Differences in the Mathematical Connection Capabilities of Students Taught by Using Guided Discovery Learning and Problem Based Learning Models Assisted by Autograph Viewed from Students' Numerical Ability

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Received April 10, 2020; Revised May 12, 2020; Accepted May 19, 2020

Abstract This study aims to determine (1) whether the mathematical connection ability of students taught with Autograph-assisted Guided Discovery Learning (GDL) models is higher than students taught with Autograph-assisted Problem Based Learning (PBL) models, (2) whether there is interaction between the Guided Discovery Learning (GDL) model and the Problem Based Learning (PBL) model with numerical ability on students' mathematical connection abilities. This type of research is quasi-experimental research with a population of all students of class XI Pancur Batu Private High School Methodist. This study uses two-way ANAVA. Then proceed with the Scheffe test to see whether the two groups are significantly different. Based on the statistical calculation of the Scheffe test and confirmed with SPSS, it can be concluded that (1) The ability of students' mathematical connections taught by Guided Discovery Learning (GDL) assisted by Autograph Software is higher than that of students taught with Problem Based Learning (PBL) assisted by Autograph Software, (2) There is an interaction between the learning model with numerical ability on the ability of students' mathematical connections.

Keywords: Guided Discovery Learning, Problem Based Learning, connection ability, numerical ability, Autograph


1. Introduction

The ability of mathematical connections is the ability to link mathematical concepts both between mathematical learning topics and to link mathematical concepts with other fields of science as well as linking mathematical concepts with real life. According to [1] the ability of connections in mathematics plays an important role in solving mathematical problems, where the ability of connections makes students better understand mathematical problems in detail. Curriculum Standards in China in 2006 for elementary and secondary schools also emphasized the importance of mathematical connections in the form of mathematical applications, connections between mathematics and real life, and the relationship of mathematics with other subjects.

The results of the research [2] and [3] also stated the importance of increasing students' mathematical connection ability to overcome students' difficulties in solving mathematical problems that have links with previously learned material. This is in line with the opinion [4] which states the ability of students to connect between topics in mathematics and connect mathematics with everyday problems, it is very important for students because these relationships can help students understand topics in mathematics and can create everyday problems into the mathematical model.

From some of the statements it can be concluded that the ability of mathematical connections plays an important role both in solving mathematical problems and in solving problems of everyday life, real or everyday.

There are several factors that affect the low ability of students' mathematical connections, one of which is the role of the teacher in learning activities in the classroom. For this reason, teachers need to determine learning strategies or models that can improve mathematical connection skills. The conventional method used by the teacher in class only requires students to solve problems based on formulas and examples of questions given by the teacher, not teaching students how students should solve problems. Because it is necessary to strive for learning mathematics that can improve the ability of mathematical connections. In order for these abilities to develop properly, in the mathematics learning process teachers need to provide opportunities for students to be able to improve students' abilities in developing mathematical
Numerical mastery is also a factor influencing the basic ability to use numbers and the calculation of numbers and solve problems related to number concepts. Furthermore, another opinion states the numerical ability interpreted as the ability to understand the relationship of mathematics. Numerical intelligence can also be numerical intelligence is intelligence related to numbers or mathematical problem solving abilities. This is shown from the results of other studies indicate that the Problem Based Learning (PBL) learning model involves students directly in carrying out the stages of activities to solve problems in their own way with a variety of information or references without relying on the way the teacher solves problems so as to increase student creativity in solve problems and help students to learn new knowledge related to these problems.

In addition to the problem based learning (PBL) learning model, the Guided Discovery Learning model can also be a solution or an alternative in solving students' mathematical connection ability problems. Guided discovery learning is a learning activity that is designed so that students can independently discover concepts or principles through mental processes. Mental processes can observe, classify, make hypotheses, explain, measure, make conclusions and so on. The application of this learning model can stimulate students to have high curiosity so that they are more active in learning. Some research results indicate that the guided discovery learning model can affect the improvement of students' mathematical abilities. This is shown from the results of other studies where the results of the study showed an increase in the ability to understand concepts and students' mathematical problem solving abilities. When students 'problem solving abilities increase, this will also affect the ability of students' mathematical connections, where when students are able to solve problems, it means students can already know the relationship between concepts that must be used in solving mathematical problems.

