The analysis of the implementation of discovery-based learning to improve students’ creative thinking skills in solving the number multiplication problems

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Abstract. This study aims to investigate the analysis of the implementation of discovery-based learning to improve students’ creative thinking skills in solving the number multiplication problems. Students’ creative thinking skills are very important, even though the current condition is not as well as the expectation. This type of research used is a mixed method, which is a combination of quantitative and qualitative methods. Quantitative methods are used to analyze interval data types for student learning outcomes, while qualitative methods will be used to analyze ordinal data of creative thinking skills. The research respondents consisting of two classes, namely 30 students for control class and 30 students for experimental class. The results showed that implementation of discovery-based learning to improve students’ creative thinking skills in solving the number multiplication problems in the experimental class is more effective than control class used conventional learning. The independent sample t-test from the post-test showed that there was a significant difference between the control class and the experimental class with the sig (2-tailed) value is 0.000 ($p = <0.05$). It can be concluded that implementation of discovery-based learning can improve students’ creative thinking skills in solving the number multiplication problems.

1. Introduction

Education for everyone is very important. The development of science and technology now demands the availability of competent human resources. Mastery of mathematics has an important role to support the success of the development of education because mastery of mathematics is a means to master other subjects. Mathematics is basically given to practice the ability to think logically, critically, creatively and practically. The teacher's role is very important to grow up students' creative thinking in learning mathematics. The Torrance Test of Creative Thinking (TTCT) uses three main components in assessing creativity as fluency, flexibility, and novelty [6].

In teaching and learning process, especially on the subject of number theory, the aim is not only to understand the math materials taught by lecturers but also the ability of reasoning, communication, representation, problem solving, and good behavior after studying mathematics is a general purpose that must be mastered by students [8]. To improve students’ thinking skills, teachers must be creative in creating a learning environment by using a variety learning strategies as well as a number of actors that can facilitate learners[5].
According to (Sabrila, Dafik, Tirta, & Malik, 2019), 'The results of the study show that discovery-based learning learning models can improve students’ creative thinking skills in solving mathematical modeling problems'[5]. Discovery-Based Learning aims to find out the application of discovery-based learning models that succeed to improve students’ creative thinking in solving mathematical problems. These results explain that the implementation of discovery-based learning can improve students’ creative thinking skills in solving the number multiplication problems.

Learning products are not only related to products in the form of grades, but also the understanding of the substance of the contents of learning materials having an important role both on the assessment products and in the lives of students themselves. Through the learning process and mastery of the essence of the material, students are expected to be able to analyze all the problems that emerge clearly, and be able to solve them. Of course with creative thinking that is critical, logical, sequential, and objective. The ability to think creatively is in line with the importance of 21st Century mathematics learning that is emphasizing the importance of development in 4 aspects (4C), namely: creativity, critical thinking, collaboration and communication. The capabilities mentioned above are very much needed in the 21st century.

Through the implementation of Discovery Based Learning (DBL), students are asked to discover what they have learned then build on the knowledge by understanding its meaning. In this model the teacher is only a facilitator. The main characteristics of the development of Discovery Based Learning (DBL) are: 1) exploring and solving problems to create, combine and generalize knowledge; 2) focusing to student centered; 3) combining new knowledge and existing knowledge. The discovery-based learning model allows students to follow their own interests to achieve the competence and satisfaction of their curiosity. According to Bruner, (Kristin, 2016) "Discovery-Based Learning is useful in: 1) increasing students’ intellectual potential; 2) transfer from extrinsic to intrinsic rewards; 3) comprehensive learning through discovery processes; 4) tools for storage training”.

In the aspect of solving mathematical problems required creative thinking in making (formulating), interpreting and solving models or planning problem-solving [6]. In learning process in the classroom, the ability to think creatively can grow from curiosity and the ability to imagine. Students’ creative abilities can be trained so that these abilities can help these goals. The teacher as the field implementer needs to do careful planning before starting the learning process. This can be done by the teacher in preparing a Learning Implementation Plan (RPP) based on discovery based learning (DBL). The teacher must also provide a learning situation or environment that is challenging and interesting. One of the ways to develops students' creative thinking abilities is providing learning media. The function of learning media is as a communication tool to convey messages that can stimulate students' minds and abilities so that learning activities can work well. Learning media are expected to be able to motivate students to dare to explore their thinking skills in an effort to solve problems.

