Mathematical Representation Ability of Students Taught with Problem-Based Learning Model Using GeoGebra Application

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ABSTRACT

This research is an experimental research that aims to determine the mathematical representation ability of students taught with a problem-based learning model accompanied by the use of the GeoGebra application. The research was conducted at SMP Negeri 5 Kendari. The research sample consisted of two classes consisting of one class taught with a problem-based learning model accompanied by the use of the GeoGebra application and one class taught with problem-based learning without the use of the GeoGebra application. The instruments used for data collection consisted of two types, namely observation sheets and mathematical comprehension ability tests. The data analysis technique used statistics consisting of descriptive statistics and inferential statistics. The results of the study showed: (1) the learning activity of students taught using the problem-based learning model accompanied by the use of the GeoGebra application was 85.65, included in the fairly active category with an average percentage of 87% from six meetings, (2) the average value of mathematical representation ability of students taught using the problem-based learning model with the use of the GeoGebra application was 82.24, higher than the average value of those taught using the problem-based learning model without the use of the GeoGebra application with an average value of only 76.45.

Keywords: PB model, GeoGebra application, mathematical representation

INTRODUCTION

Mathematics is a main pillar in the world of education because it has a crucial role (Hasibuan, 2019). Mathematics helps other sciences in everyday life. Social, professional, personal, and scientific problems can be solved by students who have good mathematical abilities.

The objectives of mathematics learning by Permendikbud No. 22 of 2006 concerning the criteria for elementary and secondary education units are to instill the following abilities: (1) Students' understanding of mathematical concepts, expressing the relationship between concepts, and using understanding flexibly, in detail, and appropriately to solve problems; (2) Application of reasoning to many patterns and characteristics, and mathematical manipulation and operating algorithms and concepts effectively to solve problems; (3) Problem solving includes understanding problems, making mathematical equations, solving equations, and interpreting solutions; (4) Using symbols, charts, or diagrams to communicate concepts and explain situations; (5) recognizing the benefits of learning mathematics in real life, such as fostering sensitivity and self-confidence when solving problems.

The current reality is that Indonesian students often have difficulty understanding mathematics and often get low scores, so it can be said that education in Indonesia is not optimal. Based on the results of the PISA test scores, which are held every three years by the OECD, which measure the numeracy skills, achievements of 15-year-old students in 79 countries for language and science subjects, it was found that in mathematics, around 71% of students do not have minimum mathematics skills. This shows that more students in Indonesia have difficulty solving math problems. Not only that, the achievements of Indonesian students in the last PISA survey in 2022 showed that Indonesian students were ranked 73 out of 79 countries with an average score of 379, while the comparison with other countries was 487 seen from the average OECD comparison score. In addition, the TIMSS score implemented through the IEA can see students' abilities in science and mathematics at the fourth grade elementary school level and eighth grade junior high school, as an indicator of the quality of Indonesian education. Indonesian students' TIMSS score reached 397. This score is at the 44th level out of 49 countries and has an average score of 500 throughout the world (Shazlin et al., 2023).

The OECD, TIMSS and PISA rankings cannot be used as an absolute measure to see the level of learning success in Indonesia. Everyone who works in education can make an evaluation of this unsatisfactory condition. Among the factors that can make Indonesian students still have difficulty finding solutions to mathematical problems is the lack of ability to represent solutions to mathematical problems (Inayah, 2018). Not only factors from the students themselves, teacher factors also influence. The results of the study stated that teachers think that mathematical representations such as pictures, tables, and graphs are only complementary. In the teaching and learning process, teachers do not see how students' mathematical representation abilities improve. This shows that the ability for mathematical representation when the teaching and learning process is lacking in mathematics learning is a concern for teachers so that it becomes a factor that results in a lack of ability to represent mathematics (Fajriah, et al, 2020).

