

The Effectiveness of the Discovery Learning Model on Students' Mathematical Conceptual Understanding in Trigonometric Comparison Materials

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Abstract— This study aimed to analyze the effectiveness of the Discovery Learning model in improving students' mathematical conceptual understanding in trigonometric comparison materials. This study was motivated by students' low conceptual understanding caused by teacher-centered instruction. A quantitative descriptive approach with a pre-experimental one-shot case study design was employed. The participants were 36 tenth-grade students at SMA Negeri 1 Dukun Gresik, Indonesia. Data were collected through classroom observations, mathematical conceptual understanding tests, and student response questionnaires. The data were analyzed descriptively by evaluating teacher performance, student activities, learning outcomes, and student responses. The findings revealed that the Discovery Learning model was effective in improving students' conceptual understanding. The teacher's ability to manage learning achieved an average score of 3.47, categorized as good. Student activities reached 81.25%, indicating active participation. In addition, 86.11% of students achieved learning mastery, while students showed positive responses toward the learning model, with an average percentage of 66.11%. Therefore, the Discovery Learning model can be considered effective in enhancing students' mathematical conceptual understanding in trigonometric comparison materials.

Keywords— Discovery Learning, conceptual understanding, mathematics learning, trigonometry, learning effectiveness.

I. INTRODUCTION

Education is one of the important aspects of life that plays a role in developing potential, shaping character, and improving the quality of human resources. In the context of education, mathematics has a very strategic role because it is not only related to the ability to calculate, but also to train logical, critical, and systematic thinking skills. Mathematics learning is given at all levels of education because it contributes to developing various mathematical skills of students, such as concept comprehension, problem solving, reasoning, connection, and mathematical communication [1]. Therefore, mathematics learning needs to be optimally designed to be able to achieve comprehensive educational goals [2].

Understanding mathematical concepts is one of the basic skills that students must have in learning mathematics. Understanding concepts is not just knowing or memorizing formulas, but also includes the ability to reinterpret concepts in one's own

language, connect between concepts, and apply them in various situations [3]. Students who have a good understanding of concepts will be able to develop mathematical ideas, understand the relationships between concepts, and solve problems effectively [4]. In addition, understanding concepts is also the basis for developing high-level thinking skills and building new knowledge on an ongoing basis [5].

However, in reality, students' understanding of mathematical concepts is still relatively low. The low understanding of this concept is caused by various factors, one of which is the use of inappropriate learning models. The learning process that is still teacher-centered causes students to be less active and only passively receive information [6]. In addition, the use of monotonous learning methods also makes students less motivated and less involved in the learning process [7]. This condition shows that innovation in learning is needed that is able to increase student involvement actively [8].

The results of observations conducted at SMA Negeri 1 Dukun Gresik show that the mathematics learning process is still dominated by the lecture method. Teachers are the center of learning, while students play the role of recipients of information. The interaction that occurs in learning tends to be one-way, so students are less active in asking questions and expressing opinions. In addition, some students seem to be less focused, talking to friends, and less enthusiastic in participating in learning. When given the opportunity to solve the problem in front of the class, many students feel doubtful and lack confidence. This shows that student involvement in learning is still low, which has an impact on students' low understanding of mathematical concepts.

To overcome these problems, a learning model is needed that can increase student activity and help them understand concepts in depth. One of the learning models that can be used is the Discovery Learning. This model emphasizes the process of discovering concepts by students through exploration, investigation, and problem-solving activities [9], [10]. In this model, students are encouraged to actively search for and discover the concepts learned for themselves, so that learning becomes more meaningful [11]. Models Discovery Learning It is also based on the theories of cognitivism and constructivism which view that knowledge is built by students through direct learning experiences [12], [13].

The application of the Discovery Learning model also has a positive impact on the development of students' thinking skills. Students are trained to think critically, analytically, and creatively in solving problems. In addition, learning that actively involves students can increase learning motivation, confidence, and social skills through discussion activities and group work. Thus, learning not only focuses on the cognitive aspect, but also includes affective and psychomotor aspects.

Some previous studies have shown that the Discovery Learning effective in improving students' understanding of mathematical concepts. The results of the study showed that students who learned using the model Discovery Learning have a better ability to

understand concepts compared to students who learn using conventional learning models [14]. This shows that the Discovery Learning can be a solution in overcoming the problem of low understanding of students' mathematical concepts.

However, research related to the application of the Discovery Learning model is still largely focused on basic mathematical materials, such as algebra and simple geometry. Meanwhile, trigonometric comparison material is one of the materials that has a fairly high level of abstraction and is often considered difficult by students. This material requires students to understand the relationships between sides in a triangle and apply the concept in a variety of situations. Therefore, a learning model is needed that is able to help students understand concepts in depth, one of which is through the Discovery Learning model.