The purposes of this study are: 1) To find out that the process of discovery-based learning can improve students’ creative thinking skills in solving the number multiplication problems. 2) To find out that the results of the implementation discovery-based learning can improve students’ creative thinking skills in solving the number multiplication problems. 3) To find out the effectiveness of discovery-based learning to improve students’ creative thinking skills in solving the number multiplication problems. 4) To analyze students’ activities when discovery-based learning is applied and 5) To analyze phase portraits of creative thinking skills in solving the number multiplication problem through the implementation of discovery-based learning.
Table 1. Aspects and indicators of creative thinking skills in completion multiplication problems.

| No | Aspects  | Indicators                                                                 |
|----|----------|---------------------------------------------------------------------------|
| 1  | Fluency  | a. Do multiplication with integers.                                      |
|    |          | b. Resolve issues related to integer multiplication.                    |
| 2  | Fleksibility | a. Explain and do integer multiplication.                           |
|    |          | b. Solve integer multiplication problems                                |
|    |          | c. Determine the results of integer multiplication.                     |
| 3  | Novelty  | a. Resolve issues related to integer multiplication                      |

Silver (1997) provides indicators for assessing creative thinking (fluency, flexibility and novelty) using problem solving. This relationship can be explained in the following table.

Table 2. Relationship between problem solving and archiving with the creativity component.

| No | Solution to Problem                                                                 | Components of Creativity | Submitting Problems                                                                 |
|----|------------------------------------------------------------------------------------|--------------------------|-------------------------------------------------------------------------------------|
| 1  | Students solve various kinds of interpretation problems, methods of solving or answering problems | Fluency                  | Students create problems to be solved                                               |
|    |                                                                                    |                          | Students share the problems to be solved                                           |
| 2  | Students solve problems with a certainty technique, then by using another technique. Students discuss many kinds problem solving methods. | Fleksibility             | Students submit problems that have different ways to be solved                     |
|    |                                                                                    |                          | Students use the "what-if-not?" approach to solve the problem                       |
| 3  | Students examine some solving methods or answers, then try another method           | Novelty                  | Students examine some problems, then submit another problem                        |

A worksheet or LKS is often used by teachers in giving assignments to students. The worksheets must be oriented towards developing students’ competence and independence in thinking. To provide opportunities for students in developing their creative thinking skills, worksheets are developed by using the DBL model. Characteristics of DBL-based RPP and LKS include: students face contextual problems; students are asked to conduct an investigation to find a solution. The students explain the solutions they’ve got. Thus, students will get used to think creatively.

2. Methods
This type of research uses a mixed method, which is a combination of quantitative and qualitative methods. Quantitative methods are used to analyze interval data types for student learning outcomes, while qualitative methods will be used to analyze ordinal data of creative thinking skills. The research respondents consisting of two classes, namely 30 students for control class of and 30 students for experimental class.
Figure 1. The Model of Triangulation of Mixed Method [5]

Mixed methods are research methods that combine qualitative and quantitative methods [3]. In brief, we can illustrate the triangulation model in Figure 1. This can be seen from the picture; we started the research by determining two classes of grade 5 elementary school students as the experimental class and the control class. They consisted of 30 students from the experimental class and 30 students from the control class. Next, we develop pre-tests and we provide both classes and analyze the results for the next step. We did a sequential mixed method, starting from qualitative, quantitative and ended by qualitative. Since the qualitative results gave the result analysis narratively, we convince the result by statistical inferential and then we ended with doing an in-depth interview to some respondents to capture their portrait phase of their higher order thinking skills as well as to know the level of students’
higher order thinking skills and to convince the improvement of students’ higher order thinking skill. The combination of the two methods also aims to resolve the weaknesses of each method. The statement based on the reasoning process where its truth is not yet certain. Quantitative research was experimental research model by using pre-test and post-test [7].

