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The Effect of the Guided Discovery Learning Model on Students' Mathematical Reflective Thinking Skills

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ABSTRACT Students' mathematical reflective thinking skills remain limited, particularly in understanding problems, connecting mathematical concepts, evaluating solution processes, and drawing conclusions when solving linear equations in one variable. This quasi-experimental study investigated the effect of guided discovery learning on students' mathematical reflective thinking skills. The population comprised 183 eighth-grade students at SMP Negeri 2 Sumberejo. Through cluster random sampling, class VIII.2, comprising 30 students, was selected as the experimental group, while class VIII.3, comprising 31 students, was selected as the control group. A pretest-posttest control group design was employed, and data were collected using a test of mathematical reflective thinking skills. Improvement was measured using N-Gain scores and compared through an independent-samples t-test. The experimental group obtained a higher mean N-Gain score (0.62) than the control group (0.54). The hypothesis test also showed that the calculated t-value (2.65) exceeded the critical value (1.67) at the 5% significance level. These findings indicate that guided discovery learning produced a significantly greater improvement in students' mathematical reflective thinking skills than conventional learning, particularly in connecting concepts and evaluating solutions.

Keywords: mathematical reflective thinking, guided discovery learning, linear equations in one variable, quasi-experimental study

INTRODUCTION

Education is a planned process designed to develop students' potential through learning activities and prepare them to address various challenges in life. Indonesia's National Education System Law No. 20 of 2003 emphasizes that education should develop individuals who are faithful, demonstrate noble character, possess relevant competencies, think creatively, and contribute to the nation. Mathematics is important for achieving these goals because it develops logical, systematic, critical, and creative reasoning skills, which are essential for responding to advances in science and technology. Within the Merdeka Curriculum, mathematics instruction emphasizes reasoning and problem-solving through structured and reflective thinking activities, particularly in topics such as linear equations in one variable.

Reflective thinking is a higher-order thinking skill that should be developed through mathematics instruction (Fuady, 2016). It involves reviewing the steps used to solve a problem, evaluating the selected strategies, and determining whether the results are consistent with the problem conditions (Jayanti, 2018). Reflective thinking also requires students to reconsider initial assumptions, compare alternative solutions, and draw logical conclusions from evidence. These processes are closely related to metacognitive awareness, through which students consciously monitor and regulate their thinking. Mathematical reflective thinking is therefore an essential competence for meeting the demands of twenty-first-century learning.

However, mathematical reflective thinking skills among Indonesian students remain relatively limited. In TIMSS 2015, Indonesian fourth-grade students achieved an average mathematics score of 397 and ranked 44th among 49 participating countries (Mullis et al., 2016). Similarly, the PISA 2022 results show that Indonesian students achieved a mathematics score of 366, below the OECD average of 472 (OECD, 2023). These findings suggest that many students continue to experience difficulty with higher-order processes such as analyzing, evaluating, and reflecting on problem-solving outcomes.

Previous studies support this concern. Masamah (2017), Ramadhani and Aini (2020), Umbara and Herman (2023), and Jozua et al. (2015) reported that students experienced difficulty identifying problems, connecting prior knowledge, and verifying solutions. However, most of these studies addressed broader mathematical content and did not specifically examine reflective thinking in the context of linear equations in one variable at the junior high school level. Empirical evidence regarding the effectiveness of guided discovery learning in specific school contexts also remains limited. These limitations reveal a research gap that warrants further investigation.

A similar pattern was observed at SMP Negeri 2 Sumberejo. The preliminary test results showed that students had difficulty checking the accuracy of their answers, connecting the given information, and reflecting on their problem-solving processes. These results indicate that students were not yet accustomed to reflective thinking when solving problems involving linear equations in one variable. The preliminary test item is presented in Figure 1.

1. Sebuah persegi panjang memiliki keliling 34 cm. Jika ukuran panjangnya $(3x - 4)$ cm dan lebarnya $(x + 1)$ cm, tentukan luas persegi Panjang tersebut. Setelah menemukan menemukan jawabannya, periksa kembali bahwa jawaban yang kamu dapatkan sudah benar!

