UNP JOURNAL MANAGEMENT CENTER

math.ppj.unp.ac.id
p-ISSN 2716-0726
e- ISSN 2716-0734

Indexed

The Effect of the Discovery Learning Model with Student Worksheets on Students' Mathematical Concept Comprehension Ability

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Article History
Vol. 4, No. 1, 2025

Subject Areas:
Mathematics Educations

Keywords:
Discovery Learning, Student Worksheets, Mathematical Concept Comprehension Ability, Quasi-Experimental Design

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Abstract- Mathematical concept comprehension is essential in learning mathematics. However, students' comprehension of mathematical concepts is still low. This research aims to determine the effect of the discovery learning model with student worksheets on students' mathematical concept comprehension ability. The method used in this research is quantitative. The type of research is a quasi-experimental design. The simple random sampling technique selected two classes as the research sample. The instruments used in this research are a test of mathematical concept comprehension abilities and observation sheets of learning implementation. The data analysis techniques used in this research were descriptive analysis and inferential analysis (Independent Sample T-Test). Based on the data analysis results, the research shows that the discovery learning model with student worksheets positively affects students' mathematical concept comprehension ability. This research implies that discovery learning with students' worksheets can be an effective alternative to improve students' comprehension of mathematical concepts in classroom practice.

1. Introduction

Concept comprehension is one of the objectives of mathematics, as stated in Ministerial Regulation No. 22 of 2006 (Depdiknas, 2006). According to Sanjaya (Effendi, 2017), mathematical concept comprehension means mastering a set of mathematics lessons in which students do not merely know or remember various learned concepts, but are also able to rephrase them in another easily understood form, interpret them, and apply the concepts by their cognitive structure. Mathematical concept comprehension is the foundation

RANGKIANG MATHEMATICS JOURNAL
Journal of Mathematics and Mathematics Education

for mastering higher-level mathematical concepts and supports the

Ability to interconnect these concepts (Diana et al., 2020). Therefore, to effectively master mathematics content, students must thoroughly understand the concepts being taught (Irna, 2020).

Despite concept comprehension being one of the learning objectives stated in the Ministerial Regulation, the reality in Indonesia is that students' mathematical concept comprehension abilities remain relatively low. This is evidenced by the Programme for International Student Assessment (PISA) survey in 2022, where Indonesian students ranked 69th out of 81 countries with a score of 366, below the OECD average score of 472. The aspects evaluated in PISA include concept comprehension, problem-solving ability, reasoning, connection skills, communication skills, and representation ability (Schleicher, 2022). This survey indicates that Indonesian students' mathematical concept comprehension ability is considerably lacking compared to other countries.

The students of SMPN 4 Majene, particularly those in Class VIII, also experience low comprehension of mathematical concepts. Interviews conducted in September 2023 with a mathematics teacher revealed that most students struggle with questions that apply mathematical concepts in contexts different from the examples taught or in problems requiring a deeper application of these concepts. Students tend to merely mimic examples and follow the pattern provided by the teacher. This suggests that students are memorizing concepts rather than truly understanding them.

According to Putri (2016), one factor causing low mathematical concept comprehension among students is that teachers do not optimize or provide sufficient opportunities to construct mathematical concepts independently. Moreno (2018) similarly stated that the resulting concept comprehension will be suboptimal when teachers do not allow students to create their ideas. In line with this, Saragih and Afriati (2012) mentioned that if students only act as passive recipients of information, the taught material is more easily forgotten, and the concepts are not truly understood.

Based on interviews, it was found that the mathematics learning process at SMPN 4 Majene is still teacher-centered, with students having little opportunity to construct their Knowledge; they only passively receive information directly from the teacher. Moreover, the researcher found that teachers rarely use teaching materials besides textbooks during lessons. Therefore, a learning model is needed to enhance students' mathematical concept comprehension and encourage them to build their Knowledge actively. One such model is the discovery learning model. Widyaningrum and Suparni (2023) argue that discovery learning allows students to construct Knowledge independently, making the learning process more meaningful and ultimately providing long-term benefits.

Ghozali (2018) defines the discovery learning model as a form of instruction in which students are not presented with a finalized concept; instead, they must organize and discover it themselves. This learning model fosters logical, analytical, and systematic thinking because students solve problems and independently build and discover concepts (Rosdianwinata, 2015; Wahyudi & Siswanti, 2015). Discovery learning enables students to find personal meaning and to learn concepts in language they understand (Setiawan et al., 2017). Additionally, Knowledge acquired independently tends to be retained longer in students' memory (Gulo, 2022).