Based on this description, this research was conducted to examine the effectiveness of the Discovery Learning learning model in improving students' understanding of mathematical concepts in trigonometric comparison materials.

It is hoped that through the application of this model, students can be more active in learning, have a better understanding of concepts, and be able to apply mathematical concepts in various situations.

Therefore, this study is entitled "The Effectiveness of the Discovery Learning Model in Students' Understanding of Mathematical Concepts".

II. RESEARCH METHODS

This research uses a quantitative descriptive approach with a type of pre-experimental design research. The research design used is a one-shot case study, which is a study conducted on one group without a comparison group, where subjects are given treatment in the form of learning using the Discovery Learning model, then the results are measured after the treatment is given.

The research design can be described as follows:

$$X \rightarrow O$$

Description:

X = The treatment provided is learning using the Discovery Learning model

O = Observation of results after being given the treatment of the Discovery Learning model, namely learning management, student activities, test results, and student response questionnaires after learning

This research was carried out at SMA Negeri 1 Dukun Gresik in the even semester of the 2024/2025 school year. The subjects in this study are students in class X-4 which totals 36 students. Subject selection is carried out by purposive sampling technique, which is the selection of classes based on certain considerations that are relevant to the research objectives.

The data collection techniques in this study include observation, tests, and questionnaires. Observation is used to observe the teacher's ability to manage learning and student activities during the learning process. The observation instruments are prepared based on the syntax of the Discovery Learning model which includes the stages of stimulation, problem statement, data collection, data processing, verification, and generalization. The test is used to measure students'

understanding of mathematical concepts after participating in learning. The test given is in the form of description questions that are compiled based on indicators of understanding mathematical concepts. Meanwhile, the questionnaire was used to find out the students' response to the learning that had been carried out.

The data analysis technique in this study uses quantitative descriptive analysis. The analysis was carried out to illustrate the effectiveness of learning using the Discovery Learning model in understanding students' mathematical concepts. The data analyzed included teachers' ability to manage learning, student activities, results of mathematical concept comprehension tests, and student responses to learning.

Analysis of Teachers' Abilities in Managing Learning

Teacher ability data is obtained from observation sheets filled in by observers during the learning process. The results of the assessment are then categorized based on the following criteria:

Table 1. Category Teacher Assessment Score

Average Score	Category
$1.00 \leq SP < 2.00$	Not Good
$2.00 \leq SP < 3.00$	Not Good
$3.00 \leq SP < 3.50$	Good
$3.50 \leq SP < 4.00$	Excellent

Source [15]: The category of the results of the teacher's assessment score is said to be able to manage learning well if it gets a score. $\geq 3,00$

Student Activity Analysis

Data on student activities was obtained through observation during learning. The category of student

activity percentage results is said to be active if the percentage of student activity The level of student activity is categorized as follows: $\geq 70\%$

Table 2. Categories of Student Activity Aspects

Percentage (%)	Categories
85 – 100	Highly Active
70 – 84	Active
60 – 69	Quite Active
51 – 59	Less Active
0 – 50	Inactive

Source [15]: Analysis of Mathematical Concept Comprehension Test Results

Students' test results were analyzed to measure learning mastery at both the individual and classroom levels. Classical mastery was considered to be achieved when the percentage of students who attained individual mastery met or exceeded the established benchmark $\geq 85\%$ [16].

Student Response Analysis

Student response data was obtained through a questionnaire given after learning. The category of student response percentage results is that students are said to be active if the percentage of student activity. The results of the students' responses are categorized as follows: $\geq 60\%$

Table 3. Categories Aspects of Student Response

Student Response Percentage (%)	Category
$80\% \leq N < 100\%$	Very Positive
$60\% \leq N < 80\%$	Positive
$40\% \leq N < 60\%$	Quite Positive
$20\% \leq N < 40\%$	Less Positive
$N < 20\%$	Very Less Positive

Source [17]

III. RESULTS AND DISCUSSION

The results of this study were obtained from data on teachers' ability to manage learning, student activities, mathematical concept understanding test results, and student responses to learning using the Discovery Learning model.

Teachers' Abilities in Managing Learning

Teacher ability is the ability or skill possessed and mastered by the teacher to carry out a certain activity or activity [18]. In the teacher's ability in learning activities, there are several aspects that are assessed. The following are the results of observations made by fellow students in assessing the researcher's teaching ability.