2.1. Task
In this study students in the control class and the experimental class were given assignments in the form of essay about the number multiplication problems. Inferential statistics use the independent sample t-test to test the difference between the experimental class and the control class by comparing the mean values of the two groups with a significance level of 0.05. To measure the level of creative thinking skills used essay tests. The teacher gave an explanation of some techniques. Students answered the questions related to the material using the easiest multi techniques.
In this study, researchers used two different unique techniques to solve mathematical multiplication problems, namely Line Doubling and Circle Doubling.

a. Line Multiplication
This line doubling basically has the same process as the standard multiplication algorithm taught in school, but looks more visual. Using cross lines to represent where you multiply various place values, this method is useful for students who are more visually oriented. The completion steps are as follows. Make a line according to how many digits the number is multiplied, as shown below. Pay attention to the number of crossing lines at each place. Then add the number of intersections of the lines diagonally. If the number is a two-digit number (tens) then add the tens number to the next number.

![Figure 2. Line multiplication technique](image_url)
Determine the place value of the first number. We need to know how many places are in our numbers, and how many numbers are in each place. For example, if we multiply $23 \times 13$, we will determine that the first number, 34, is 4 in place of unit number, and 3 in places of tens. Draw parallel lines to represent dozens of places from the first number. The number of lines we draw will match the numbers in dozens of places. So the result is $23 \times 13 = 299$.

b. Circle multiplication

Circle multiplication is a multiplication method using a circle image. The circle that is drawn in layers after that draw a line according to the length of the radius of the largest circle. The number of layers of circles and lines corresponds to the number multiplied. For example, in the following $3 \times 4$ products.

First, we draw a 3-layer circle and the layered circle is divided into 4 sections with 4 lines, as in the following image:

![Figure 3. Circle multiplication](image)

The results can be seen from the number of intersections of fields (note the picture above on the right). Each yellow dot in the picture is in each different part. So the result or number of works is $3 \times 4 = 12$.

If the number is more than 1 digit, for example $21 \times 34$, you can draw two layers two layers to the place of tens in the first number, in this example the place of tens in number 21 is 2. Then draw a line to divide a circle, the number of lines dividing two circles is adjusted to the size of each digit in the second number. For the first circle drawn 3 line segments (according to the number of places tens) and the second circle drawn 4 line segments (according to the number of place units). The result is like the picture above,

Almost the same in step 1, we draw a circle again but it is not layered because now we are referring to the place unit for the first number one. So only one circle layer will be drawn for both circles. The number of lines remains the same in the first step. The results are illustrated under the two circles made in step 2, as follows: Add the number of plane intersections diagonally, for two digit numbers, add tens of digits to the next number. So the result is $21 \times 34 = 714$. 

![STEP 1](image)

![STEP 2](image)
c. Lattice Multiplication Technique

Lattice Multiplication is a multiplication technique that uses a grid to multiply two numbers, multi digits. This kind of box technique has actually appeared in the Middle Ages, but in this box technique, we use a grid with each box divided diagonally. The top of the diagonal line is filled with dozens and the bottom line is the unit number. The number of lines is adjusted by the number of digits multiplied by numbers. Two numbers will be written on the top and left side of the grid. For example, in the case of multiplication 453 x 25 = ...

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**Figure 4. Circle multiplication**
With the completion steps as follows, draw a box according to the numbers that have been multiplied. Multiply the pairs of numbers above and to the side, which is 4 X 2 = 08. Likewise, for other pairs of numbers. Next add the diagonal according to each lattice. For two digit numbers, add tens of digits to the left, so the result is 453 x 25 = 11,325

**Figure 5. Lattice Multiplication Technique**

d. Multiplication 2 Variables

Problem solving is as follows, Subtract the number 100 with the first 2 numbers of this variable as shown in the picture (100-92 = 8, 100-96 = 4). Then multiply the two numbers obtained (8x4 = 32), then take the last 2 digits into the last 2 answer variables. Now it's time for us to count the 2 variable numbers in front. Add the two numbers subtracted earlier (8 + 4 = 12), then subtract 100 from the result of the encroachment (100-12 = 88). So now you can get the answer is 92 x 96 = 8,832
3. Result and discussion

3.1. Results

Creative thinking skills require students to provide various alternative solutions from various perspectives in solving to the problems using the provided information. Besides, students must be required to learn actively during the learning process. Students’ creative thinking skills can be seen in learning outcomes. The average value of student learning outcomes is used to determine the improvement of creative thinking skills using the DBL model. Meanwhile, the average value of student activity is used to know the student learning activities during the learning process by using the DBL model based on student's activities criteria.