Several studies have shown that the discovery learning model can enhance students' comprehension of mathematical concepts. Research by Hayati et al. (2022) and Manalu et al. (2023) indicates that students taught with the discovery learning model exhibit higher concept comprehension than those taught through direct learning. Similarly, Sutrisno (2014) stated that students who independently discover concepts show improved mathematical concept comprehension. Besides improving concept comprehension, the discovery learning model can transform a passive learning environment into one that is active and creative, shifting from a teacher-oriented classroom to a student-oriented one, where students are active learners (Ana, 2018).

In applying the discovery learning model, teachers need to use teaching materials beyond the textbook to support the learning model. One such resource is the student worksheets. Student worksheets are more flexible than textbooks since they can be designed to suit the chosen learning model (Wiranata & Sujana, 2021). Student worksheets are printed materials containing content, summaries, and instructions for learning tasks aligned with the Basic Competencies that must be achieved (Prastowo, 2014). They facilitate teaching and learning by helping students receive and understand the material more effectively (Pertiwi, 2018; Umbaryati, 2021).

Furthermore, using student worksheets in learning simplifies the teaching process and positively affects the students' comprehension of mathematical concepts. Research by Sari and Firman (2019) and Sari et al. (2019) found that students' concept comprehension improved after lessons using student worksheets. Sagita (2016) also noted that worksheets can guide students to discover concepts through their

individual activities or group work. Thus, student worksheets align with the discovery learning model, which requires students to learn concepts independently. It can be concluded that mathematics instruction using the discovery learning model is more effective when combined with student worksheets.

Based on the explanation above, the researcher intends to conduct a study entitled "The Effect of Discovery Learning Model with Student Worksheets on Students' Mathematical Concept Comprehension Ability."

2. Methods

(a) Research Design

The method used in this research is quantitative research. According to Sugiyono (2021), quantitative research is a research method based on the philosophy of positivism, used to study a specific population or sample, with data analysis being quantitative/ statistical, aiming to test predetermined hypotheses. This research follows a quasi-experimental design. Sugiyono (2021) explains that a quasi-experiment is a study to determine whether a given treatment affects the research subjects. The quasi-experimental design was chosen because, in practice, it is difficult to obtain a control group that can be used for research (Sugiyono, 2021).

The design used in this study is the nonequivalent control group design. According to Sugiyono (2021), the design involves two sample groups for comparison: an experimental group that receives the treatment and a control group that does not. Both groups are given a pretest and a post-test. The pretest measures initial conditions and checks for any differences between the groups, and the post-test assesses the differences after the treatment. The nonequivalent control group design is illustrated in Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Post-test
A	O_{A1}	X_1	O_{A2}
B	O_{B1}	X_2	O_{B2}

Notes:
A: Experimental Group
B: Control Group
O_{A1}: Experimental Group Pretest
O_{B1} : Control Group Pretest
X_1 : Treatment for Experimental Group (Discovery Learning Model with Student Worksheets)
X_2 : Treatment for Control Group (Direct Learning)
O_{A2} : Experimental Group Posttest
O_{B2} : Control Group Posttest

The research was conducted from March 6 to April 24 during the even semester of the 2023/2024 academic year at SMPN 4 Majene, located at Jl. Letjen Hertasning, Baurung, Kec. Banggae Timur, Majene Regency,West Sulawesi Province. The population of this research is all of Class VIII students at SMPN 4 Majene. Using a simple random sampling technique, the sample of this research is Class VIII B (experimental group) and VIII D (control group).

(b) Research Instruments

1. Test

Data on mathematical concept comprehension were collected using a mathematical concept comprehension test, which included both a pretest and a post-test. The pretest measured the initial ability of both groups, while the post-test was used to identify differences between the experimental and control groups. The characteristics of the test items for both the pretest and post-test were the same. The test was in the form of subjective essay questions designed to measure students' concept comprehension.

2. Observation Sheet

An observation sheet was used to evaluate the implementation of the learning process. This sheet determined the extent of learning implementation during each meeting in both the experimental and control classes. Observations were carried out from the beginning to the end of each class session.

(c) Data Analysis Technique

1. Descriptive Statistical Analysis

Descriptive statistics were used to describe the profile of students' mathematical concept comprehension in both the experimental and control groups. This analysis includes maximum, minimum, mean, median, mode, standard deviation, and variance. SPSS was used for this analysis. The categorization of students' mathematical concept comprehension was based on the criteria presented in Table 2.