Each student must have different mathematical connection abilities. Many factors cause these differences, in addition to the learning model used by the teacher, students 'numerical abilities also influence students' connection abilities. According to Agustin Leoni numerical intelligence is intelligence related to numbers or mathematics. Numerical intelligence can also be interpreted as the ability to understand the relationship of numbers and solve problems related to number concepts. Furthermore, another opinion states the numerical ability is the basic ability to use numbers and the calculation process. Numerical mastery is also a factor influencing student learning outcomes in mathematics.

Numerical abilities are skills related to accuracy and skills in using basic arithmetic functions. This ability is important to master because it becomes the basis in mathematical operations. Although in the process of working on mathematical problems needed other abilities such as visual abilities, verbal abilities, connections, and so on, it is not inevitable that numerical abilities play an important and comprehensive role in working on mathematical arithmetic operations. So that every student who wants to be involved in mathematics really needs a numerical ability to solve every problem in Mathematics.

In addition to the application of learning models, teachers also need to use technology or ICT in learning mathematics. One of the effective and efficient ICTs used in learning mathematics is Autograph. Autograph is a computer program used in two-dimensional, three-dimensional learning, statistics, transformation, geometry, equations, coordinates, graphs, and quadratic equations. Autograph can enhance scientific discourse in mathematics learning that directs students to the learning experience of investigating and solving mathematical problems.

With the help of dynamic software combined with guided discovery learning and problem-based learning as well as good numerical ability, students are expected to be able to carry out the learning process more flexibly and students can freely try repeatedly until finally students understand the mathematical concepts learned and can connect mathematics learning in various problem solving.

2. Literature Review

2.1. Mathematical Connection Capabilities

Mathematical connection is derived from English namely Mathematical Connection which was popularized by NCTM which became the standard curriculum for elementary and secondary school mathematics learning. The ability of mathematical connections is the ability to determine the relationship of mathematical concepts with mathematical material, the relationship of mathematics with other disciplines and the relationship of mathematics with real life.

Based on the understanding of the ability of mathematical connections described previously, then in this study the indicators of mathematical connection ability are: 1) recognize the equivalent representation of the same concept, 2) recognize the mathematical procedure of a representation to the equivalent representation procedure, 3) use and assess the relationship between mathematical topics and relationships outside mathematics, 4) using mathematics in everyday life.

2.2. Problem Based Learning

Problem based learning (PBL) is a student-centered learning model and the teacher acts as a facilitator where students are confronted with mathematical problems and in groups of students conduct research, integrate theory and practice, and apply knowledge and skills to develop solutions to solve problems.

The syntax in the Problem Based Learning (PBL) model is: (1) proposing or orienting students to the problem; (2) organizing students to learn; (3) Students gather information; (4) guiding investigations individually and in groups; (5) develops and presents the work; (6) analyze and evaluate the problem solving process.

2.3. Guided Discovery Learning

Model Guided Discovery Learning (GDL) is a learning process that makes students actively find out for
themselves information, investigate a problem that is
guided by the teacher through supporting questions to
build a mathematical concept so that students can solve a
problem.

The syntax in the Guided Discovery Learning (GDL)
model, namely: Introduction (Introduction), Overview
data), Data collection (data collection), Data Processing
data processing), Summary (conclusion), Assessment
(assessment).

3. Research Methods

This research uses a quantitative descriptive approach
with a quasi experimental method. Based on the research
design that will be used, this study aims to examine
the ability of students' mathematical mathematical
connections affected by autograph-assisted Problem Based
Learning (PBL) models and autograph-assisted Guided
Discovery Learning models. The design of this research is
Post Test Only Control Design. The experimental design
used is factorial design. The factorial design used is a 2 x
3 factorial design, as in Table 1 below:

<table>
<thead>
<tr>
<th>Numerical ability</th>
<th>Height (T)</th>
<th>Medium (S)</th>
<th>Low (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDL Assisted Autograph (G)</td>
<td>GT</td>
<td>GS</td>
<td>GR</td>
</tr>
<tr>
<td>PBL Assisted Autograph (P)</td>
<td>PT</td>
<td>PS</td>
<td>PR</td>
</tr>
</tbody>
</table>

4. Research Results

The data analyzed are tests of students' numerical
ability and tests of students' mathematical ability. Then the
test analysis is done by two-way analysis of variance
(ANAVA). The test results provide information about
students' mathematical connection skills after being taught
with the Autograph-assisted Guided Discovery Learning model in Experiment I class and students who are taught with the Autograph-assisted Problem Based Learning model in Experiment II class.

