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Mathematical Representation Ability of Students on Linear Program Material in Terms of Learning Interests in Problem-Based Learning

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ABSTRACT

This study aims to determine the completeness of the implementation of Problem-Based Learning (PBL) to the achievement of students' mathematical representation skills, determine the influence of learning interest on the mathematical representation ability of students in PBL, and describe the mathematical representation skills of students in terms of learning interest. The research method used is a mixed method with a concurrent embedded strategy. The results showed that PBL did not complete the mathematical representation ability of students. This is due to several factors including (1) the difficulties experienced by students in online learning, (2) the time gap between the last meeting of PBL and the mathematical representation ability tests, (3) the weakness of PBL learning that takes a long time, (4) the number of students who are the subject is too little, and (5) the problem of mathematical representation ability test instrument is difficult. Furthermore, there is an influence of learning interest in the mathematical representation ability of students in PBL by 56.2%. Then, the mathematical representation ability of subjects with high and medium categories of learning interest tends to be able to meet the three indicators of mathematical representation ability, while subjects with low categories of learning interest are not able to meet the three indicators of mathematical representation ability. The three indicators of mathematical representation ability are visual representation, Representation of Mathematical Equations or Expressions Ability, and representation of words or written text.

Keywords: *mathematical representation ability, learning interest, problem-based learning.*

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INTRODUCTION

Mathematical representation ability is one of the basic abilities that must be possessed by students. There are five basic abilities in the mathematics set by NCTM (2000) in Fonna and Mursalin (2018), namely problem solving, reasoning, communication, connection, and representation. According to Sabirin (2014) mathematical representation can be used as a tool to find the solution of a problem in the form of interpretation. Then, it is also emphasized by Elmagustilla and Masrukan (2021), that mathematical representation is one way to solve mathematical problems.

Risdianti, et al (2021) stated that mathematical representation ability is an important parameter in mathematics education in Indonesia today. High representation ability in mathematics learning will certainly help students in solving a problem. Conversely, low representation ability can make students feel difficulty in solving a problem. The low ability of representation causes students difficulty to find and express ideas or mathematical ideas of the problems at hand. This will certainly hamper the problem-solving process so that students often find it difficult to learn mathematics.

According to Sabirin (2014) representation is divided into two, namely internal external representation. Internal representation can be interpreted as an activity that occurs in the minds of students about a mathematical idea that allows students to work on the basis of that idea. Then the external representation can be defined as the result of the construction or communication of an internal representation that can take the form of verbal, images and/or concrete objects. In mathematics learning, teachers can guess and see the thinking activities of students through external representations.

Based on Goldin's statement, mathematical representation ability can be interpreted as the ability of students to communicate their ideas or ideas in other forms. Syafri (2017), said that the standard of representation in mathematics is emphasized on the use of images, tables, symbols, charts, graphs in communicating mathematical ideas. Thus, it can be concluded that the mathematical representation ability is the ability of students to communicate their ideas or ideas in other forms such as images, tables, symbols, charts, and graphs. Mudzakir (2006) in Oktaria, Alam, and Sulistiawati (2016) divided mathematical representation ability into three aspects with indicators presented in Tabel 1. The indicators of mathematical representation ability that being used in this study are presented in Tabel 2.

Mathematical representation ability on linear program material of 11^{th}-grade students of Sekolah Indonesia Luar Negeri (SILN) Singapore is known to be not optimal. This can be seen from the initial mathematical representation ability of linear program material of 11th grade students in the 2021/2022 school year which shows that there are still some students who get learning outcomes less than the Minimum Completion Criteria

(MCC), which is 70. From the 9 students who took the daily test, only 5 students could reach the MCC.

