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IMPLEMENTATION OF PROBLEM BASED LEARNING TO IMPROVE STUDENTS' MATHEMATICAL UNDERSTANDING ABILITY AND MATHEMATICAL CONNECTION ABILITY ON VOCATIONAL SCHOOL

Euis Nur Komariah[1], Irfan Taufik Nurdin[2], Harry Dwi Putra[3], Anik Yulani[4]

[1]SMKN 1 Pagelaran, Jl. Raya Pasirpari, Cianjur, Indonesia.
euisnurkomariah83@gmail.com
[2]IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.
irfantaufiknurdin85@gmail.com
[3]IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.
harrydp@ikipsiliwangi.ac.id
[4]IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.
anik_yuliani070886@yahoo.com

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ABSTRACT

In achieving educational goals, mathematical understanding and connection ability are very important for students. However, the fact is mathematical understanding and connection ability still very low. So, to achieve these learning objectives, a learning approach model is needed to improve students' mathematical understanding and connection ability. The purpose of this study is to see the improvement of mathematical understanding and connection ability on vocational shool. In order to do so, we used quasi-experimental research by comparing groups with different treatments. One class as experimental using problem based learning model and another class as control using directed learning. We used mathematical understanding and connection ability test to collect the data. The results shows that mathematical understanding and connection ability improved by using problem based learning model. N-Gain for mathematical understanding ability is in high category and mathematical connection ability is in moderate category. Based on the results, we can conclude that problem based learning model can improve mathematical understanding ability and mathematical connection ability.

Corresponding author:

Euis Nur Komariah,
SMKN 1 Pagelaran,
Jl. Raya Pasirpari, Cianjur, Indonesia,
Email: euisnurkomariah83@gmail.com

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INTRODUCTION

The four pillars of education in mathematics learning refer to the principles of active student learning and "how to learn", namely: 1) learning to know 2) learning to do 3) learning to be 4) learning to be 4) learning to be living together. The secondary school mathematics curriculum contains details of the topics, basic mathematics skills, and attitudes that students are expected to have at school level. In general, basic mathematical abilities can be classified into five types of abilities, namely: 1) recognizing, understanding and applying mathematical concepts, procedures, principles and ideas 2) solving mathematical problems (*mathematical problem solver*) 3) reasoning mathematically 4) making mathematical connections 5) mathematical communication (Hendriana & Soemarmo, 2014).

As stated by Ruseffendi (2006) There are still many students who after studying mathematics are unable to understand even the simplest parts, many concepts are misunderstood so that mathematics is considered a difficult, complicated and difficult science. Even though understanding concepts is the most important part of learning mathematics, as stated by Zulkardi (2003) that mathematics subjects emphasize concepts. This means that when studying mathematics, students must understand the concepts first in order to be able to solve problems and be able to apply this learning in the real world. Mathematics is a subject that deals with abstract ideas and concepts arranged systematically and thinking deductively (Agustina & Fuadiah, 2018). Concepts in mathematics are arranged systematically, logically and hierarchically from the simplest to the most complex. Understanding mathematical concepts is the basis for studying mathematics meaningfully (Septiati, 2016).

In achieving educational goals, mathematical understanding and connections are very important for students, but in reality mathematical understanding and abilities are still very low. In the 2018 PISA, Indonesia obtained a score of 379 below the international average score of 489 and was ranked 73rd out of 79 countries (OECD, 2019). The door to a brilliant career will open when students succeed in studying mathematics (NRC, 1989).

Students' understanding is low due to students' slow cognitive development in understanding abstract mathematical concepts (Putra et al., 2018). In solving various real problems, students must master mathematical concepts for use in other sciences (Ulya et al., 2016). Students must have mathematical connection skills to be able to link mathematical concepts with various other sciences and be able to solve real problems with mathematical concepts (Andriani & Aripin, 2019). So, to achieve these learning objectives, a learning approach model is needed that can improve students' mathematical understanding and connection abilities.