3.1.1. The results of the validity and reliability test

Before showing the results, we need to test the reliability and validity of our post-test instrument. The reliability and validity of the post-test results can be seen in the following table:

| Correlations | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Total |
|---------------|--------|--------|--------|--------|--------|--------|-------|
| Item _1 Pearson Correlation | 1.000** | .885** | .811** | .602* | .602* | .952** |       |
| Sig. (2-tailed) | .000 | .000 | .001 | .038 | .038 | .000 |       |
| N | 12 | 12 | 12 | 12 | 12 | 12 |       |
| Item _2 Pearson Correlation | 1.000** | .885** | .811** | .602* | .602* | .952** |       |
| Sig. (2-tailed) | .000 | .000 | .001 | .038 | .038 | .000 |       |
| N | 12 | 12 | 12 | 12 | 12 | 12 |       |
| Item _3 Pearson Correlation | .885** | .885** | 1 | .717** | .816** | .816** | .963** |
| Sig. (2-tailed) | .000 | .000 | .009 | .001 | .001 | .000 |       |
| N | 12 | 12 | 12 | 12 | 12 | 12 |       |
| Item _4 Pearson Correlation | .811** | .811** | .717** | 1 | .488 | .488 | .823** |
| Sig. (2-tailed) | .001 | .001 | .009 | .108 | .108 | .001 |       |

**Note:** The table above shows the post-item validity test results: correlation.
Based on table 3, it can be seen that the calculated $r$ value for question number 1 is 0.952, number 2, amounting to 0.952, number 3, amounting to 0.963, number 4, amounting to 0.523, number 5, amounting to 0.81, number 6, amounting to 0.801. It is known that the calculated $r$ value for all items is greater than $r$ table with $N = 12$, so it can be said that the six items are valid and can be used.

**Table 4.** Item reliability test results: reliability statistics.

| Reliability Statistics | Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|------------------------|------------------|---------------------------------------------|------------|
|                        | .936             | .945                                        | 6          |

Based on table 4, it can be seen that there are $N$ indicators (number of bulls) there are 6 (six) items with Cronbach Alpha values of $0.936 > 0.06$, so it can be concluded that all items are reliable and consistent.

**Table 5.** Homogeneity test results.

| Test of Homogeneity of Variances | Levene Statistic | df1 | df2 | Sig. |
|----------------------------------|------------------|-----|-----|------|
| PreTest Based on Mean            | 1.911            | 1   | 58  | .172 |
| Based on Median                  | 1.742            | 1   | 58  | .192 |
| Based on Median and with adjusted df | 1.742     | 1   | 57.846 | .192 |
| Based on trimmed mean            | 1.707            | 1   | 58  | .197 |

Based on table 5, it can be seen that the pre-test scores between the control class and the experimental class have significant (homogeneous) differences. So that the two classes can be used as research samples with different treatments, namely the control class using conventional learning, while the experimental class used DBL.
3.1.2 Student Activity
To ensure our results, we conduct an evaluation of all the student activities below that submit scientific applications. The observation items were carried out by 3 observers, and were approved using the Linkert scale which included very active (score 4), active (score 3) quite active (score 2) and Less active (score 1). The observations result can be show in the following chart.

![Observation Results for Student Activities](image)

**Figure 6. Observation Results for Student Activities.**

The cart, it can be seen of the criteria for very active is 45%, active is 35%, quite active 15% and Less active 5%. It indicates that, during scientific approach implementation, students are strongly active to engage with the solving the problem, and 45% of student reach the active level, and the rest of 5% are on less active. It can be concluded that scientific approach can work well in the learning process on solving sequence problem, it is able to improve the students critical thingking skills

3.1.3. Distribution of Students’ Creative Thinking Skills based on posttest
3.1.3.1. Distribution of the post-test result in the control class
The results of observing learning activities in the Control class with conventional techniques on the results of the Post-test to be evaluated. This finding shows that 18% of students are in a very creative position, 13% are creative, 14% are quite creative, and 59% are not creative. With this distribution, it is evident that learning based on conventional techniques cannot improve students’ creative thinking skills in solving multiplication problems.
3.1.3.2 Distribution of the Post-test result in the eksperiment class

The results of observing learning activities in the Experiment class with DBL techniques on the Post-test results to be evaluated. This finding shows that 45% of students are in a very creative position, 33% are creative, 12% are quite creative, and 10% are not creative. With this distribution, it is proven that DBL-based learning can improve students’ creative thinking skills in solving multiplication problems.