Figure 1. Test Item on Mathematical Reflective Thinking Skills

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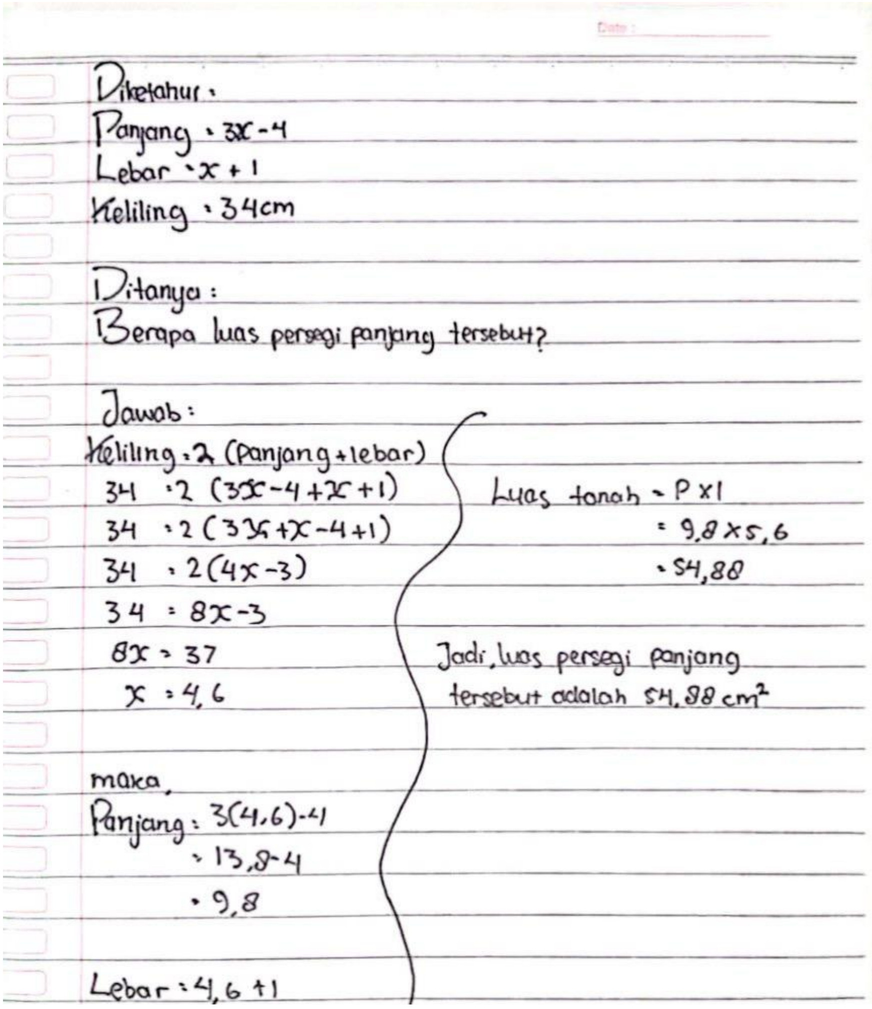
Of the 30 students who completed the preliminary test, 7 answered correctly, 4 provided no answer, and 19 answered incorrectly. Figure 2 presents an example of a student's error when solving the mathematical reflective thinking item.


Diketahui :
Panjang : 3x - 4
Lebar : x + 1
Keliling : 34cm

Ditanya :
Berapa luas persegi panjang tersebut?

Jawab :
Keliling : 2 (Panjang + lebar)
34 : 2 (3x - 4 + x + 1)
34 : 2 (3x + x - 4 + 1)
34 : 2 (4x - 3)
34 : 8x - 3
8x : 37
x : 4,6

maka,
Panjang : 3(4,6) - 4
: 13,8 - 4
: 9,8

Lebar : 4,6 + 1

Luas tanah : P x l
: 9,8 x 5,6
: 54,88

Jadi, luas persegi panjang tersebut adalah 54,88 cm²

Figure 2. Example of a Student's Error in Answering the Question

Figure 2 shows that the student identified the given information and correctly selected the rectangle perimeter formula, $K = 2(p+l)$. The student also substituted the length, $(3x - 4)$ cm, and width, $(x + 1)$ cm, using nearly correct algebraic steps. However, the equation was simplified as $34 = 8x - 3$ rather than $34 = 8x - 6$, resulting in an incorrect value of x. The student did not verify the result by substituting the calculated length and width into the perimeter formula and therefore failed to identify the inconsistency. This response indicates limited reflective thinking, particularly in the comparing and contemplating indicators: the student accepted the calculation without critical evaluation, did not compare the answer with the given perimeter, and did not reconsider whether the final result was reasonable.