Students are required to learn and will remember too many concepts with separate mathematical procedures if there is no mathematical connection (NCTM, 2000). Students' understanding of mathematics will deepen and last longer if students are able to link ideas -mathematical ideas because they are able to see the relationship between mathematical ideas, with the context between mathematical topics, and with everyday life experiences (Principles, 2000). Therefore, students can understand and not experience difficulties in learning mathematics So mathematical connection skills are needed so it is very important for students to have them.

Based on the problem raised, namely students' low understanding and connection to mathematics can be caused by several components, including a less supportive learning model. So from this problem, efforts need to be made by every mathematics teacher to find and adapt learning models to achieve educational goals.

In this case, solving problems using the right learning model will influence the learning process thereby increasing mathematical understanding and connections as a result of learning. Learning models that can improve learning outcomes include the Problem Based Learning (PBL) model. PBL is a learning model that presents real problems as a context for students to learn critical thinking, problem solving skills and gain knowledge and leads to better learning outcomes, being more active in building their learning. According to Glazer (2001) suggests *Problem Based Learning* (PBL) is a teaching strategy in which complex problems in real situations are actively confronted students to find solutions.

The Problem Based Learning (PBL) learning model is a learning model developed based on the constructivist view. Learning with the PBL model has several advantages, including being able to improve student learning outcomes and making it easier for students to understand lesson content. According to Trianto (2009) As a learning model, Problem Based Learning has advantages , including : (1) factual with students' lives; (2) the concept is appropriate to student needs; (3) fostering students' creativity; (4) increase students' understanding; (5) fostering students' abilities in problem solving".

The importance of having the ability to understand mathematics and the ability to make mathematical connections is one of the mathematical skills or abilities that is expected to be achieved in learning mathematics. Therefore, this ability can show students' understanding of the mathematical concepts they are studying, so that they can explain the relationships between concepts and apply concepts or algorithms flexibly, accurately, efficiently and precisely in solving problems and achieving learning goals.

Apart from the importance of understanding mathematical concepts, developing mathematical connections is also important because it is an important skill that high school students must master. The importance of having mathematical connection skills is stated in the objectives of learning mathematics in (BSNP, 2006). Hendriana et al. (2017) namely "understanding mathematical concepts, explaining relationships between concepts and applying concepts or algorithms flexibly, accurately, efficiently and precisely in solving problems".

Based on the background above, in this research what will be tested to improve students' mathematical understanding and connections is matrix material. To analyze this improvement, the class PBL model is used in the experimental class and the control class uses regular learning. This research aims to : (1) describe the correlation of students' mathematical understanding and connection abilities through the PBL model; (2) describe the effectiveness of PBL learning on comprehension abilities and mathematical connection .

METHOD

This research uses a quasi-experimental method. The quasi-experimental method is research that uses existing groups and does not use random assignment. Quasi research Experimental aims to find cause-and-effect relationships by comparing groups with different conditions or treatments. Shadish et al. (2002) Grouping quasi-experimental designs into four large groups, namely (1) designs without a control group or designs without pretreatment measurements, (2) designs with a control group and pretreatment measurements, (3) time-series design, (4) regression discontinuity design.

According to Hermawan & Hidayat (2018) in research using quasi-experimental methods, subjects are not grouped randomly. And in this research there are two classes of research samples, namely the experimental class and the control class. At the beginning and end of the lesson, both classes were given a test so that the research design was a pretest-posttest control group design.

Quasi-experimental method research uses a group of research subjects into two groups, namely the experimental group and the control group. Furthermore, the two groups carried out the same learning outcomes test. The test results of the two groups were tested statistically to see the differences that occurred due to the treatment of the experimental class and the control class. The research design used was a pretest-posttest control group design proposed by Ruseffendi as follows :

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Sugiyono (2019) The form of quasi-experimental research design is a development of *true experimental design*, which is difficult to implement. This design has a control group, but it cannot function fully to control external variables that influence the implementation of the experiment.