Table 1. Indicator of Mathematical Representation Ability According to Mudzakir

No.	Aspects Representation	Indicators
1.	A visual representation (diagram, table, graph, or image)	1.1 Present data or information from a representation of a diagram, table, or graph. 1.2 Use visual expressions to solve problems. 1.3 Create drawings of geometric patterns. 1.4 Create drawings to clarify problems or facilitate their resolution.
2.	Mathematical equations or expressions	2.1 create equations or mathematical models from other given representations. 2.2 Make a conjecture of a number pattern. 2.3 Solve problems by involving mathematical expressions.
3.	Written words or texts	3.1 create problem situations based on the data or representations provided. 3.2 An interpretation or representation. 3.3 Write down the steps of solving math problems in words. 3.4 Arrange the story in accordance with a representation presented. 3.5 Answer questions using words or written text.

Table 2. Mathematical Representation Ability Indicators Used

No.	Representation	Mathematical Representation Of Indicators
1.	The visual representation	1.1 restates the data or information to a graphical representation.
2.	Mathematical equations or expressions	2.1 create equations or mathematical models from other given representations. 2.2 Solve problems by involving mathematical expressions.
3.	Words or written text	3.1. answer questions using words or written text.

Based on observations made by researchers at SILN Singapore, mathematics learning activities do not take place well for all students. Some students can receive learning materials well but there are some other students who pay less attention and focus on learning mathematics. This can be seen from the activities carried out by students in the learning process of mathematics, such as not listening when the teacher is explaining the material, not being active in discussions, not collecting the assignments on time, and so on. The behavior shown by the learners is related to the learning interest. According to Hidayat & Widjajanti (2018), learning interest is a state of students who can foster a sense of love and enthusiasm in themselves to do an activity that can be measured through liking, being interested, and having attention and involvement in the learning process.

Heriyati (2017) stated that the learning interest of students is a force that can encourage students to learn. Students who have a learning interest will be happy to do so and continue to be encouraged to persevere in learning. Lestari (2015) said that learning interest is the inner drive possessed by learners to improve learning habits. Students ' learning interest can arise when students have a desire to get good grades or want to win the competition in learning with other students. Lestari (2015) also said that students who have a high learning

interest, tend to be more enthusiastic, tenacious, diligent, and not easy to give up. Then, it can be concluded that the interest of learning students is the desire of students to learn something that can be seen from the pleasure of students when learning something, participation and activeness during the learning process, persistence in learning, and curiosity of students about things related to something being learned.

Friantini and Winata (2019) mentioned that the indicators of learning interest are (1) the feeling of pleasure in learning, (2) the concentration of attention and mind toward learning, (3) the willingness to learn, (4) the willingness from within to be active in learning, (5) the done to realize the desire to learn. Indicators of learning interest that will be used in this study are (1) the feeling of pleasure to the learning process perceived by students, (2) the concentration of mind and attention of students in the learning process, (3) the willingness to learn, (4) the willingness of the students to active in the learning process, (5) the efforts made by students to realize the desire to learn.

SILN Singapore, is a school that has implemented the 2013 curriculum. In the learning process, curriculum 2013 requires students to be more active to learn and solve problems independently so that the learning process is no longer centered on the teacher, but on the students. One of the learning models that are often used to stimulate the activity of students and independence in solving problems is Problem Based Learning (PBL). In the learning process, PBL applies problem-based learning where students work together with their peers to solve contextual problems. PBL can help students to be able to relate the application of mathematics in the real world. Based on the results of research conducted by Nurfitriyanti, et al (2020), PBL has an influence on the mathematical representation ability of students.

Based on the description above, the problem formulation of this study are (1) determine the completeness of the implementation of PBL to the achievement of students' mathematical representation skills, (2) determine the influence of learning interest on the mathematical representation ability of students in PBL, and describe the mathematical representation skills of students in terms of learning interest.

METHODS

The method used is a mixed method with concurrent embedded strategies. The mixed method is a combination of quantitative research with qualitative research. Quantitative methods are used to test the completeness of the application of learning PBL on the achievement of the mathematical representation ability of students and determine the influence of interest in learning the mathematical representation ability of students in PBL learning, while qualitative methods are used to analyze and describe mathematical representation ability of students in terms of interest in learning PBL learning. The research design used in quantitative research is a one-shot case study design, that is, the research subject is given a certain treatment and then makes measurements of the consequences of the treatment. The design was chosen because of the limited research subjects.