In response to these difficulties, an instructional model is needed that actively engages students in discovering concepts and reflecting on their thinking. Guided discovery learning is appropriate because it emphasizes students' active construction of knowledge through guided exploration (Mabhoza and Olawale, 2024). This approach is consistent with the constructivist view that learners actively construct knowledge (General Teaching Council for England, 2006). In classroom practice, discovery learning is implemented through six stages: stimulation, problem identification, data collection, data processing, verification, and generalization (Agusriyalni et al., 2021).

Theoretically, guided discovery learning supports reflective thinking through several mechanisms. First, the stimulation and problem identification stages encourage students to activate prior knowledge and analyze problems critically. Second, the data collection and processing stages require students to explore different strategies and compare alternative solutions. Third, the verification stage trains students to evaluate the accuracy of their answers, while the generalization stage encourages them to draw conclusions and reflect on the concepts they have learned. Thus, the stages of guided discovery learning align closely with the reflective thinking indicators of reacting, comparing, and contemplating.

Previous research by Adelia (2019) and Safitri (2019) indicates that guided discovery learning can be more effective than conventional instruction in improving reflective thinking skills. However, these studies examined neither linear equations in one variable nor the context of SMP Negeri 2 Sumberejo, which has distinct learning conditions and student characteristics.

Therefore, the novelty of this study lies in:

1. Focusing on mathematical reflective thinking skills in the specific topic of linear equations in one variable.
2. Applying the guided discovery learning model in a real classroom context at SMP Negeri 2 Sumberejo.
3. Analyzing the effectiveness of this model using a quasi-experimental design.

Accordingly, this study is expected to provide empirical evidence regarding the effectiveness of guided discovery learning in improving students' mathematical reflective thinking skills and to offer practical guidance for teachers designing more meaningful and reflective mathematics instruction.

Based on the preceding discussion, this study aimed to analyze the effect of guided discovery learning on students' mathematical reflective thinking skills when learning linear equations in one variable.

RESEARCH METHOD

This quantitative study involved a population of 183 eighth-grade students at SMP Negeri 2 Sumberejo. Cluster random sampling was used because all eighth-grade classes were taught by the same teacher and demonstrated comparable mathematical ability based on their average final summative assessment scores. Through random selection, class VIII.2, consisting of 30 students, was selected as the experimental class and received guided discovery learning. Class VIII.3, consisting of 31 students, was selected as the control class and received conventional instruction. The study employed a pretest-posttest control group design, as presented in Table 1 (Sugiyono, 2022).

Table 1. Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_1	C	O_2

Description:

O_1: Pretest administered to the experimental and control classes.

O_2: Posttest administered to the experimental and control classes.

X: Guided discovery learning.

C: Conventional learning.

The research procedure consisted of three stages: preparation, implementation, and final analysis. During the preparation stage, preliminary observations and data collection were conducted to identify the school context, student characteristics, learning materials, and research sample. The research instruments were also developed and evaluated at this stage. During implementation, both classes completed a pretest before receiving their respective treatments. The experimental class then received mathematics instruction through guided discovery learning, while the control class received conventional instruction. After the treatment, both groups completed a posttest. In the final stage, the pretest, posttest, and N-Gain data from both classes were processed and analyzed.

Data were collected using a test of mathematical reflective thinking skills administered before and after the treatment. The instrument consisted of three essay questions on linear equations in one variable. The items were developed according to the mathematical reflective thinking indicators of reacting, comparing, and contemplating proposed by Kusuma et al. (2020).

The instrument's content validity was evaluated by a collaborating teacher using a checklist. The evaluation focused on whether the language was appropriate for the students' proficiency level and whether the content aligned with the test blueprint. The assessment indicated that the instrument met the required content validity criteria.

The instrument was considered suitable for use because it met the criteria for validity, reliability, differentiating power, and difficulty level. Table 2 summarizes the instrument analysis results.

Table 2. Summary of the Test Instrument Analysis

Item	Validity	Reliability	Differentiating Power	Difficulty Level
1	Valid	0.89 (Reliable)	0.48 (Good)	0.60 (Moderate)
2			0.52 (Good)	0.68 (Moderate)
3			0.41 (Good)	0.63 (Moderate)

Before hypothesis testing, the normality of the N-Gain scores was assessed using the Chi-square (χ^2) test at a significance level of $\alpha = 0.05$. The results are presented in Table 3.