Hermawan (2019) Proposing a quasi-experimental method is basically the same as a pure experiment which most closely follows procedures and fulfills the experimental requirements and controls all external variables that influence the course of the experiment. Meanwhile, quasi-experimental control is only carried out on one variable, namely the most dominant variable.

Alpansyah & Abdul (2021) Quasi-experimental research methodology is an experiment that has *treatments* and *outcome measures* (impact measures). Therefore, in quasi-experimental research there will be two groups, namely the experimental group and the control group. The experimental group is the group that receives *treatments*, while the group that does not receive treatments is the control group. The control group functions as a comparison group for the group that received *treatments.*

To find out how much students' mathematical understanding has increased before and after learning activities, a normalized gain calculation is carried out. The gain calculation is carried out if when processing the pre-test data, it is concluded that students' comprehension abilities have an average difference. The calculation of normalized gain according to Meltzer (2002) is as follows :

$$N - Gain = \frac{PostTest - PreTest}{Ideal\ Score - PreTest}$$

The level of n-gain score is grouped into three categories, namely:

Table 1. Classification of N-Gain (g)

N-Gain	Interpretation
$N - Gain > 0.70$	High
$0.30 \leq N - Gain \leq 0.70$	Moderate
$N - Gain < 0.30$	Low

The subjects of this research were 60 class XI students at SMK Cianjur. Subjects were selected based on the experimental class XI TKJ A, 30 people and the control class XI TKJ B, 30 people.

The data collection techniques used were walkthroughs, questionnaires and tests. Data processing analysis was carried out quantitatively and qualitatively. In this research, the data analysis carried out was processing posttest data and n-gain data on mathematical understanding abilities, by testing data normality, data homogeneity, similarity tests and average differences in the data.

RESULTS AND DISCUSSIONS

Results

Mathematical Understanding Ability Data Analysis

Comprehension ability results mathematics is obtained from the results of data processing of instrument questions in the form of essay questions. These questions are given at the beginning and end of the research. The questions were given to each of them the experimental class the control class consisted of 30 students. The following is a recap of the results of N-Gain post-test data processing students' mathematical understanding abilities.

Table 2. N-Gain Data of Mathematical Understanding Ability

No	N-Gain	No	N. Gain
M1	0.91	M16	0.75
M2	0.77	M17	0.91
M3	0.90	M18	0.76
M4	0.76	M19	0.84
M5	0.87	M20	0.83
M6	0.79	M21	0.83
M7	0.86	M22	0.78
M8	0.79	M23	0.90
M9	0.64	M24	0.81
M10	0.72	M25	0.87
M11	0.87	M26	0.91
M12	0.82	M27	0.80
M13	0.75	M28	0.91
M14	0.93	M29	0.91
M15	0.64	M30	0.65
		Average	0.82

N-Gain Classification Category: “High” Interpretation

Based on the table 2, it is necessary to prove and conclude the hypothesis test in the form of: "Is there a difference in increasing students' mathematical understanding abilities through the role of Problem Based Learning (PBL)?".

Because the results of the initial pretest data processing did not show any differences in students' mathematical understanding abilities, the analysis was continued with the following post-test data processing:

Post-Test Data Analysis of Mathematical Understanding Ability

Post-test data analysis aims to test that there is an increase in the mathematical understanding ability of students whose learning uses the Problem Based Learning (PBL) approach and regular learning after receiving treatment . The type of statistical test used first is the test for normality of data distribution and homogeneity of variance. If the data meets the requirements for normality and homogeneity, then the equality of means test is carried out using the t-test (independent sample t-test) , and for data that does not meet the requirements for normality, the equality of means test uses a nonparametric test, namely the Mann-Whitney U test.