The selection of research subjects was carried out using purposive sampling techniques or deliberate selection of research subjects by

researchers based on certain considerations. Consideration used in the selection of research subjects is interest in learning. Before the research subjects were selected, the researchers classified the learning interests based on the results of the learning interest questionnaire that had been filled out by the students. Research subjects were selected for as many as 6 students, each of which 2 students have high, medium, and low learning interests. In addition, the selection of research subjects also considers the willingness of students to be the research subject. Based on the data that has been collected, the results of the classification of the learning interests of students are presented in Table 3.

Table 3. The Results of The Classification of Students' Learning Interests

Students	Learning Interest Category
DNR	High
DAA	High
HMA	High
KMFA	Moderate
KAR	Moderate
MCT	Moderate
NKP	Moderate
SZ	Moderate
DAHP	Low
FHNA	Low
RKSD	High

The results of the classification of students' learning interests above are considered to choose the research subjects to be interviewed. From each category of learning interest, two students were randomly selected as research subjects. Selected research subjects are presented in the following Table 4.

Table 4. Research Subject

Learning Interest Category	Subject 1	Subject 2
High	DAA	HMA
Moderate	KMFA	MCT
Low	FHNA	DAHP

The data collection techniques used in this study are tests, questionnaires, and interviews. The test is used to determine the mathematical representations ability of students, while a questionnaire is used to obtain data on the learning interest of students in learning mathematics and an interview is used to obtain information about the difficulty of the subject in solving mathematical problem linear program material.

The analysis data for the completeness of PBL in mathematics representation ability of students were using hypothesis test with right side proportion test. Furthermore, the analysis data for the influence of learning interest on the mathematical representation of students using hypothesis tests with simple linear regression. Before testing the hypotheses, normality and linearity tests were performed as prerequisite tests. Moreover, the analysis data for the description of the mathematical representation ability of students in terms of learning interest was using triangulation.

RESULTS AND DISCUSSIONS

The normality test was carried out before testing the hypotheses whether PBL is complete the achievement on MRA students or not. Testing the normality of the data in this research using the Shapiro-Wilk test using IBM SPSS Statistics 25 software. The test criteria used are Accept H_0if the value of $Sig > 0{,}05$ and reject H_0 if the value of $Sig \leq 0{,}05$. The results of data normality test are presented in Table 5.

Table 5. The Result of Normality Test

α	$Sig.$	Conclusion	Meaning
0,05	0,284	H_0 Accepted.	Data comes from a normally distributed population.

After the normality test was carried out and it was proven that the data comes from a normally distributed population, the hypothesis test was carried out to test the completeness of the mathematical representation ability of students in PBL learning using the proportion test of one party with the statistical hypothesis as follows.

$H_0: \pi \leq 75\%$, means that the number of students who have achieved the completeness of the mathematical representation Ability Test in linear programs in PBL learning is less than or equal to 75% or has not reached the classical completeness.
$H_1: \pi > 75\%$, means that the number of students who have reached the completeness of the mathematical representation ability test on linear programs in PBL learning is more than 75% or has reached classical completeness.

The test criteria used are accept H_0 if $z_{count} < z_{table}$ and reject H_0 if $z_{count} \geq z_{table}$. The results of the calculation can be seen in Table 6.

Table 6. The Completeness Test Calculation Results

z_{count}	z_{table}	Conclusion	Meaning
−0,8704	1,64	H_0 Accepted	The number of students who have achieved the completeness of the mathematical representation Ability Test in linear programs in PBL learning is less than or equal to 75% or has not reached the classical completeness.