The basic standards required by students in learning mathematics according to NCTM state that the goal of mathematics education is to foster five basic abilities, namely problem solving, communicating, connecting, reasoning and proving and representation (Wulandari et al., 2023). These five basic abilities are the main elements in mathematics education so that they can be mastered by students. The part that needs to be improved and attached to students is the ability to represent mathematics. The ability to represent mathematics can be said to be a support and foundation to help students understand mathematical concepts, convey mathematical concepts to others, and understand the relationship between concepts, and applications to the real world through mathematical modeling, and is the most important thing because representational abilities are inherent when students are taught mathematics at every level of school (Khoerunnisa and Maryati, 2022).

The importance of mathematical representation skills by NCTM is that learning from elementary to secondary education maximizes students to: (1) create and apply representations to organize, copy, and disseminate mathematical ideas; (2) Sort, use, and solve problem solving, represent mathematical problems; and (3) Apply mathematical representation skills so that they can be modeled and understand events that are mathematical, social, and physical (Khoerunnisa & Maryati, 2022).

Currently, the Independent Curriculum has been implemented as the 2023 education program plan has been recognized by the Indonesian Ministry of Education, Culture, Research and Technology. The purpose of the education program as a way to make schools in our country successful is to provide various types of education in groups. This education program focuses on comfortable, enthusiastic, beautiful, important, and independent learning. Teachers have the freedom to select various learning materials so that the learning process can be considered through the level of educational needs and student interests (Aryanti et al., 2023). One of them is known as a problem-based learning model assisted by media as a way to manage learning in order to maximize student activity when studying indoors so that it is suitable for using the Independent curriculum concept. SMP Negeri 5 Kendari is one of the educational institutions that has started using the latest education program. Therefore, the researcher chose SMP Negeri 5 Kendari as the place of research.

The researcher conducted an interview with a mathematics teacher and obtained information that the students' ability to solve problems given in the form of statements will then be changed into images, calculation operations or reasons why students cannot understand the meaning of the questions given by the teacher and sometimes students feel confused about how to change them. In addition to student and educator factors, the teaching and learning process also supports the ability to represent mathematics which can continue to be honed, namely the use of learning methods so that students can play a greater role when learning independently and in groups. The teaching and learning process carried out by teachers when teaching has not fully used the model as recommended in this Independent Curriculum, such as implementing problem-based learning, project-based learning and discovery learning. In its implementation, the teaching and learning process mostly emphasizes teachers being more active or direct learning which makes students not

get the opportunity to try to represent what they know, students are more familiar with completing tasks that are similar to questions in the form of examples and gradually the process of solving exemplified by the teacher, so that when some questions are different, students feel confused in representing their solutions and there are still many students who have not been able to express the solution to a problem in another form as instructed in the question.

The researcher created a pre-research test and then gave it to three grade VII students randomly. There were three pre-research questions given. Each question covers each indicator of the ability to represent mathematics, such as representing through images, representing through symbols, and representing through writing.

Based on the test results, it was found that there were students on the verbal representation indicator on question number three, students had not been able to express the conclusion of the solution to the problem given in written form, namely students wrote conclusions but were not in line with the questions given, one student on the visual representation indicator on question number one, students had not been able to present information from the question correctly into a graph or through a picture that directly drew it with the same size without paying attention to the size of the graph to be drawn based on what was in the question. Likewise, there was one student on the symbolic representation indicator, students had not been able to solve the question into an equation and mathematical pattern as a solution given in the question, but immediately added them together. The conclusion that researchers can draw is that the three students are still unable to change information in written form into a graph or picture according to the directions of the question, students are still unable to write their own problem solving through writing and are still unable to create a mathematical model and then solve it. To support learning activities, researchers apply a problem-based model. Researchers apply a cooking-based learning index together with *Information and Communication Technology (ICT)* -based applications as interactive media that include three approaches, namely analytical, visual, and numerical, which are specifically designed to suit the material, attract students, and meet pedagogical principles. One of the computer programs that is very well accommodated for teaching mathematics is an application called GeoGebra which can be used to produce more dynamic mathematical concepts (Rahadyan, et al 2018). GeoGebra is free software that can be used in mathematics learning with complete and interactive features without the need for programming code, so it can be concluded that technology in this case GeoGebra software has an important role in the mathematics learning process (Lestari et al., 2023).