Table 3. Results of the Normality Test of N-Gain Scores of Students' Mathematical Reflective Thinking Skills

Class	χ^2_{count}	χ^2_{critical}	Test Results
Experimental	5.555	7.815	H_0 not rejected
Control	0.884	7.815	H_0 not rejected

The normality test indicated that the N-Gain scores of both classes were normally distributed. An F-test was then conducted to determine whether the two samples had equal variances. The calculated F value was 1.250, whereas the critical F value was 2.083 at $\alpha = 0.05$. Because $F_{\text{count}} < F_{\text{critical}}$, the null hypothesis ($H_0$) was not rejected, indicating that the two groups had homogeneous variances.

Because the assumptions of normality and homogeneity were satisfied, an independent-samples t-test was used to compare the improvement in mathematical reflective thinking skills between the experimental and control classes.

RESULTS AND DISCUSSION

Both the experimental and control classes completed a pretest to establish their baseline mathematical reflective thinking skills. The results are presented in Table 4.

Table 4. Students' Pretest Scores for Mathematical Reflective Thinking Skills

Class	Number of Students	Average	Lowest Score	Highest Score	Standard Deviation
Experimental	30	5.37	2	10	1.81
Control	31	4.87	2	9	1.82

Maximum Possible Score = 27

Table 4 shows that the pretest scores of the experimental and control classes were relatively comparable. Although the experimental class had a slightly higher mean score (5.37) than the control class (4.87), the difference of 0.50 was small, suggesting that the two groups had similar baseline abilities before the treatment.

After the treatment, both classes completed a posttest to assess their mathematical reflective thinking skills. The results are summarized in Table 5.

Table 5. Students' Posttest Scores for Mathematical Reflective Thinking Skills

Class	Number of Students	Average	Lowest Score	Highest Score	Standard Deviation
Experimental	30	18.80	14	23	2.41
Control	31	16.87	12	23	2.83

Maximum Possible Score = 27

Table 5 shows that the experimental class achieved a higher mean posttest score (18.80) than the control class (16.87), a difference of 1.93 points. This result indicates that students who received guided discovery learning performed better in understanding problems, connecting mathematical concepts, and evaluating solutions. The higher minimum score in the experimental class also suggests that the model supported improvement among lower-achieving students as well as their higher-achieving peers.

N-Gain scores calculated from the pretest and posttest results were used to assess improvement in the mathematical reflective thinking skills of both classes. The descriptive statistics are presented in Table 6.

Table 6. N-Gain Scores for Students' Mathematical Reflective Thinking Skills

Class	Number of Students	Average	Lowest Score	Highest Score	Standard Deviation
Experimental	30	0.62	0.40	0.78	0.11
Control	31	0.54	0.32	0.78	0.12

As shown in Table 6, the experimental class achieved a higher mean N-Gain score (0.62) than the control class (0.54), although both scores were categorized as moderate. The higher mean score of the experimental class suggests that guided discovery learning produced greater improvement in mathematical reflective thinking skills. This difference was subsequently examined through an independent-samples t-test.

The Chi-square test yielded $\chi^2_{\text{count}} = 5.555 < \chi^2_{\text{critical}} = 7.815$ for the experimental class and $\chi^2_{\text{count}} = 0.884 < \chi^2_{\text{critical}} = 7.815$ for the control class, confirming that both datasets were normally distributed. The homogeneity test yielded $F_{\text{count}} = 1.250 <$

$F_{\text{critical}} = 2.083$, indicating equal variances. Because both assumptions were satisfied, an independent-samples t-test was conducted. The results are shown in Table 7.

Table 7. Independent-Samples t-Test Results for the Improvement in Students' Mathematical Reflective Thinking Skills

Learning Model	Number of Students	Mean	Variance	t_{count}	α	t_{critical}	Test Results
GDL	30	0.62	0.012	2.65	0.05	1.67	H_0 rejected
CL	31	0.54	0.015				

Table 7 shows that the calculated t-value (2.65) exceeded the critical t-value (1.67) at the 5% significance level. The null hypothesis was therefore rejected, indicating that the experimental class achieved a significantly greater improvement in mathematical reflective thinking skills than the control class.

To examine the pattern of improvement in greater detail, the achievement percentages for each mathematical reflective thinking indicator were calculated for both classes, as presented in Table 8.

