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Problem Based Learning Model Based on High Order Thinking Skills for Enhancing Mathematic Literacy for High School Students

Sekar Wilujeng, *Eyus Sudihartinih, Aan Hasanah
Department of Mathematics Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
*e-mail: eyuss84@upi.edu

Abstract

The aim of this research is to test statistics related to the achievement and increase in mathematical literacy skills of high school students after obtaining a problem-based learning model based on high-order thinking skills and to describe student responses to the implementation of problem-based learning based on high-order thinking skills to teach composition functions and inverse functions. This research is experimental research with a research design that is a non-equivalent control group design. The population in this research were all students of Class X Science in one of the public high schools in South Lampung Regency. The sample in this research is class X IPA 5 as the experimental class and class X IPA 3 as the control class. The instruments used in this research are mathematical literacy ability test instruments and non-test instruments in the form of questionnaires and observation sheets. From this research, it can be concluded: 1. Statistically, the achievement of mathematical literacy skills of students who received problem-based learning based on high-order thinking skills was higher than students who received it with a scientific approach; 2. The statistic the increase in mathematical literacy skills of students who received problem-based learning based on high-order thinking skills was higher than students who received scientific approach; 3. Student responses to the implementation of problem-based learning models based on high-order thinking skills to teach compositional function and inverse function material to high school students are included in the positive category. Therefore, PBL should be tested on other topics of mathematics learning to improve students' mathematical literacy.

Keywords: mathematical literacy, problem-based learning, high-order thinking, composition function and inverse

Abstrak

Penelitian ini bertujuan untuk menguji secara statistik terkait pencapaian dan peningkatan kemampuan literasi matematis siswa SMA setelah memperoleh model pembelajaran berbasis masalah berbasis keterampilan berpikir tingkat tinggi dan mendeskripsikan respon siswa terhadap penerapan pembelajaran berbasis masalah berbasis tinggi. urutan keterampilan berpikir untuk mengajarkan fungsi komposisi dan fungsi invers. Penelitian ini merupakan penelitian eksperimen dengan desain penelitian non-equivalent control group design. Populasi dalam penelitian ini adalah seluruh siswa kelas X IPA di salah satu SMA Negeri di Kabupaten Lampung Selatan. Sampel dalam penelitian ini adalah kelas X IPA 5 sebagai kelas eksperimen dan kelas X IPA 3 sebagai kelas kontrol. Instrumen yang digunakan dalam penelitian ini adalah instrumen tes kemampuan literasi matematika dan instrumen nontes berupa angket dan lembar observasi. Dari penelitian ini dapat disimpulkan: 1. Secara statistik pencapaian kemampuan literasi matematika siswa yang memperoleh pembelajaran berbasis masalah berbasis keterampilan berpikir tingkat tinggi lebih tinggi daripada siswa yang memperoleh pembelajaran dengan pendekatan saintifik; 2. Secara statistik peningkatan kemampuan literasi matematis siswa yang mendapat pembelajaran berbasis masalah berbasis keterampilan berpikir tingkat tinggi lebih tinggi daripada siswa yang mendapat pembelajaran dengan pendekatan saintifik; 3. Respon siswa terhadap penerapan model problem based learning berbasis keterampilan berpikir tingkat tinggi untuk pembelajaran materi fungsi komposisi dan fungsi invers pada siswa SMA termasuk dalam kategori positif. Oleh karena itu hendaknya PBL diujicobakan pada pembelajaran matematika topik lainnya untuk meningkatkan literasi matematik siswa.

Kata Kunci: literasi matematik, pembelajaran berbasis masalah, berpikir tingkat tinggi, fungsi komposisi dan invers

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INTRODUCTION

Mathematical literacy is one of the important factors in the process of learning mathematics. Mathematical literacy allows individuals to understand the role of mathematics, which includes the application of mathematical concepts, procedures, and facts (OECD, 2019). This allows individuals to develop the ability and confidence to think numerically and spatially when interpreting, analyzing, and solving problems in everyday life (Wesna, 2019).

One of the international level studies in assessing students' mathematical literacy skills is PISA (Programme for International Student Assessment) which was initiated by the Organization for Economic Co-operation and Development (OECD). Based on the PISA study, the results achieved by Indonesia show that many students have low mathematical literacy skills.