The use of the visualization feature of the GeoGebra software program makes students better understand a mathematical principle or concept according to the problems faced by students. Learning that combines problem-based learning through the help of GeoGebra can maximize interest in sharpening students and making it easier to understand lesson concepts, and attract students' attention in learning (Septian et al, 2023). Likewise, Syofran (2019) concluded that students who were taught using the Geogebra application showed better results when they learned about trigonometry in the material of function graphs than with conventional methods. The use of

the GeoGebra application makes learning more enjoyable for students because it is easier for them to find the function points and then draw the graphs in detail.

Based on the description above through the results of the OECD, TIMSS, and PISA surveys as well as information through observations and interviews with teachers and several previous research results, the researcher tried to conduct this research by implementing a problem-based learning model accompanied by the use of the Geogebra application.

METHOD

The type of research used in this study is a quasi-experiment, which is a study conducted because of difficulties in controlling several variables in the classroom, such as the interaction situation between students and students, students with their environment, characteristics of each student, and the position of students' seats in the classroom. The variables that can be controlled in the classroom in this quasi-experimental study are the learning models used by the teacher (Abraham & Supriyati, 2022). This study compares students' mathematical representation abilities influenced by the problem-based learning model assisted by the GeoGebra program in the experimental class and the problem-based learning model without the use of the GeoGebra application in the control class.

The population in this study were all students of class VIII of SMP Negeri 5 Kendari. Sampling was done using simple random sampling technique, namely randomly selecting two classes as the experimental class and the control class. The sample was the las VIII (A) dan kelas VIII (C)..

The instruments used in this study were teacher and student activity observation sheets and mathematical representation ability tests . Both test instruments were used as data collection tools. Data collection through observation sheets was carried out in six meetings both in the experimental class and in the control class. Data from the calculation of teacher and student observation sheets were then matched with the assessment criteria for teacher and student observation sheets, h Sudjana (Nissa and Sukardiyono, 2017) as in Table 1 below.

Table 1
Category of Student and Teacher Activity Observation Results

Value Range	Category
$k \geq 90$	Very good
$80 \leq k < 90$	Good
$70 \leq k < 80$	Enough
$60 \leq k < 70$	Not enough
$k < 60$	Very less

The next data collection instrument is a mathematical representation ability test that is compiled and developed by researchers in the form of descriptive questions that include indicators of

mathematical representation ability. Before the questions are given to students, their validity and reliability are first tested. The question grid is as in Table 2 below.

Table 2
Mathematical Representation Ability Test Instrument Grid

Representation Ability Aspect	Representation Ability Indicator	Question Form	Question Number
Symbolic Representation	Presenting problem solving in the form of a mathematical model using calculation operations.	Description	2
Visual Representation	Presenting problem solving in image form	Description	1
Verbal Representation	Writing problem solving procedures in words	Description	3
Number of Questions	3		

Holistic or tubric scoring guidelines are used to score students' mathematical representation abilities, as shown in Table 3 below.

Table 3
Mathematical Representation Ability Test Scoring Guidelines

No	Mathematical Representation Ability Indicator	Scoring Rubric	Score
1	Presenting problem solving in the form of a mathematical model using calculation operations	No answer	0
		The answer is incorrect, the attempt made is incorrect	1
		Create mathematical models with calculation operations but only a few are correct	2
		Create a mathematical model with calculation operations but not yet complete	3
		Creating a mathematical model with complete calculation operations but the answer at the end is wrong	4
		Create a mathematical model with calculation operations, the answers are complete and correct	5
2	Presenting problem solving in the form of images	No answer	0
		The answer is incorrect, the attempt made is incorrect	1
		Only a few of the images created are correct	2
		Made a picture but it's not complete	3
		Creates a complete image but there are still a	4

No	Mathematical Representation Ability Indicator	Scoring Rubric	Score
		few errors	
		Make sure the image is complete and correct	5
3	Writing down the solution to the problem with your own answer using writing	No answer	0
		The answer is incorrect, the attempt made is incorrect	1
		The explanation provided does not match the content of the question.	2
		The explanation is made according to the contents of the question but is not complete	3
		The explanation is made according to the content of the question but there are still a few errors.	4
		The explanation made is complete and correct	5

(Source: Saleha & Nuraeni, 2023)

The mathematical representation ability test scores were then categorized into three categories, namely: high, medium, and low. Students' mathematical representation abilities are grouped into three categories as shown in Table 4.