Because the two groups have the same variance and the data is normally distributed, the t test is used to test the significance of the difference between two means. The proposed hypothesis is as follows:

$$H_0 : \mu_1 = \mu_2$$

There is no difference in students' mathematical understanding abilities between those whose learning uses Problem Based Learning (PBL) and those who use regular learning.

$$H_1 : \mu_1 \neq \mu_2$$

There are differences in students' mathematical understanding abilities between those whose learning uses Problem Based Learning (PBL) and those who use regular learning.

Table 3. t test results on students' mathematical understanding ability

	t-test for Equality of Means		
	Q	Df	Sig. (2-tailed)
Equal variances assumed	1 0.689	58	0,000

The output results in Table . 3 shows that the calculation results for posttest data on mathematical understanding ability obtained a value of Sig. (2-tailed) = 0.000 S ig. (1-tailed) = $\frac{1}{2}$Sig.(2-tailed). If it is found $\frac{0,000}{2}$= 0.000 then the P value <0.005 which means H0 is rejected. Thus it is concluded that There are differences in students' mathematical understanding abilities between those whose learning uses Problem Based Learning (PBL) and those who use regular learning.

From the results of the data processing analysis presented in descriptive parametric inferential statistics above, the overall results obtained are: There are differences in students' mathematical understanding abilities between those who apply learning using Problem Based Learning (PBL) and those who use regular/regular learning.

Mathematical Connection Ability Data Analysis

The same is true for the results of students' mathematical understanding abilities and connection abilities Mathematics is also obtained from the results of data processing of instrument questions in the form of essay questions. These questions are given at the beginning and end of the research. The questions were given to each of them the experimental class the control class consisted of 30 students . The following is a recap of the results of N-Gain post-test data processing students' mathematical connection abilities.

Table 4. N-Gain Data of Mathematical Connection Ability

No	N. Gain	No	N. Gain
M1	0.47	M16	0.58
M2	0.52	M17	0.75
M3	0.62	M18	0.53
M4	0.51	M19	0.60
M5	0.64	M20	0.75
M6	0.39	M21	0.72
M7	0.58	M22	0.50
M8	0.69	M23	0.64
M9	0.42	M24	0.41
M10	0.54	M25	0.57
M11	0.50	M26	0.41
M12	0.59	M27	0.42
M13	0.54	M28	0.63

M14	0.51	M29	0.66
M15	0.73	M30	0.44
		Average	0.56

N-Gain Classification Category: "Medium" Interpretation

From table. These 4 need to be proven and concluded by testing the hypothesis in the form of: "Is there a difference in increasing students' mathematical connection abilities through the role of Problem Based Learning (PBL)?".

Because there were already differences in the results of pretest data processing on students' initial mathematical connection abilities, posttest data calculation analysis was not carried out, so to test the hypothesis further analysis was carried out on the N-Gain data.

Post Test Data Analysis of Mathematical Connection Ability

Data test analysis aims to test that there is an increase in connection capabilities mathematics of students whose learning uses the Problem Based Learning (PBL) approach. The t test statistical type first tests the normality of data distribution and homogeneity of variance. If the data meets the requirements for normality and homogeneity, then the next step is to use the t-test (independent sample t-test), and for data that does not meet the requirements for normality, the equality of means test uses a nonparametric test, namely the Mann-Whitney U test.

Because the two groups have the same variance and the data is normally distributed, the t test is used to test the significance of the difference between two means. The proposed hypothesis is as follows:

$$H_0 : \mu_1 = \mu_2$$

There is no difference in connection capabilities mathematics between students whose learning uses Problem Based Learning (PBL) and those who use regular learning.

$$H_1 : \mu_1 \neq \mu_2$$

There are differences in connection capabilities mathematics between students whose learning uses Problem Based Learning (PBL) and those who use regular learning.