Table 2. Categories for Mathematical Concept Comprehension

Score Range	Category
85 – 100	Very High
75 – 84,99	High
55 – 74,99	Moderate
40 – 54,99	Low
0 – 39,99	Very Low

(Putri & Hakim, 2022)

Descriptive analysis was also conducted on the observation data to evaluate the quality of the learning implementation in each session. The results were calculated using the formula:

$$K = \frac{Observation\ Score\ Total}{Total\ Score} \times 100 \qquad (2.1)$$

Categories for the percentage of learning implementation are provided in Table 3.

Table 3. Categories for Learning Implementation

Percentage Range	Category
$75 < K \leq 100$	Very Good
$50 < K \leq 75$	Good
$25 < K \leq 50$	Fairly Good
$0 \leq K \leq 25$	Poor

(Marnita, 2013)

2. N-Gain Test

An n-gain test was conducted to determine the improvement in mathematical concept comprehension of students taught using the discovery learning model with student worksheets compared to those taught via direct learning. SPSS was used for this test. The n-gain criteria are provided in Table 4.

Table 4. N-Gain Criteria

N-Gain Index	Category
$0{,}70 \leq N \leq 1{,}00$	High
$0{,}30 \leq N < 0{,}70$	Moderate
$N < 0{,}30$	Low

(Ramadhani & Amudi, 2020)

3. Inferential Statistical Analysis

Inferential statistics were employed to test the research hypothesis:

H_0: The discovery learning model with student worksheets does not positively affect students' mathematical concept comprehension ability.

H_1: The discovery learning model with student worksheets positively affects students' mathematical concept comprehension ability.

The hypothesis was tested using an independent sample t-test. Prerequisite tests included normality and

homogeneity tests.

1) Normality Test: The normality of the pretest and post-test scores for both groups was examined using the Shapiro-Wilk test in SPSS with a significance level of 5% ($\alpha = 0.05$). If sig. < 0.05, the data are not normally distributed; if sig. > 0.05, the data are considered normally distributed.
2) Homogeneity Test: A homogeneity test was performed to ensure that both groups had equal variances. The homogeneity of variance test in SPSS was conducted with a significance level of 5% ($\alpha = 0.05$). If sig. < 0.05, the variances are not homogeneous; if sig. > 0.05, the variances are homogeneous.
3) Hypothesis Testing: The independent sample t-test (comparing two means of independent groups) was used with a one-tailed test (right-tailed) at a significance level of 5% ($\alpha = 0.05$). The decision rule was: if sig. (1-tailed) < 0.05, reject H_0 and accept H_1; if sig. (1-tailed) > 0.05, accept H_0 and reject H_1.

3. Results and Discussion

Result

This study was conducted in two classes: Class VIII B (experimental group) with 22 students and Class VIII D (control group) with 23 students. Class VIII B was taught using the discovery learning model with student worksheets, while Class VIII D received direct learning.

(a) Descriptive Analysis Results

1. Pretest and Posttest Data Analysis

The average mathematical concept comprehension of the experimental class before instruction was in the very low category. After the instruction, the comprehension of the experimental class improved to the moderate category. Conversely, the control group's average comprehension remained low after direct learning. Table 5 shows the processed pretest and post-test scores for both groups.

Table 5. Pretest and post-test Data for Experimental and Control Groups

Data	Experimental Groups		Control Groups	
	Pre	*Post*	*Pre*	*Post*
Max	53,8	74,9	53,8	54,3
Min	19,2	53	19,2	21,9
Mean	35,7	61,7	35,1	37,6
Median	34,4	60	38	41
Mode	24	57,1	30,8	41
Std. Deviation	11,1	5,7	8,9	8,3
Variance	123,7	32,7	80,4	69

1) Observation of Learning Implementation

Both groups achieved very good ratings for the learning process, indicating that implementing the discovery learning model with student worksheets in the experimental group and the direct learning in the control group was carried out very well. Table 6 shows the observation data for learning implementation for both groups.

Table 6. Observation Data for learning Implementation

Session	Analysis Results		Category
	Experimental Groups	Control Groups	
I	85,87	84,21	Very Good
II	85,87	84,21	Very Good
III	86,97	85,53	Very Good

2. N-Gain Test Results

N-gain test results show that the experimental group's average n-gain falls in the moderate category, while the control group's average is low. This indicates that the improvement in mathematical concept comprehension was higher in the experimental group than in the control group. Table 7 shows the

average n-gain values for both groups.