Tab 44
Criteria and Categories of Students' Mathematical Representation Abilities

Value Range	Category
$x > \bar{x} + s$	Tall
$\bar{\bar{x}} - s \leq x \leq \bar{x} + s$	Currently
$x < \bar{x} - s$	Low

RESULTS AND DISCUSSION

The data analyzed in this study consisted of observation data on teacher teaching activities in learning, student learning activities, and mathematical representation test results. The results of the descriptive analysis of students' mathematical representation abilities can be seen in Table 5.

Table 5
Results of Descriptive Analysis of Mathematical Representation Ability

Descriptive Statistics	Experimental Class	Control Class
N	30	30
Mean	82.24	76.45
Median	86.00	80.00
Mode	87	81
Std. Deviation	9,143	11,167
Variance	82,621	124,139
Minimum	58	52
Maximum	95	90

The above values indicate that the mathematical representation ability of students in the experimental class taught with a problem-based learning model accompanied by the use of the GeoGebra application is better than the control class taught with a problem-based learning model without the use of the GeoGebra application. The mathematical representation ability of students grouped into high, medium and low categories can be seen in Table 6.

Table 6
Students' Mathematical Representation Ability in Category
High, Medium, and Low

Category	Experimental Class		Control Class	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Tall	10	30.30	7	21.21
Currently	18	54.55	16	48.48
Low	6	18.18	12	36.36
Amount	33	100	33	100

The distribution of students' mathematical representation abilities for each indicator of the experimental class and control class can be seen in Table 7.

Table 7
Students' Mathematical Representation Ability Per Indicator

Aspects/Indicators	Percentage of Experimental Class (%)	Category	Percentage of Control Class (%)	Category
Visual Representation	85.71	Currently	79.86	Currently
Symbolic Representation	73.86	Currently	87.00	Currently
Verbal Representation	75.00	Currently	64.14	Low

Based on Table 7, the percentage of students' mathematical representation ability levels based on indicators in the experimental class and control class are in the same category, namely moderate in the visual and verbal aspects, while in the symbolic aspect the control class is in the low category. The next stage is inferential analysis which aims to determine whether the research hypothesis is accepted or rejected. This process involves several prerequisite steps. First, a normality test is carried out to check whether the data comes from a normally distributed population, and a homogeneity test to ensure that the data is homogeneous to the population. After these prerequisites are met, the next step is a hypothesis test. The following table shows the results of data hypothesis testing for the mathematical representation ability of students taught with a problem-based learning model using the GeoGebra application and students taught with a problem-based learning model without using the GeoGebra application.

Table 8
Independent Sample T-Test Analysis Results

t_{hitung}	$Sig.\ (2-Tailed)/2$	Decision
2,281	0,013	RejectH_0

Based on the results of the Independent Sample T-Test test in Table 10 above, it was obtained that the significance value was $= 0{,}013 < \alpha(0{,}05)$, so the decision $H_0$was rejected. Thus, it can be concluded that the average mathematical representation ability of students taught with a problem-based learning model accompanied by the use of the GeoGebra application is higher than those taught with a problem-based learning model without the use of the GeoGebra application. Thus, the use of the Geogebra application has an influence on learning outcomes in this case the mathematical representation ability of students.

CONCLUSION

The learning activities of students taught with problem-based learning models accompanied by the use of GeoGebra applications are quite active. This is indicated by the average percentage of student activity during six meetings reaching 85.65%. The average value of mathematical representation ability of students taught with problem-based learning model with the use of GeoGebra application is 82.24 higher than the average value taught with problem-based learning model without the use of GeoGebra application with an average value of only 76.45. Thus, the problem-based learning model accompanied by the use of GeoGebra application has an effect on students' mathematical representation ability.

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