4.1. Student Numerical Ability Data Results

Numerical ability tests are given to students to find out
the types of numerical abilities especially mathematical
skills students have. The numerical ability grouping of
students (high, medium, and low) is formed based on the
classification criteria of numerical ability of students. The results of the grouping are presented in the following Table 2:

<table>
<thead>
<tr>
<th>Research Sample Class</th>
<th>Kemampuan Numerik</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>GDL</td>
<td>5</td>
</tr>
<tr>
<td>PBL</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
</tr>
</tbody>
</table>

From Table 2 above obtained in the GDL class the
numerical ability of students for the medium category
there are 5 students, the medium category is 15 students
and the high category is 15 students. Whereas in the PBL
class the level of numerical ability of students for the medium category was 5 students, the medium category
was 24 students and the high category was 6 students.
Furthermore, to see whether the connection capability of
the GDL and PBL classes is the same or not, a statistical
test is carried out, namely the normality test, homogeneity
test, and two-way ANAVA.

The normality test was carried out using the
Kolmogorov-Smirnov one sample test statistic in the
SPSS Statistics 20.00 program with a confidence level of
95%. In this study, the homogeneity test was performed
using the Levene test in the SPSS program.

4.2. Post-Test Results for Students'
Mathematical Connection Ability

After the two classes are given learning by using the
Guided Discovery Learning model in the experimental
class I and the Problem Based Learning model in the
experimental class II, then the end of the learning of the
two classes is given a post-test to see the development of
students' mathematical connection ability after the
learning model is applied. Description of the results of the
post-test mathematical connection ability of students
calculated the lowest value, the highest value, and the
average, and the standard deviation of each experimental
class. The following are descriptive statistics from the
post-test experimental class I and experimental class II presented in the following table.

<table>
<thead>
<tr>
<th>Class</th>
<th>Ideal Value</th>
<th>N</th>
<th>Xmin</th>
<th>Xmax</th>
<th>(\bar{x})</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDL</td>
<td>100</td>
<td>35</td>
<td>64</td>
<td>99</td>
<td>81.057</td>
<td>10.204</td>
</tr>
<tr>
<td>PBL</td>
<td>100</td>
<td>35</td>
<td>50</td>
<td>93</td>
<td>72.8</td>
<td>11.253</td>
</tr>
</tbody>
</table>

From Table 3 above, it can be seen that the average
post-test mathematical connection ability of students in
both experimental I and experimental II classes is different.
Next it needs to be tested whether the post-test connection
capability of the GDL class and the PBL class are the
same or not. To test the hypothesis, first test the normality
and homogeneity of the post-test. Based on the
Kolmogorov-Smirnov test using SPSS, it was concluded
that the results of students' mathematical connection
abilities in the GDL class and PBL class were normally
distributed. Furthermore, the Levene test concluded that
the GDL class and PBL class had homogeneous variances.

4.3. Hypothesis Testing

The purpose of data analysis to be done with inferential
statistics is to test the research hypothesis. Testing the
statistical hypothesis in this study is the two-way Anava
using SPSS version 20.00. The linear model for this
research is:

\[
Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk};
\]

\(i = 1, 2, 3; j = 1, 2; k = 1, 2, \ldots \)
Keterangan:

\[ Y_{ijk} \] is a score of the connection ability of the k-student, in the i-numerical ability which gets j-learning.

\( \mu \) is the average score of a student's actual learning ability.

\( \alpha_i \) is the additive effect of i-numeric ability

\( \beta_j \) is the additive effect of the j-the learning model

\( (\alpha \beta)_{ij} \) is the interaction effect of the i-numerical ability and the j-learning model

\( \epsilon_{kij} \) is the effect of experimental deviations from k-the student scores, on the i-numerical ability, which get j-learning model.

