post-test data were normally distributed, and the normality test was obtained. Due to the normal distribution of the data, the hypothesis test can be conducted, and it was found that the problem-based learning model affected students' mathematical literacy.

The Effect of the Problem-Based Learning Model

To find out the effect of the problem-based learning model on students' mathematical literacy can be seen through the students' pre-test and post-test based on the level of mathematical literacy.

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>77%</td>
<td>69%</td>
<td>53%</td>
<td>43%</td>
<td>34%</td>
</tr>
<tr>
<td>Posttest</td>
<td>87%</td>
<td>87%</td>
<td>79%</td>
<td>64%</td>
<td>61%</td>
</tr>
</tbody>
</table>

Based on Table 3, it can be seen that, on the pre-test, students can achieve 77% on level 1, 69% on level 2, 53% on level 3, 43% on level 4, and 34% on level 5, and 23% on level 6. After being given treatment, students' mathematical literacy was increased. Students can achieve
87% on level 1. 87% of students can answer questions in a general context, and all relevant information is available. They can identify information and receive instructions based on clear instructions on the situation. They are also able to show an action according to the given simulation.

Students can achieve 87% on level 2, which means that 87% of students can evaluate and recognize situations requiring direct conclusions. They can extract essential information from a single source and deliver it using a single format. They are competent with fundamental algorithms, formulas, procedures, or agreements, and correct simulation of the solution's outcomes.

Students can achieve 79% on level 3, which means that 79% of students can execute procedures, particularly those requiring sequential decisions. Capable of selecting and employing simple problem-solving techniques. Able to interpret and employ representations based on a variety of data. Capable of explaining the outcomes of their interpretation and the underlying reasoning.

Students can achieve 64% on level 4, which means that 64% of students can move with specific methods effectively in complex but concrete situations that may involve obstacles or assumptions. Able to select and use different representations, including symbols. Able to use skills and knowledge in a clear context. Able to explain his opinion based on their understanding, reasons, and formulation.

Students can achieve 61% on level 5, which means that 61% of students may construct and utilize models for complex situations, as well as recognize difficulties and formulate hypotheses. Capable of selecting, comparing, and evaluating ways to address complicated model-related problems, applying critical thinking and deductive reasoning to appropriately relate symbol representations to the scenario, and describing and formulating the findings of his work.

Students can achieve 52% on level 6, meaning that 52% of students can conceive, generalize, and apply information based on research and modeling in complicated circumstances. Able to connect and translate diverse information sources flexibly. They can apply their knowledge by mastering mathematical symbols and processes and by creating new tactics and approaches for handling novel circumstances. Able to effectively formulate the outcomes of his work by taking into account his findings, interpretations, opinions, and correctness in real-world settings. It can be concluded that a problem-based learning strategy could improve mathematical literacy among students.

For more details, the summary of pre-test and post-test based on the level of mathematical literacy data is shown in the following bar chart in Figure 1.
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How Problem-Based Learning Affects Students’ Mathematical Literacy

The problem-based learning was applied to affect the students' mathematical literacy in class VII SMP Negeri 3 Medan, which was classified as low based on the results observed at school. Problem-Based learning has five syntax/phases.

The initial step of problem-based learning is for the teacher to introduce the problem to the students. The teacher encourages pupils to engage in direct problem-solving activities. For the development of student's critical thinking and problem-solving abilities, pupils are presented with authentic/real challenges. In this initial stage, students will be able to recognize and comprehend contextual problems, transform story problems into mathematical models, and then apply these skills in real-world situations.

Picture 1. Students Pretest Answer Sheet

Picture 2. Student Worksheet Answer

Picture 3. Students’ Post-Test Answer Sheet
Based on the answer sheet from the sample, it can be seen that when students are given a pre-test, students tend to directly work on the questions without identifying the information and converting it into the mathematical form can be seen in picture 1. Meanwhile, when students learn with a problem-based learning model, students identify information and convert it into mathematical form, which can be seen in figure 4.4. So that the results at the time of giving the post-test students were able to identify and convert it into a mathematical form that can be seen in picture 3.

In this step, students could identify the problems that related to the indicator of mathematical literacy, namely using knowledge to solve routine and general problems. Based on the answer sheet, it can be concluded that mathematical literacy has been achieved.

The second stage is the teacher organizes students to learn. Student-centered learning, where students are encouraged to be able to develop their knowledge. In this second stage, students will understand the material provided and correct deficiencies in performing calculations.

Based on the pictures above, when the pre-test was given, students tended to still make errors in calculations, as shown in picture 3. Meanwhile, students are expected not to make calculation mistakes when studying with the problem-based learning model, as shown in figure 4. So, when students are given a post-test, students no longer make mistakes in the calculations shown in picture 5. Based on this, it can be concluded that the students already understood the material and did not make a calculation error when giving the post-test.
In this step, students might formulate the problem connected to the mathematical literacy indicator of understanding and solving the problem with formulae. Based on the answer sheet, it is possible to conclude that the indication of mathematical literacy has been met.

The teacher guides individual and group investigations during the third stage. Students acquire new knowledge when they can comprehend or investigate a source through independent research. Small-group talks, scientific engagement, and the sharing of ideas will contribute to the development of collaborative knowledge. In this third stage, students will be able to comprehend the offered material, develop independence and reasoning, and hone their problem-solving skills.

Students then develop and display their work in the fourth step. The instructor assists students in sharing assignments and planning/preparing relevant work from problem-solving LKPD reports. In this fourth level, students can articulate mathematical arguments and ideas, discuss problem-solving, pose questions, and exchange knowledge to deepen their understanding of material concepts.

The final step involves analyzing and evaluating the problem-solving procedure. The instructor assists pupils in reflecting on or evaluating the problem-solving process. In this final phase, students will have a deeper understanding of the newly acquired knowledge because evaluation allows them to identify and correct errors, as well as determine the most suitable answers to problems. The phases of the problem-based learning methodology can aid students in acquiring mathematical literacy indicators. These stages also develop students' mathematical literacy abilities to increase students' mathematical literacy skills concerning social arithmetic material in Class VII at SMP Negeri 3 Medan.

CONCLUSION

The research entitled "The Effect of Problem-Based Learning on Mathematical Literacy of Students at SMP Negeri 3 Medan" concluded that the problem-based learning model could improve students' mathematical literacy skills. This can be seen from the average value of the experimental class before treatment was 49, while the average value of the experimental class after treatment was 72. From the results of the average difference test using paired t-test, the $t_{arithmetic}$ value is 8.44, and the $t_{table}$ is 2.13 at a significance level of 5%. Since $t_{arithmetic} > t_{table}$, the null hypothesis is rejected and the alternative hypothesis is accepted, it can be interpreted that problem-based learning models affect students' mathematical literacy.

There are five stages in the problem-based learning model. The stages in the learning model can assist students in mastering indicators of mathematical literacy. These stages also train students' mathematical literacy to improve students mathematical literacy skills. Therefore, it is hoped that teachers will pay attention to the problem of mathematical literacy skills on all math topics to achieve good student mathematical literacy skills. teachers also have to design learning processes that can improve students' mathematical literacy skills and train students to get used to working on questions that can improve students' mathematical literacy skills. Meanwhile, for other researchers who will use this topic in their further research, it is expected to equip them with the ability to apply problem-based learning as well as possible so the implementation and the result will be better.
REFERENCES
The Effect of Problem-Based Learning Model on Students’ Mathematical Literacy

NUMERICAL: Jurnal Matematika Dan Pendidikan Matematika, 9–18. https://doi.org/10.25217/numerical.v3i1.326