Next, inferential statistical analysis is carried out to determine differences in the application of DBL, namely the independent sample t-test, where previously the prerequisite test was conducted, namely the normality test.
Table 6. Normality Test Results.

Tests of Normality

| Class              | Kolmogorov-Smirnov | Shapiro-Wilk |
|--------------------|--------------------|--------------|
|                    | Statistic  | df | Sig. | Statistic | df | Sig. |
| Posttest           | Control Class    | .177 | 30 | .017 | .938 | 30 | .081 |
| Experimental Class | .152 | 30 | .074 | .937 | 30 | .075 |

a. Lilliefors Significance Correction

Based on table 6 above, with a significance level of 0.05, it can be seen that the sphirowilk column in the control class has a significant value of 0.81 (Sig.> 0.05) so that the control class data is said to be normally distributed. While, in the experimental class which has a significant value of 0.75 (Sig.> 0.05) so that the experimental class posttest data is said to be normally distributed. From the results of the normality test above, data from two classes, namely the control class and the experimental class are said to have fulfilled the requirements for the average difference test with independent sample tests.

Table 7. Independent sample-test results.

Independent Samples Test

| Levene's Test for Equality of Variances | t-test for Equality of Means | 95% Confidence Interval of the Difference |
|----------------------------------------|-----------------------------|-----------------------------------------|
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error | Difference | Lower | Upper |
| Posttest | Equal variances assumed | 1.524 | .222 | -6.833 | 58 | .000 | -16.100 | 2.356 | -20.816 | -11.384 |
|          | Equal variances not assumed | -6.833 | 56.52 | .000 | -16.100 | 2.356 | -20.819 | -11.381 |

Based on table 7 above, with a significance level of 0.05 obtained a Sig (2-tailed) value from the control class results and the experimental class results of 0.062 (p <0.05). It means that there is a significant average between control class and experimental class. So that it can be said the application of DBL has a significant effect in improving students' creative thinking skills in solving multiplication problems.
Figure 9. The results of observing the learning process in the Control class.

Table 8. The results of observing the learning process in the control class.

| t-Test: Paired Two Sample for Means | Variable 1 | Variable 2 |
|-------------------------------------|------------|------------|
| Mean                                | 74,7       | 80,03333333 |
| Variance                            | 7,044827586 | 1,826436782 |
| Observations                        | 30         | 30         |
| Pearson Correlation                 | 0,166307026 |           |
| Hypothesized Mean Difference        | 0          |            |
| df                                  | 29         |            |
| t Stat                              | -10,54218784 |           |
| P(T<=t) one-tail                    | 9,82767E-12 |           |
| t Critical one-tail                 | 1,699127027 |           |
| P(T<=t) two-tail                    | 1,96553E-11 |           |
| t Critical two-tail                 | 2,045229642 |           |

Based on the picture and table above, students are in a very flexible position. It shows that the application of DBL has been proven to increase students' creative thinking abilities in solving multiplication problems. The different of students' thinking abilities has an impact on the results of their achievements.
Figure 10. Creative thinking skills in the experimental class in the post-test.

Table 9. Observation results creative thinking skills in the experimental class.

| Variable 1 | Variable 2 |
|------------|------------|
| Mean       | 75.76666667| 79.3       |
| Variance   | 4.254022989| 2.631034483|
| Observations| 30          | 30         |
| Pearson Correlation | 0.361781148 |             |
| Hypothesized Mean Difference | 0         |             |
| df         | 29         |             |
| t Stat     | -9.15936263|             |
| P(T<=t) one-tail | 2.32682E-10 |             |
| t Critical one-tail | 1.699127027 |             |
| P(T<=t) two-tail | 4.65364E-10 |             |
| t Critical two-tail | 2.045229642 |             |

The experimental class showed better results than the control class. Based on the picture above, students are in a very flexible position. This shows that the application of DBL has been proven to increase students' creative thinking abilities in solving multiplication problems. Based on this evidence, we conclude that based-based learning (DBL) in the experimental class is more effective than the in the control class.