Table 5. t test results on mathematical connection ability

	t-test for Equality of Means		
	Q	Df	Sig. (2-tailed)
Equal variances assumed	6,814	58	0,000

The output results in Table 5 shows that the calculation results for the N-Gain connection capability m mathematically obtained the value Sig.(2-tailed) = 0.000 S ig. (1-tailed) = $\frac{1}{2}$ Sig.(2-tailed). If it is obtained $\frac{0,000}{2}$= 0.000, the P value is <0.005, which means the null hypothesis is rejected. Thus it is concluded that there are differences in connection capabilities mathematics between students whose learning uses Problem Based Learning (PBL) and those who use regular learning.

From the results of the data processing analysis presented in descriptive parametric inferential statistics above, the overall results obtained are: There are differences in students' mathematical connection abilities between those who apply learning using Problem Based Learning (PBL) and those who only use conventional/ordinary learning.

The novelty of this research is measuring 2 (two) cognitive aspects of students at once, namely mathematical understanding abilities and mathematical connection abilities using the Problem Based Learning (PBL) model learning approach.

Discussions

The ability to understand mathematics is important for students because it is needed to solve mathematical problems, problems in other scientific disciplines and problems in everyday life, which is the vision for developing mathematics learning to meet future needs. Students are said to understand if they are able to express situations-pictures-diagrams into language, symbols, ideas, mathematical models; explaining mathematical ideas, situations and relationships orally or in writing, listening, discussing, presenting, writing mathematics, reading mathematical representations; and restating mathematical descriptions in their own language (Hendriana & Soemarmo, 2014) .

The research results Fitriani et al. (2022) reveal the ability to understand and make connections mathematically with the PBL learning model with a STEM approach, students' understanding of learning has increased, there is a relationship between understanding ability and mathematical connections.

Setiawati (2014) Conclusions from the results obtained from the research are 1) an increase in students' mathematical understanding abilities as a whole and based on Initial Mathematical Ability (KAM) where learning using PBL is better than increasing students' mathematical understanding abilities using conventional methods, 2) an increase in students' mathematical connection abilities as a whole. overall and KAM-based learning using problem-based learning is better than increasing students' mathematical connection abilities using conventional learning models, 3) there is a correlation between understanding and students' mathematical connection abilities, 4) student and teacher activity increases at each meeting in carrying out mathematics learning using PBL.

According to Nurdin et al. (2023) Problem Based Learning (PBL) has implications for providing an interactive mathematics learning environment, so that students are able to understand mathematical concepts with the initial knowledge they already have. In line with research Firmansyah et al. (2020) in conclusion states the understanding ability of mathematical connections of students who receive Problem Based Learning experienced better improvement than students who received regular learning.

Aisyah et al. (2022) Opinionated that the implementation of the PBL model has a positive impact compared to direct learning on students' mathematical connection abilities . Learning mathematics using a problem-based learning approach can not only improve understanding abilities, but can also improve students' mathematical connection abilities. The improvement that occurs cannot be separated from the teacher's performance in planning and implementing learning according to PBL syntax (Afifah et al., 2017).

The results of this research are the achievement of indicators of mathematical understanding of the PBL model which is quite significant , proves that the role of the PBL learning model is able to improve students' mathematical understanding and connection abilities in vocational school student matrix material.

CONCLUSIONS

The development of the learning approach in this research provides information about vocational school students' mathematics learning activities using the Problem Based Learning (PBL) model which is reviewed based on the students' ability to understand and mathematical connections and from all of this research activity, conclusions are obtained from Similarity test of two averages of post-test data on mathematical understanding ability, difference test of two averages n-gains of students' mathematical understanding abilities and test results of differences between two averages of students' mathematical connections Sig value obtained = 0.000 Sig value. (2-tailed) = the output is sig. (1-tailed) = $\frac{1}{2}$Sig.(2-tailed). Obtained $\frac{0,000}{2}$= 0.0000 so the P value<0.005 which means the null hypothesis is rejected . These two test results show that the PBL model can improve the ability to understand and make mathematical connections in vocational school students' matrix material compared to the regular learning model.

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