Table 4. Results of Observation of Teachers' Abilities During Learning Activities

No.	Observed Aspects	Score
1.	Implementation	8
	Introduction	41
	Core Activities	6,5
	Closing	10,5
2.	Time Management	66
Quantity		66

Based on table 4, it is known that the total score obtained by the researcher in observing teachers' abilities in learning activities is 66 out of a total score of 76 and a total of 19 overall aspects assessed. Then the value can be found as follows:

$$\begin{aligned}
 SPP &= \frac{\text{total average value}}{\text{many aspects are observed}} \\
 &= \frac{66}{19} \\
 &= 3,47
 \end{aligned}$$

In the process of collecting data on teachers' abilities, the researcher plays the role of a teacher who delivers learning materials, while fellow students act as observers who assess the implementation of learning carried out by researchers. Observation of teachers' abilities is carried out through two aspects, namely: (1) the stages of learning activities which include preliminary activities, core activities, and closing activities; and (2) time management which includes the preparation, implementation, and closing stages of learning.

Based on the results of the observations listed in Table 4, a score of learning management ability of 3.47 was obtained which was in the score range, so the teacher's ability to manage the learning process can be categorized in the good category. $3,00 \leq SPP < 3,50$

Student Activities

According to Asuke et al. (2023), Learning activities are a whole series of actions or activities that are

carried out consciously by a person so that they cause changes in him/her, both in the form of increasing knowledge and skills. This student activity data is based on the activities carried out by students during learning. The student activity observation sheet has been validated by the lecturer and teacher of SMA Negeri 1 Dukun Gresik. The data on the results of student activities was obtained as follows:

Table 5. Results of Student Activity Observation

No.	Student Activity Indicators	Average
1	Listening to and paying attention to the teacher's explanations in learning	9,38%
2	Pay attention to and observe examples, pictures, or problems presented by the teacher	6,77%
3	Read and understand the LKPD or teaching materials provided by the teacher	7,81%
4	Ask questions related to problems or material that you don't understand	8,33%
5	Identify and formulate problems to be solved	5,73%
6	Gather relevant information or data to resolve issues	7,81%
7	Discuss with a friend or teacher in the process of discovering math concepts	7,29%
8	Putting forward an opinion or idea during the discussion	5,21%
9	Processing data or information to find mathematical concepts or formulas	7,81%
10	Using the concepts found to solve problems or problems	8,33%
11	Summarizing and reexplaining the math concepts learned	6,77%
12	Showing irrelevant attitudes in learning	18,75%
Quantity		100%

In the data collection process, the researcher was assisted by fellow students to record the results of observation of student activities during learning by observing six students who were randomly selected as research subjects. Each activity that appears is recorded based on the indicator number on the observation sheet, which consists of 11 relevant activity indicators and 1 irrelevant activity indicator. Based on the results of observations, it was obtained that the level of student participation in mathematics learning using the Discovery Learning model in trigonometric ratios materials was in the good category, with a percentage of active activity of 81.25% and inactive activity of 18.75%. The high percentage of active activities shows that most students are directly involved in each stage of learning, such as paying attention to the teacher's explanations, utilizing learning resources, discussing, and applying concepts in problem solving. This shows that learning takes place actively and is student-centered, in

accordance with the characteristics of Discovery Learning which emphasizes the process of discovering and building knowledge independently. Although there are still a small number of students who show irrelevant activities, overall the learning atmosphere can still be categorized as active because it has exceeded the minimum limit of activity, which is $\geq 70\%$.

Mathematical Concept Comprehension Test Results

Learning outcomes are achievements obtained by students after participating in the learning process for a certain period of time [20]. After the mathematics learning activity with trigonometric comparison material using the Discovery Learning learning model, a test was held to find out the learning outcomes of students. The learning outcome test used was in the form of essay story questions with the subject of trigonometry comparison which amounted to 3 questions. The test was given to students in grades X-4 at SMAN 1 Dukun Gresik which totaled 36 students,

and this test was used as a benchmark to determine students' understanding of mathematical concepts

regarding trigonometric comparison material with the Discovery Learning learning model.