3.1.5. Students' Test Results
From the posttest results, 3 samples were taken representing high-level creative thinking skills in the category of very creative thinking skills, moderate creative thinking skills, and less creative thinking skills categories.
3.1.5.1 Student test results with a very creative level

Students can do multiplication with integers well.

Students are able to solve problems related to multiplication of integers.

Students can solve problems related to integer multiplication well.
Figure 11. Figure test results of students with very creative thinking skills.

3.1.5.2. The portrait phase of students’ very creative thinking skills
To solve multiplication problems, researchers conducted interviews with selected students because these students had obtained criteria for very creative thinking skills. Data obtained through the interview process are transcribed below.

Interviews with students about the ability to think very creatively
Teacher: "What's the assignment about?"
Student: "It's about mathematical multiplication"
Teacher: "Do the questions belong to the difficult, medium, or easy category?"
Student: "The question can be said easy."
Teacher: "What do you need in solving multiplication problems?"
Student: "Concentrate on calculating and choosing good techniques to work on."
Teacher: "Can you choose the right, effective and fun technique?"
Student: "Yes, using the multiplication calculation technique using the line technique"
Teacher: "Please, explain how you are working in solving multiplication problems with the line technique!"
Student: "Namely by making a straight line crossing from left to bottom and right to the top, a number of numbers on the multiplication problem that we are working on as an initial result. Then determine the number of points from which the lines intersect, then add the points in-line points."
Teacher: "Very good. Then how do you count the results of the multiplication?"
Student: "According to the way the teacher explained, if the number of points obtained is more than one digit, then the number is taken first, while for tens added with numbers in the previous point group."
Teacher: "Please explain how you solve the problem!"
Student: "When I do math problems using the line technique, then I feel more confident, and get the maximum value than using conventional techniques."
Teacher: "can you finish it?"
Student: "Yes, but the teacher also helps"
Teacher: "Can you find your answers without teacher's help?"
Student: "Yes, after understanding the technique described, I can do it myself."
Teacher: "After getting the teacher's help in solving problems, can you solve new problems without teacher's help?"
Student: "At first I had difficulties, but I tried using another method."
Teacher: "Can you solve this problem?"
Student: "Yes, I can work on other techniques taught by the teacher. These include lattice or box multiplication techniques, circle multiplication techniques, and multi-variable multiplication techniques.

Figure 12. Portrait phase Students with very creative level of thinking.

4. Discussion
Concept formation and understanding of mathematical multiplication through work on problems that occur in everyday life will give students several advantages. Among them, (1) students can better understand the existence of a close relationship between mathematics and situations, conditions, and events in their environment, because many cultures around them contain mathematical elements in them. (2) Students are skilled at solving problems independently by using abilities that exist within themselves (instincts, reasons, logic, and science). (3) Students develop their understanding of mathematical...
knowledge independently so that they develop proportional beliefs in mathematics and students are not afraid of mathematics.

With the development of the ability to think creatively, it is hoped that it can contribute to improve the quality of mathematics education in elementary schools, especially SD NegeriLembengan 02.

Moderate students from the control class gave negative responses when the researcher gave triggering directions about cardinality, but positive responses were given by students from the experimental class. Based on these two concerns, the researcher found a positive correlation between the application of problem-based learning and student motivation in getting the way of problem solving. Implementation of problem-based learning in the experimental class affects student motivation in getting the core of problem solving. Setiani et al. (2019), said that improving students’ competency and responsibility is a significant influence of self-assessment. Suratno et al. (2019), stated that problem solving is included in higher order thinking skills. Therefore, the accompanying impact makes students able to adapt and actively participate in better and comprehensive 21st century learning.

5. Conclusion
The implementation of discovery-based learning to improve students’ creative thinking skills in solving the number multiplication problems. This is evidenced by the results of the t-test which showed significant differences in the average posttest results between the control class and the experimental class. In addition, the implementation of discovery-based learning can improve students’ activity so that learning takes place more effectively. Phase portraits of higher order thinking skills students solve the problem of passing through the application of discovery-based learning shows that there are differences in the pattern of phase portraits. This is according to the ability of different students so that students’ answers are varied.

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