In line with the research that has been carried out (Muzaki & Masjudin, 2019) the research results obtained are generally students with Early Mathematics Ability who fall into the high, medium, or low category have low literacy skills, as evidenced by the students' ability to solve problems. mathematical problems that are familiar with procedural and concrete answers. Furthermore, research conducted by (Mahdiansyah & Rahmawati, 2014) explains that the achievement of mathematical literacy of High School students who are the sample of this study is still low, even though the questions have been adapted to the Indonesian context, the answer choices for mathematics questions are answered by students without explanation and calculation work steps, this shows that students are less able to provide descriptions or arguments against the mathematical problems tested in the math test.

Seeing these conditions, it is important to develop student-centered mathematics learning innovations and provide opportunities for students to increase their learning activities so that students can find their own concepts in learning mathematics (Pratiwi & Ramdhani, 2017). To facilitate this, mathematics learning must also be innovative in order to make it easier for students to develop mathematical literacy. One of the learning models that can be used is the Problem Based Learning model based on High Order Thinking Skills (HOTS). The problem based learning model itself has several advantages, namely according to (Pratiwi & Ramdhani, 2017) PBL is a learning model in which students are faced with authentic (real) problems so that they are expected to be able to construct their own knowledge, develop high-level thinking skills and problem solving skills, make students independent. and increase his confidence. In addition, students who learn through PBL will be able to solve problems either by using existing knowledge or by trying to acquire the knowledge needed to overcome the situation at hand (Wardono et al., 2018).

Problem Based Learning model based on High Order Thinking Skills (HOTS) is a learning model in which students are faced with real problems and are required to use high order thinking skills or HOTS in solving mathematical problems (Riadi, 2016). Through high order thinking skills students will be able to identify ideas or concepts clearly, argue persuasively, solve problems, develop explanations, speculate, and understand difficult concepts more clearly through higher order thinking, where these skills show how students reason (Dinni, 2018).

Mathematics learning innovation is very important to be developed, but in addition to innovation in learning student responses to mathematics learning with a problem based learning model based on high order thinking skills, it is also an important factor to know so that the implementation of learning can provide good results. Through positive student responses to learning, students will develop an

appreciation of the learning components and will be happy to participate in further learning (Nasution et al., 2020). Based on the importance of some students' mathematical literacy but there is a phenomenon of low students' mathematical literacy skills as previously explained, the purpose of this research is to find out the increase in the mathematical literacy skills of high school students by using a problem based learning model based on high order thinking skills.

METHODS

This study aims to determine the increase in mathematical literacy skills of high school students through learning the Problem Based Learning (PBL) model based on High Order Thinking Skills (HOTS). The approach used in this research is a quantitative approach. The research method used in this study is a quasi-experimental method. Quasi-experimental research can be interpreted as research that approaches experiments or quasi-experiments (Sukardi, 2018). The research design used was a non-equivalent control group design. In this study, there is an experimental class (learning using the HOTS-based PBL model) and a control class (learning using a model with a scientific approach). So that the design structure is based on (Pratiwi & Ramdhani, 2017) as follows:

O X_1 O

O X_2 O

Information :
O : Pretest and posttest of mathematical literacy ability.
X_1 : Learning using the HOTS-based PBL learning model
X_2 : Learning uses a learning model with a scientific approach

The population in this study were all students of Class X Science in one of the public high schools in South Lampung Regency which was held in the even semester of the 2021/2022 Academic Year. The samples in this study were class X IPA 5 as the experimental class and class X IPA 3 as the control class.

The instruments used in this study were test instruments is in the form of essay questions from mathematical literacy (see Table 1) and the non-test instrument is in the form of questionnaires and observation sheets.

Table 1. Mathematical literacy test instrument grid

No.	Indicators of Mathematical Literacy	Indicators of Question	Items
1.	Formulate real problems mathematically	Students can identify mathematical aspects of real problems and represent situations mathematically	A company uses two machines to turn raw materials into finished goods. Machine I converts raw materials into semi-finished materials, and machine II converts from semi-finished materials into finished materials. Machine I is analogous to the function $f(x) = 2x – 3$ and machine II is analogous to fungtion $g(x) = x^2 – x$.