Based on the results of the completeness test, it is known that the mathematical representations ability of students in PBL has not reached completeness. Therefore, PBL learning has not complete to the achievement of mathematical representation ability of students. This can happen due to several factors, namely the difficulties experienced by students in online learning. This study was conducted online because the students were in Singapore while the researchers were in Indonesia. The difficulty was confirmed by one of the subjects, namely Subject DAHP who claimed that since mathematics learning was carried out online, many students found it difficult to follow the learning. Subject DAHP stated that most of the XI grade learners have difficulty to focus on learning. This can be seen from some students who open or discuss about other things outside the topic of learning.

Online learning in SILN Singapore has been carried out since the covid-19 pandemic until the time this research report was written. In addition to the covid-19 pandemic, SILN Singapore organizes online learning also due to the lack of educators in schools. The lack of completeness of PBL learning on the mathematical

representation ability due to students ' difficulties with online learning is supported by the results of research conducted by Tasdik and Amelia (2021). Research conducted by Tasdik and Amelia (2021) concluded that online learning makes students have difficulties in learning mathematics.

The next factor that causes PBL learning is not complete on the mathematical representation ability of students is the time gap between the last meeting of PBL learning and the implementation of mathematical representation ability test. The last meeting of PBL learning was held on August 10, 2022, then the mathematical representation ability test was held on August 23, 2022. It is known that the distance between the last meeting of PBL learning and the implementation of the mathematical representation ability test was 13 days. This is because mathematics learning is only carried out in two meetings in one week and most students must train to become heritage flag raising team on August 16, 2022 and serve as heritage flag raising team on August 17, 2022 at the Embassy of the Republic of Indonesia in Singapore. The time gap between the last meeting of PBL learning and the implementation of the mathematical representation ability test and the busyness of students who have to practice being heritage flag raising team every day makes the results of the mathematical representation ability test of students is not optimal.

Then, the weakness possessed by PBL learning is also a factor in the incompleteness of PBL learning to the students ' representation ability. The weakness was revealed by Sanjaya (2007) in Tyas (2017), that PBL learning takes a long time, while PBL learning in this study was only carried out in three meetings.

Another factor that causes PBL learning is not complete on the mathematical representation ability of students in this study is the students who became the subject of research that is too little, which is only 11. The number of students who are the subject of research will certainly affect the calculation results in the hypothesis test.

In addition, the mathematical representation ability test instrument and the learning design used also influenced the results of the study. Based on the results of the analysis of the level of difficulty in the mathematical representation ability test instrument, it is known that the level of difficulty of each item is difficult. Then, the design of learning conducted in this study is also less appropriate. This can be seen from the lesson plan on learning tools that are less appropriate, namely discussing the concept or prerequisite material at the first meeting of PBL. Supposedly, the first meeting of PBL was held on linear program material.

The Results and Discussion of The Analysis of The Influence of Learning Interest on The Mathematical Representation Ability of Students in PBL

Normality test and linearity test carried out before testing the influence of learning interest on the mathematical representation ability of students in PBL learning. Normality test has been done before, and it is known that the data is normally distributed. Furthermore, linearity test was performed using IBM SPSS Statistics 25 software. The test criteria used are accept H_0 if the value of $Sig > 0{,}05$ and reject H_0 if the value of $Sig \leq 0{,}05$. The results of data linearity test are presented in Table 7.

Table 7. The Result of Linearity Test

α	$Sig.$	Conclusion	Meaning
0,05	0,454	H_0 Accepted	There is a linear relationship between learning interest and the mathematical representations ability of students.

After the data is known to be normally distributed and there is a linear relationship between learning interest and mathematical representation ability of students, a simple regression analysis was performed to determine the effect of learning interest on mathematical representation ability of students. Simple regression analysis was performed using IBM SPSS Statistics 25 software with statistical hypotheses used as follows.

H_0: There is no influence of learning interest on the mathematical representation ability of learners.
H_1: There is an influence of interest in learning the ability of mathematical representations of learners.