Table 7. N-Gain Categories of the Experimental and Control Groups

Group	Average N-Gain	Category
Experimental	0,36	Moderate
Control	0,03	Low

(b) Inferential Analysis Results

1. Normality Test Results

The normality test results show that the significance values for the pretest and post-test in the experimental and control groups are greater than 0.05. This indicates that the data in both groups follow a normal distribution. Table 8 shows the normality test results for both groups.

Table 8. Normality Test Result for Pretest and post-test Scores

Group	Sample Size	Pretest Significance	Pretest Conclusion	Post-test Significance	Post-test Conclusion
Experimental	22	0.119	Normal	0.102	Normal
Control	23	0.360	Normal	0.562	Normal

2. Homogeneity Test Results

The homogeneity test result shows that the significance value for the pretest in the experimental and control groups is greater than 0.05. This indicates that the data variances in both groups are homogeneous. Table 9 shows the homogeneity test results for both groups.

Table 9. Homogeneity Test Results

Nilai	**Signifikansi**	**Kesimpulan**
Pretest	0,114	Homogen

3. Hypothesis Test Results

The hypothesis test was carried out after performing the prerequisite tests and obtaining results that both data groups are normally distributed and have homogeneous variances. Table 10 shows the results of the independent samples t-test.

Table 10. Independent Samples T-Test results

Independent Samples Test		
	t-test for Equality of Means	
	df	Sig. (2-tailed)
N-Gain	29,097	0,000

Based on Table 10, the sig. (2-tailed) The value obtained is 0.000. Because this research uses a one-tailed test, the P-value obtained is divided by 2, resulting in a sig. (1-tailed) value of 0.000. Since the sig. (1-tailed) value is less than 0.05, H_0 is rejected, and H_1 is accepted, concluding that the discovery learning model with student worksheets positively affects students' mathematical concept comprehension ability.

Discussion

The descriptive analysis showed that students' mathematical concept comprehension ability was very low before instruction. After the instruction, it was in the medium category. This means students' mathematical concept comprehension ability increased significantly when taught with the discovery learning model and student worksheets. This is in line with the research results of Rohayati et al. (2023), which showed that the discovery learning model can improve students' mathematical concept comprehension ability.

The descriptive statistical analysis also showed that students' mathematical concept comprehension ability was very low before instruction. After the instruction, students' mathematical concept comprehension ability remained very low. This means students' mathematical concept comprehension

ability, taught with direct learning, did not increase. This is consistent with the research results of Kase et al. (2024), which also indicated that in direct learning, students' mathematical concept comprehension ability remains very low.

Based on the above explanation, it is evident that students' mathematical concept comprehension ability taught with the discovery learning model with student worksheets is higher than that of students taught with direct learning. This is in line with the research by Ilviandri et al. (2020), which also showed that the students' mathematical concept comprehension ability taught with the discovery learning model is higher than that of students taught with direct learning. Furthermore, research conducted by Jannah (2021) also showed a significant difference between the students' mathematical concept comprehension ability taught with the Discovery Learning model and those taught with direct learning.

Then, based on the inferential analysis results, it was found that the discovery learning model with student worksheets positively affects students' mathematical concept comprehension ability. This is supported by the n-gain test results, which show that the average increase in students' mathematical concept comprehension ability taught with the discovery learning model with student worksheets is in the medium category. In contrast, the average increase in students' mathematical concept comprehension ability taught with direct learning is in the low category. This is also supported by the research conducted by Nuzulil (2021), which showed that the discovery learning model positively affects students' mathematical concept comprehension ability. The same was demonstrated by the research conducted by Margareta et al. (2022) as well as the study by Situmorang and Siregar (2024), both of which indicated that there is a significant positive effect of the discovery learning model on students' mathematical concept comprehension ability.

4. Conclusion

Students' mathematical concept comprehension ability was categorized as low before instruction using the discovery learning model with student worksheets. However, after the instruction, it improved to the moderate category. In contrast, students who received direct learning remained in the very low category after the learning process. This indicates that discovery learning with student worksheets positively affects students' mathematical concept comprehension ability. Despite this positive effect, several challenges emerged during its implementation. The most prominent obstacles were time constraints and limited use of instructional media, which sometimes hindered students from fully constructing their understanding. Therefore, future research is recommended to utilize alternative teaching materials or instructional media beyond worksheets, and to plan time allocation and instructional strategies more carefully so that each phase of the discovery learning model can be carried out more effectively and provide optimal opportunities for students to construct their conceptual understanding.

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