No.	Indicators of Mathematical Literacy	Indicators of Question	Items
			a) If the amount of raw materials used is x, determine the equation for the yield of finished materials b) If 100 kg of raw materials are used, how much is produced?
2.	Using concepts, facts, procedures and reasoning in mathematics	Students are able to apply facts, concepts and mathematical procedures when looking for solutions.	If f(x) = $\frac{2x}{3x-4}$, x $\in R$, x $\neq \frac{4}{3}$ a. determine the value of $f^{-1}(x)$ b. if known $f^{-1}(x+1) = 1$ Is x = 3 the correct value?
3.	Interpret, apply, and evaluate the results of solving mathematical problems	Students can interpret solutions from solving problems and can provide arguments based on the interpretation of the mathematical problems presented	Is known f (x) = x − 7 and g (x) = 4x + 1, a) Determine $(f \circ g)^{-1}(x)$ and $(g^{-1} \circ f^{-1})(x)$. b) Based on the answers in part a, are the results of the two the same? Give a conclusion!

Before the test is tested on the subject, there are several criteria that must be considered, namely validity, reliability, discriminatory power and index of difficulty of each test item on the instrument. The conclusion of the test results of the mathematical literacy ability test instrument is presented in Table 2 below.

Table 2. Conclusion of instrument test results

No.	Validity	Reliability	Distinction Power
	r_{count}	r_{11}	DP
1	0,612		0,3125
2	0,760	0,517	0,4875
3	0,818		0,6875

Based on the data contained in Table 2, it was concluded that the mathematical literacy ability test instrument was suitable for use in research. The research was conducted in seven meetings consisting of one meeting for the pretest, five meetings for the learning process and one meeting for the posttest. The material taught during the research is the composition function and the inverse function.

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RESULTS AND DISCUSSION

Quantitative data on students mathematical literacy were obtained from the results of the pretest, posttest and gain index. Pretest data analysis was used to determine students' initial mathematical literacy skills, posttest data analysis was used to determine the achievement of students' mathematical literacy skills in the experimental class and control class, and Gain data

analysis (Normalized Gain) was used to determine the increase in students' mathematical literacy abilities, both students experimental class and control class. The inference test performed on the pretest data, namely the normality test and the similarity test of the two averages, while the posttest and N-Gain data inference test includes a normality test and an average difference test. The following is a description of the pretest, posttest, and N-Gain data analysis:

Data Analysis of Students' Early Mathematical Literacy Ability

The pretest was conducted to determine the initial ability of students' mathematical literacy in the experimental class and the control class.

a. Normality test

The results of the analysis of the Saphiro Wilk normality test using SPSS are as follows:

Table 3. Normality test of pretest data

Class	*Shapiro-Wilk*		
	Statistic	df	Sig.
Control	0,662	36	0,000
Experiment	0,909	36	0,032

Based on Table 3, the value of sig. for the control class pretest score is 0.000 <0.05 then H¬0 is rejected, the test results mean that the control class pretest data comes from a population that is not normally distributed. sig value. for the experimental class pretest score is 0.032 <0.05 then H¬0 is rejected, the test results mean that the experimental class pretest data comes from a population that is not normally distributed.

b. Similarity Test of Two Averages

The similarity test of the two averages has the aim of knowing whether the average pretest data of students' mathematical literacy abilities from the experimental class and control class is the same or not. Because the normality test of the two classes is not normally distributed, the hypothesis testing is carried out using a non-parametric test using the Mann Whitney U test. The results of the similarity test of the two averages of the pretest data using SPSS are as follows:

Table 4. Similarity test of two average pretest data

Mann-Whitney U non-parametric test	
Z	Sig.
-0,402	0,688

Based on Table 4, the significance value of the Mann-Whitney U test obtained is 0.688 > 0.05, so H0 is accepted. The test results mean that the average mathematical literacy ability of the experimental class students and the control class students is not significantly different. The next step is to treat it in the form of a problem based learning model based on high order thinking skills for the experimental class and a learning model with a scientific approach for the control class.