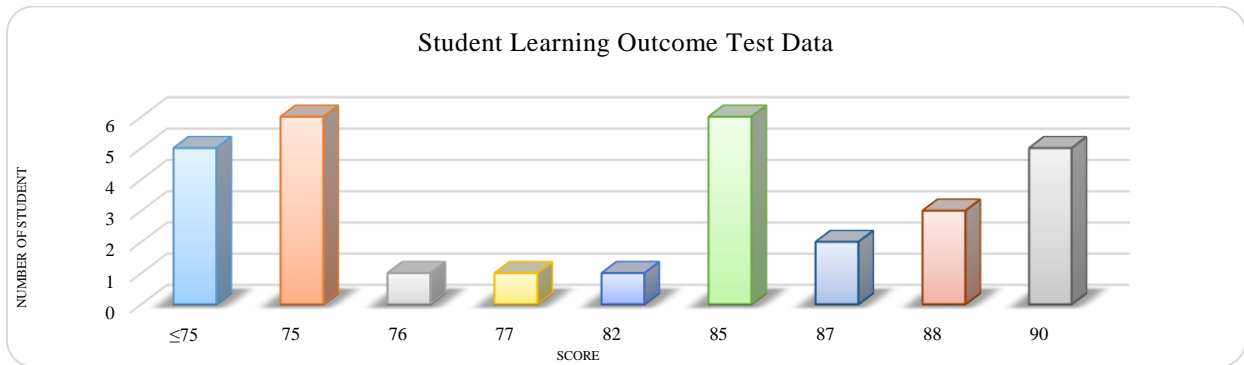


Figure 1. Student Learning Outcome Test Data

Based on the picture, it can be seen that the number of students who obtained scores ≥ 75 or scores that achieved learning completeness at least amounted to

31 students. Thus, the percentage of students who are declared classically complete or obtain scores can be calculated as follows: ≥ 75 .

$$\begin{aligned} \text{Classical Completeness} &= \frac{\text{the number of student who graduated}}{\text{number of student}} \times 100\% \\ &= \frac{31}{36} \times 100\% \\ &= 86,11\% \end{aligned}$$

Based on the results of the calculation, it was obtained that the percentage of students who achieved a score of ≥ 75 on the learning outcome test was , so it can be concluded that the completeness of student learning outcomes has been classically achieved, because most of the students have met the minimum completeness criteria set in learning. 86,11%

place with the model Discovery Learning. The response data of students from class X-4 of SMA Negeri 1 Dukun is presented as follows:

Student Response

Student responses can be interpreted as a form of reaction or response that appears, either in the form of acceptance, rejection, or indifference to the message conveyed by the information conveyor [21]. Student response data is data obtained after the mathematics learning process is carried out by applying the learning model Discovery Learning. Data collection was carried out using a questionnaire instrument made in the form of Google Form and shared with students through class groups. The results of this questionnaire were used to describe the level of acceptance and student response to mathematics learning that took

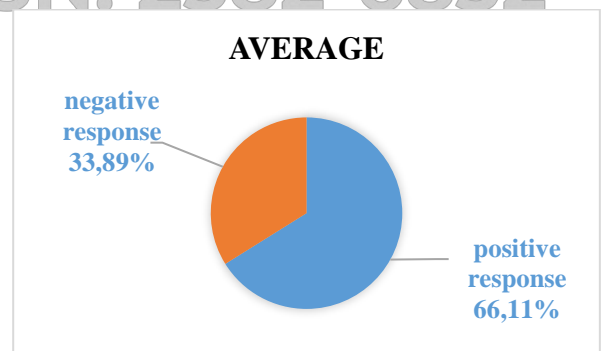


Figure 2. Average Student Response

From the results of the analysis of student response questionnaire data after the implementation of learning, it was found that students in grades X-4 of SMA Negeri 1 Dukun Gresik showed a mostly positive response to the application of the Discovery

Learning learning model in mathematics learning related to student concept understanding. The average percentage of student answers who gave positive responses reached 66.11%, while negative responses were recorded at 33.89%. Based on the percentage of positive responses that are in the range, it can be concluded that student responses to the learning activities that have been carried out are included in the positive category. $60\% \leq R < 80\%$

IV. CONCLUSIONS AND SUGGESTIONS

The findings indicate that the Discovery Learning model effectively improves students' mathematical conceptual understanding in trigonometric comparison materials. The effectiveness was demonstrated through positive teacher performance, active student participation, high classical learning mastery, and positive student responses. The implementation of Discovery Learning also encouraged students to become more engaged and independent during the learning process. Therefore, the model can be recommended as an alternative instructional strategy for mathematics learning, particularly in conceptual and abstract topics.

Based on these conclusions, it is recommended that teachers can apply the Discovery Learning learning model in mathematics learning, especially in materials that require an in-depth understanding of concepts. Students are also expected to be more active in participating in learning and dare to participate in discussions so that their understanding of concepts increases. The school is expected to support the implementation of innovative learning models by providing adequate facilities. In addition, for future researchers, it is recommended to develop this research on different materials or use a broader research design to obtain more comprehensive results.

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