The test criteria used are Accept H_0 if the value of $Sig > 0{,}05$ and reject H_0 if the value of $Sig \leq 0{,}05$. The results of a simple regression analysis are presented in Table 8.

Table 8. The Result of Simple Regression Analysis

α	$Sig.$	Conclusion	Meaning
0,05	0,008	H_0 Rejected	There is an influence of interest in learning the ability of mathematical representations of learners.

Based on the results of the linearity test as a condition of hypothesis testing to determine the effect of interest in learning on the mathematical representation ability of students in PBL learning, it is known that there is a linear relationship between interest in learning with the ability of mathematical representation. Then, based on a simple regression analysis, it is known that there is an influence of interest in learning the ability of mathematical representations of students by 56.2%. This is in line with the results of Kusumah's research (2018) which said that there is a correlation between the ability of mathematical representation, mathematical communication skills, and students' learning interests. Furthermore, in the regression equation can also be Y =17.012+0.153 X.

Based on the regression equation above, variable X expresses interest in learning and variable Y expresses the mathematical representation ability of students. The value of the coefficient in the regression equation is positive, it can be said that the interest in learning a positive effect on the ability of mathematical representations of students. This is in accordance with the results of Kusumah's research (2018), namely there is a positive influence of learning interest on the mathematical representation ability and mathematical communication skills. Then, according to the regression equation, each increase of one unit of learning interest, then the mathematical representation ability of students increased by 0.153. This is in accordance with the results of Kusumah's research (2018), namely there is a positive influence of learning interest on the mathematical representation ability and mathematical communication skills.

The Results and Discussion of The Analysis of The Mathematical

Representations Ability of Students in Terms of Learning Interest

The ability of mathematical representation in this study is the ability of students to communicate mathematical ideas in other forms, which is seen from three aspects, namely (1) aspects of the ability of visual representation that contains indicators to present data or information to the graphic representation to explain the problem or facilitate problem solving, (2) aspects of the ability to represent the form of equations or mathematical expressions that contain indicators to make equations or mathematical models from other representations given and solve problems by involving mathematical expressions, and (3) aspects of the ability to represent words or written text that contain indicators to answer questions using words or written text.

The classification of students 'learning interests has been done previously to classify students' learning interests into three categories, namely high, medium and low learning interests. In each category of learning interest, two subjects were selected to analyze their mathematical representation ability. Based on the analysis of mathematical representation ability of students in Class XI SILN Singapore found that students who have an interest in learning in different categories have different mathematical representation ability. The results of the description of the ability of mathematical representation in each category of learning interest are described as follows.

Subject in *High* Category of Learning Interest

Based on the results of the analysis of mathematical representation ability of subjects with a high interest in learning category, it is known that both subjects were able to meet the indicators of mathematical representation ability in the aspect of visual representation. Both subjects are able to present data or information back to a graphical representation to explain the problem or facilitate the resolution of the problem.

However, the results of the test of mathematical representation ability belonging to both subjects can be seen that there is an incomplete solution. This can happen because both subjects do not have enough time to solve the problem. Then, both subjects were also able to meet the indicators of mathematical representation ability in the aspect of representation of mathematical equations or expressions. Both subjects are capable of creating equations or mathematical models from other given representations as well as involving mathematical expressions.

In the last indicator, which is an indicator of the ability to mathematical representation in the aspect of words or written text, there is a difference between the two subjects. Subject DAA were able to meet these indicators, but Subject HMA were not able to. Subject DAA were able to answer questions in words or written text, while Subject HMA had difficulty. Subject DAA are able to solve problems coherently and correctly. Subject HMA have difficulty writing Ways or steps to solve problems coherently. This is not in accordance with the results of Komariah research, et al (2018) which states that students who have a high interest in learning are able to understand and solve problems coherently and correctly. Similarly, the results of research conducted by Holidun, et al (2018) that students who have a high interest in learning are able to solve problems with the right steps. However, Subject HMA were able to find the correct results.