Data Analysis of Students Mathematical Literacy Achievement

Data on the achievement of students' mathematical literacy skills in both the experimental class and the control class were obtained from the results of the posttest score analysis.

a. Normality test

The normality test was conducted to determine whether the data on the mathematical literacy ability of the two classes came from a population that was normally distributed or not. The results of the analysis of the Saphiro Wilk normality test using SPSS are as follows:

Table 5. Normality test of posttest data

Class	*Shapiro-Wilk*		
	Statistic	df	Sig.
Control	0,911	36	0,007
Experiment	0,900	36	0,003

Based on Table 5, the value of sig. for the control class posttest score is 0.007 <0.05 then H¬0 is rejected, the test results mean that the control class posttest data comes from a population that is not normally distributed. sig value. for the experimental class posttest score is 0.003 <0.05 then H¬0 is rejected, the test results mean that the experimental class posttest data comes from a population that is not normally distributed.

b. Test the Difference of Two Averages

The difference test of the two averages has the aim of knowing whether the average posttest data of students' mathematical literacy abilities from the experimental class and control class is different or not. Because the normality test of the two classes is not normally distributed, the hypothesis testing is carried out using a non-parametric test using the Mann Whitney U test. The results of the difference between the two posttest data averages using SPSS are as follows:

Table 6. Test the difference of two average posttest data

Mann-Whitney U non-parametric test	
Z	Sig.
-3,032	0,002

Based on Table 6, the significance value of the Mann-Whitney U test obtained is 0.002 < 0.05, then H0 is rejected, the test results mean that the average achievement of students' mathematical literacy skills in the experimental class is significantly higher than students in the control class. . It can be concluded that students who receive learning using a problem based learning model based on high order thinking skills have a higher final mathematical literacy ability than students who receive a learning model with a scientific approach.

Data Analysis of Increasing Students Mathematical Literacy Ability

Calculation of the N-Gain data has the aim of knowing the increase in students' mathematical literacy skills in the experimental class and control class.

a. Normality test

The normality test was conducted to determine whether the data on the N-Gain score or the increase in mathematical literacy ability of the two classes came from a population that was normally distributed or not. The results of the analysis of the Saphiro Wilk normality test using SPSS are as follows:

Table 7. Normality test of N-gain data

Class	*Shapiro-Wilk*		
	Statistic	df	Sig.
Control	0,889	36	0,002
Experiment	0,920	36	0,013

Based on Table 7, the value of sig. for the control class N-Gain score is 0.002 <0.05 then H¬0 is rejected, the test results mean that the control class N-Gain score data comes from a population that is not normally distributed. sig value. for the experimental class N-Gain score is 0.013 <0.05 then H¬0 is rejected, the test results mean that the experimental class N-Gain score data comes from a population that is not normally distributed.

b. Test the Difference of Two Averages

The difference test of the two average N-Gain scores has the aim of knowing whether the average increase in mathematical literacy skills of experimental class students is higher or not compared to the control class. Because the normality test of the two classes is not normally distributed, the hypothesis testing is done by non-parametric test using the Mann Whitney U test. The results of the difference test of the two average N-Gain scores using SPSS are as follows:

Table 8. Test the difference of two average N-gain data

Uji non-parametrik *Mann-Whitney U*	
Z	Sig.
-2,899	0,004

Based on Table 8, the significance value of the Mann-Whitney U test obtained is 0.004 < 0.05, then H0 is rejected, the test results mean that the increase in students' mathematical literacy skills in the experimental class is significantly higher than students in the control class. It can be concluded that students in the experimental class who received learning using a problem based learning model based on high order thinking skills had a higher increase in mathematical literacy skills than students in the control class who received a learning model with a scientific approach.

After processing quantitative data, there is qualitative data processing obtained from the results of non-tests in the experimental class, namely questionnaires and observation sheets which have the aim of knowing student responses to learning mathematics by using a problem-based learning model based on high order thinking skills.

Student Response Questionnaire Analysis

Questionnaires were given to students in the experimental class to determine student responses to learning mathematics. The questionnaire data obtained is ordinal data, so the data must first be transformed into interval data through the Interval Successive Method (MSI) using Microsoft Excel software and the stat97 application. After the data is transformed into interval data, the Ideal Maximum Score (SMI) data and categorization are needed to see student responses to learning mathematics with a problem based learning model based on high order thinking skills. The results of the questionnaire data processing can be seen in Table 9 below.

Table 9. Summary of questionnaire data

Average total score	SMI	Percent	Category
44,477	67,7773	65,622	Positive

It can be seen in Table 9 that the average value of the student response questionnaire results to the problem based learning model based on high order thinking skills is 65.622%. This means that the overall student response to learning with a problem based learning model based on high order thinking skills is included in the positive category.