4.3.1. Hypothesis Test I

After the test requirements are met then the next hypothesis test is done using two-way ANAVA. The first hypothesis that will be tested in this study is to test differences in the ability of students' mathematical connections taught by the Guided Discovery Learning model and students who are taught with the Problem Based Learning model assisted by Autograph Software. The test criterion is H0 if sig. < 0.05. Tests conducted based on Hypothesis I, namely:

\[ H_0: \beta_1 = \beta_2 = 0 \]

\[ H_1: \beta_1 \neq \beta_2 \neq 0 \]

Information:

\( \beta_1 \): The influence of Autograph-assisted Guided Discovery Learning models on the ability of students' mathematical connections.

\( \beta_2 \): The influence of Autograph-aided Problem Based Learning models on students' mathematical connection abilities.

The results of two-way ANAVA test calculations to test Hypothesis I, were confirmed by SPSS 20 statistics with sig values. amounted to 0.019. Because the value of sig. < 0.05, then H0 is rejected. Means there is an influence of interaction between the Guided Discoveri Learning model and the Problem Based Learning model assisted by Autograph Software.

4.3.2. Hypothesis Test II

Hypothesis II that will be tested in this study is that there is an interaction between the learning model with numerical ability on students' mathematical connection ability. Statistically the hypothesis can be formulated:

\[ H_0: (\alpha \beta)_{ij} = 0 \]

\[ H_1: \text{paling tidak ada satu} (\alpha \beta)_{ij} \neq 0. \]

Information:

\( (\alpha \beta)_{ij} \) is the interaction between learning models with numerical abilities on students' mathematical connection abilities.

The results of two-way ANAVA test calculations to test Hypothesis II, were confirmed by SPSS 20 statistics with sig values. of 0.039. Because the value of sig. < 0.05, then H0 is rejected, this shows the influence of interaction between the learning model with numerical ability on the ability of students' mathematical connections.

4.3.3. Scheffe Test of Mathematical Connection Ability

After conducting the two-way ANAVA test, then further tests are performed with the Scheffe method, namely comparison between rows, between columns and between cells. The summary of the results of the average calculation between cells of students' mathematical connection ability is presented in Table 4.

a. Comparative test between rows with the results of the comparative summary in the following Table 4.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Ho</th>
<th>H1</th>
<th>Fobs</th>
<th>Ftable</th>
<th>The decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>G vs G</td>
<td>Ho</td>
<td>H1</td>
<td>4.6573</td>
<td>3.14</td>
<td>H0 rejected</td>
</tr>
<tr>
<td>G vs P</td>
<td>F0</td>
<td>H1</td>
<td>7.3711</td>
<td>3.14</td>
<td>H0 rejected</td>
</tr>
<tr>
<td>G vs T</td>
<td>F0</td>
<td>H1</td>
<td>4.5215</td>
<td>3.14</td>
<td>H0 rejected</td>
</tr>
</tbody>
</table>

Based on Table 4 above, it can be concluded that in the hypothesis test \( \mu_G \) vs \( \mu_P \), \( \mu_G \) vs \( \mu_T \), and \( \mu_T \) vs \( \mu_S \) \( H_0 \) are rejected, it can be concluded that there are significant differences in mathematical connection ability between students who have moderate and low numerical abilities, students who have high and low numerical ability, and students who have high and medium numerical ability.

b. Comparative test between columns with the computational summary results in the following Table 5.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Ho</th>
<th>H1</th>
<th>Fobs</th>
<th>Ftable</th>
<th>The decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>G vs G</td>
<td>Ho</td>
<td>H1</td>
<td>4.129605</td>
<td>3.99</td>
<td>H0 rejected</td>
</tr>
</tbody>
</table>

Based on Table 5 above, it can be concluded that the hypothesis test \( \mu_G \) vs \( \mu_P \), \( \mu_G \) vs \( \mu_T \), and \( \mu_T \) vs \( \mu_S \) \( H_0 \) is rejected, so it can be concluded that there are significant differences in mathematical connection ability between students taught with the GDL model and PBL models. Based on Table 3 above, the marginal average for the GDL learning model is 81.057, while for the PBL learning model is 72.8, so it can be concluded that the mathematical connection ability of students taught with the Guided Discovery Learning (GDL) model is higher than students taught with the Problem model Based Learning (PBL).