Thus, with this it can be concluded that subjects with a high category of interest in learning tend to be able to meet all three indicators of mathematical representation ability. The three indicators are indicators of the ability of mathematical representation in the aspect of visual representation, representation of the form of mathematical equations or expressions, and representation of words or written text.

Subject in Moderate Category of Learning Interest

Based on the results of the analysis of mathematical representation ability of subjects with interest in learning medium category, it is known that both subjects were able to meet the indicators of mathematical representation ability in the aspect of visual representation. Both subjects are able to present data or information back to a graphical representation to explain the problem or facilitate the resolution of the problem. However, the results of the MCT subject's mathematical representation ability test can be seen that there are incomplete solutions. The MCT subject forgets to draw a graph that facilitates the resolution of one of the questions.

Then, both subjects were also able to meet the indicators of mathematical representation ability in the aspect of representation of mathematical equations or expressions. Both subjects were able to make equations or mathematical models from other representations given and involving mathematical expressions although the results of the KMFA subject's mathematical representation ability test showed that there was an error in the mathematical expressions made.

Furthermore, in the last indicator of mathematical representation ability, that is, in the aspect of the representation of words or written texts, there are differences between the two subjects. Subject MCT were able to answer questions using words or written text, while Subject KMFA were not able to. Subject KMFA have difficulty answering questions using words or written text. Nevertheless, the KMFA subject was able to find the correct solution to the question. This is in line with the results of research conducted by Komariyah, et al (2018) that students who have an interest in learning are able to solve a problem, but have not been able to apply the concept coherently and correctly. Then, it is also in accordance with the results of research conducted by Holidun, et al (2018) that students who have an interest in learning are able to solve problems but have not been systematic and maximal.

This phenomenon is the same as that experienced by subjects with a high category of interest in learning. Thus, with this it can be concluded that subjects with an interest in learning the medium category tend to be able to meet all three indicators of mathematical representation ability. The three indicators are indicators of the ability of mathematical representation in the aspect of visual representation, representation of the form of mathematical equations or expressions, and representation of words or written text.

Subject in Low Category of Learning Interest

Based on the results of the analysis of the mathematical representation ability of subjects with low interest in learning categories, it is known that the two subjects were unable to meet the three indicators of mathematical representation ability. According to the results of the

mathematical representation ability test and the results of the interview, both subjects had difficulty understanding the meaning of the questions and the steps to solve the problems. Subjects with low learning interest have difficulty understanding the relationship of mathematical concepts so that difficulties in solving problems (Hamdani & Nurdin, 2020). This is in line with the results of research conducted by Komariyah, et al (2018) that students with low interest in learning feel confusion and difficulty in designing strategies and implementing strategies to solve a problem.

Thus, with this it can be concluded that subjects with a low category of interest in learning are not able to meet all three indicators of mathematical representation ability. The three indicators are indicators of the ability of mathematical representation in the aspect of visual representation, representation of the form of mathematical equations or expressions, and representation of words or written text.

CONCLUSION

Based on the result and discussion, it can be concluded that PBL did not complete the mathematical representation ability of students. This is due to several factors including (1) the difficulties experienced by students in online learning, (2) the time gap between the last meeting of PBL and the mathematical representation ability tests, (3) the weakness of PBL learning that takes a long time, (4) the number of students who are the subject is too little, and (5) the problem of mathematical representation ability test instrument is difficult. Furthermore, there is an influence of learning interest in the ability of mathematical representations of students in PBL by 56.2%. Then, the mathematical representation ability of subjects with high and medium categories of learning interest tends to be able to meet the three indicators of mathematical representation ability, while subjects with low categories of learning interest are not able to meet the three indicators of mathematical representation ability. The three indicators of mathematical representation ability are visual representation, representation of mathematical equations or expressions, and representation of words or written text.

Based on the results of the study, suggestions that can be given by researchers are (1) teachers should pay more attention to students who have poor representation skills, and (2) teachers should provide exercises that can improve the ability of students representation.

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