Analysis of the Observation Sheet

The teacher activity observation sheet has the aim of observing the suitability of using the problem based learning model based on high order thinking skills and evaluating the teacher whether the learning activities take place in accordance with the implementation steps of the problem based learning model based on high order thinking skills or not. After the data from the observations of the teacher's activities are summarized, then there is a description of the data from the observations of the teachers in Table 10 below.

Table 10. Description of Observation Sheet Result Data

No.	Aspect Observation	Percentage
1	Introduction	87%
2	Core activities	95,55%
3	Closing	88%
	Average	90,02%

Based on the results of processing the observation sheet data, the percentage of teacher activities implementation is 90.02%. This shows that problem-based learning based on high order thinking skills in the experimental class was carried out well.

From the results of testing and data analysis, it was found that the achievement and improvement of mathematical literacy skills of high school students who received a problem based learning model based on high order thinking skills was higher than students who received a learning model with a scientific approach. In addition, based on descriptive data processing, it is known that the increase in students' mathematical literacy skills in the experimental class is in the high category, while the increase in the control class is in the medium category.

Differences in the achievement and improvement of students' mathematical literacy skills between classes using problem based learning models based on high order thinking skills and classes using learning models with a scientific approach occur because of different learning characteristics. In the problem-based learning model, problems are solved through the stages of the scientific method, so that students are not only taught concepts, but also how to do scientific work in the process of finding solutions to real-world problems presented at the beginning of learning (Nurhayati et al., 2019). Supported by using high-order thinking skills type questions, students will be able to identify ideas or concepts clearly, argue persuasively, solve problems, develop explanations, speculate, and understand difficult concepts more clearly through higher-order thinking, where these skills shows how students reason (Dinni, 2018). So that with the problem-based learning model based on high order thinking skills students will be accustomed to solving problems with higher-order thinking and improving students' mathematical literacy skills. This is in line with the opinion (Paloloang et al., 2020) that the application of the problem based learning model has a significant positive impact on students' mathematical literacy skills. It is also supported by the opinion (Herman et al., 2022) that when the HOTS-problem-based learning instrument is used, some high-level abilities will develop automatically.

Statistically, the problem based learning model based on high order thinking skills can improve students' mathematical literacy skills. However, student responses regarding problem based learning models based on high order thinking skills are also important to know. The learning process will take place well if there is interaction between teachers and students, the interaction is in the form of responses given by students to the learning carried out (Simanjuntak & Imelda, 2018).

The implementation of learning using a problem based learning model based on high order thinking skills in the experimental class conducted by the teacher reached 90.02%. There are learning activities that have not been carried out by the teacher, this is due to several things, namely students are not familiar with the learning model that is implemented so it takes longer for students to fill out student worksheets, besides that because learning in schools is done offline and online then require more time to carry out teaching and learning activities. In the control class that uses a model with a scientific approach, the implementation of learning is in accordance with the learning steps of the scientific approach, but the implementation assessment will be better if the control class is assessed using an observation sheet.

Student response questionnaires were only given to the class with a problem based learning model based on high order thinking skills, preferably in the control class a student response questionnaire was also given. Student responses to learning using a problem based learning model based on high order thinking skills based on the results of the analysis there were 10 students gave negative responses, 25 students gave positive responses, and 1 student gave a very positive response. Furthermore, based on the average total score of MSI obtained data of 44,477 from the ideal maximum score of 67,777 so that the average student response to learning is 65.622% and the student's response is included in the positive category.

The positive response of students is influenced by several factors, namely when learning using a problem based learning model based on high order thinking skills students are given the opportunity to study independently and discuss with their groups so that students will be more active and dare to express opinions about problem solving that has been obtained during learning activities. . In line with the opinion (Imelda & Anzelina, 2019) students responded positively to learning which was indicated by students being happy with the learning components, the learning components used were new so

that they aroused students' curiosity and motivation to participate in learning activities. However, there are still some negative student responses to learning using a problem based learning model based on high order thinking skills.

CONCLUSION

Based on the results of the research and discussion that have been presented, it can be concluded that statistically the achievement of mathematical literacy skills of students who receive problem based learning based on high order thinking skills is higher than students who receive learning with a scientific approach, statistically increasing mathematical literacy skills of students who getting problem based learning based on high order thinking skills is higher than students who get learning with a scientific approach, and student responses to the implementation of problem based learning models based on high order thinking skills to teach composition and inverse function materials to high school students are included in the category positive.

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