From Table 6 we can see the Sig value in the types of numerical ability Low, medium and high. If the Sig value < 0.05, then accept \( H_1 \), which means there is a difference in the average connection ability between the Guided Discovery Learning model and the Problem Based Learning model for each type of numerical ability. From this table we can look at the analysis output with multiple comparisons. An asterisk on the mean difference or Sig. which is smaller than alpha (5%), it appears that there are differences in the ability of connections between students who are taught with the Guided Discovery Learning model and students who are taught with the Problem Based Learning model in each type of numerical ability.
and high numerical ability are not too difficult to follow the existing learning process. With the guidance of the teacher they can collaborate with friends. The cooperative learning model is in line with underlying learning theories such as constructivism learning theory. Basically, the approach of the theory of constructivism requires students to find themselves and transform information, check new information with old rules. So students succeed in building their own knowledge in their minds. According to Trianto cooperative learning is ruled by the theory of constructivism. This learning arises from the concept that students more easily understand and find if among students discuss each other [12].

Based on the results of the study described earlier, that the cooperative learning model can have a positive influence on the problem solving process and on the ability of students' mathematical connections. This reinforces the results of previous studies that also use cooperative learning models to improve other mathematical abilities. Among other research results states that learning using guided discovery learning models with video learning assistance is more effective than learning with conventional models [13].

Other research results state that the Problem Based Learning model is better and even more recommended than the Guided Discovery Learning model [14]. However, this study found different things. Where the results of the study show that the mathematical connection ability of students taught with the Guided Discovery Learning model is higher than students taught with the Problem Based Learning model.

5.2. Interactions between Learning Models and Numerical Abilities of Mathematical Connection Capabilities

Interaction is the collaboration of two independent variables or also more influential on the dependent variable. In this case, what is investigated is the collaboration between the learning model and numerical ability on students' mathematical connection abilities. Based on the results of descriptive analysis, the average value of students' mathematical connection ability in the GDL class in the category of low numerical ability was 66.4, medium numerical ability was 81.87, and High

### Table 6. Multiple Comparisons

<table>
<thead>
<tr>
<th>Numeric ability type</th>
<th>(J) Numeric ability type</th>
<th>Mean Difference (I-J)</th>
<th>Std Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Medium</td>
<td>-14.61°</td>
<td>1.847</td>
<td>.000</td>
<td>-13.24 - 16.02</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>-24.01°</td>
<td>2.002</td>
<td>.000</td>
<td>-27.03 - 21.09</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
<td>14.61°</td>
<td>1.847</td>
<td>.000</td>
<td>9.98 - 19.24</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>-9.40°</td>
<td>1.410</td>
<td>.000</td>
<td>-12.93 - 5.86</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>24.01°</td>
<td>2.002</td>
<td>.000</td>
<td>18.99 - 29.03</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>9.40°</td>
<td>1.410</td>
<td>.000</td>
<td>5.86 - 12.93</td>
</tr>
</tbody>
</table>

Based on observed means. The error term is Mean Square(Error) = 27.157. * The mean difference is significant at the .05 level.
The conclusions in this study after analyzing the data are as follows:

1. Mathematical connection ability of students taught by the Guided Discovery Learning model assisted by Autograph software is higher than students taught by the Problem Based Learning model assisted by Autograph software.

2. There is an interaction between learning models with numerical ability on students' mathematical connection abilities.

6. Conclusion

The conclusions in this study after analyzing the data are as follows:

1. Mathematical connection ability of students taught by the Guided Discovery Learning model assisted by Autograph software is higher than students taught by the Problem Based Learning model assisted by Autograph software.

2. There is an interaction between learning models with numerical ability on students' mathematical connection abilities.

References


The same thing as [15] who stated that there was an interaction between the learning model and the level of students' numerical ability on learning achievement. In as [16] results show that there is an interaction between learning models with numerical ability on mathematical logic intelligence.