Table 8. Achievement of Mathematical Reflective Thinking Indicators

No	Mathematical Reflective Thinking Indicator	Experimental		Control	
		Pretest	Posttest	Pretest	Posttest
1.	Reacting	52	89	50	85
2.	Comparing	6	69	4	61
3.	Contemplating	1	51	0	42

Maximum Possible Score = 27

Table 8 shows that all three mathematical reflective thinking indicators improved in both classes. For reacting, the experimental class increased by 37 percentage points, compared with 35 percentage points in the control class. For comparing, the experimental class increased by 63 percentage points, whereas the control class increased by 57 percentage points, a difference of 6 percentage points. For contemplating, the respective increases were 50 and 42 percentage points, a difference of 8 percentage points.

The effectiveness of guided discovery learning can be understood through its instructional stages, which align closely with reflective thinking processes. The stimulation and problem identification stages encourage students to understand and respond to problems (reacting). The data collection and processing stages require them to connect concepts and explore alternative solutions (comparing). Finally, the verification and generalization stages support evaluation, justification, and conclusion drawing (contemplating) (Hidayanto, 2024). This structured process enables students to construct knowledge while reflecting on their reasoning.

These findings are consistent with those of Adelia (2019) and Safitri (2019), who reported that guided discovery learning enhanced students' mathematical reflective thinking skills. The present study extends this evidence to the specific context of linear equations in one variable at the junior high school level.

During guided discovery learning, students actively participated in each instructional stage: stimulation, problem identification, data collection, data processing, verification, and generalization. These stages were incorporated into activities presented in student worksheets. According to Hamidah (2022), worksheets provide learning material and support students' understanding during instruction.

The first stage, stimulation, presented students with questions and problems in the worksheet to initiate the problem-solving process. Each student received a worksheet to support the active participation of all group members. At this stage, students independently observed, interpreted, and responded to the problems. These activities were intended to develop their understanding and encourage them to identify possible solutions.

The second stage, problem identification, involved group discussions in which students identified and formulated the problem by restating important information in their own words and mathematical symbols. They also proposed tentative answers to the worksheet problems. This process helped students connect the problem with their prior experiences and reflect on the information provided.

During the third stage, data collection, students gathered relevant information to test their initial hypotheses. They connected the available information with previously learned concepts and formulas, while the teacher guided them in identifying information relevant to the problem.

In the fourth stage, data processing, students organized and analyzed the collected information to evaluate their hypotheses. The teacher provided guidance to help them use the information to derive a solution. Fitrah et al. (2015) similarly explain that teachers should guide students in organizing information carefully to evaluate a formulated hypothesis.

In the fifth stage, verification, students rechecked the accuracy of their solutions, analyzed their answers, and justified their reasoning in their own words. Groups were then selected randomly to present their findings. According to Agusriyalni et al. (2021), verification involves carefully examining hypotheses to determine their accuracy.

In the sixth stage, generalization, students formulated conclusions based on their group discussions, communicated their ideas and solutions, and completed practice exercises to demonstrate their understanding. This stage enabled them to derive general conclusions from the problems they had solved. Isnawati et al. (2023) emphasize that problem-solving activities play an important role in developing critical, creative, reflective, and analytical thinking skills.

Several challenges arose during implementation, including classroom disruption during group formation, difficulty understanding the worksheets, and limited student confidence during presentations. The teacher addressed these challenges through clearer classroom coordination, additional initial guidance, and encouragement. These adjustments created a more supportive learning environment and increased student participation.

Despite these positive findings, the study has several limitations. First, it was conducted in a single school, which may limit the generalizability of the results. Second, it focused on only one mathematical topic. Third, the relatively short intervention may not fully reflect the long-term effects of guided discovery learning on reflective thinking skills.

Overall, the findings indicate that guided discovery learning provided a more effective environment for developing mathematical reflective thinking skills than conventional instruction. The model improved students' learning outcomes while strengthening their ability to analyze, evaluate, and reflect on their problem-solving processes.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that guided discovery learning produced a significantly greater improvement in students' mathematical reflective thinking skills than conventional instruction at SMP Negeri 2 Sumberejo, as indicated by the N-Gain scores and hypothesis test. The improvement was particularly evident in students' ability to connect concepts (comparing) and evaluate solutions (contemplating), suggesting that guided discovery learning promoted deeper cognitive engagement rather than solely procedural understanding.

Theoretically, the findings support the view that reflective thinking develops through active knowledge construction facilitated by structured stages such as problem identification, data processing, verification, and generalization. From a practical perspective, effective implementation requires clear initial instructions, well-organized group work, and continuous teacher guidance. Positive feedback is also important for strengthening students' motivation, confidence, and active participation.

Given that the study was limited to one school and one mathematical topic, future research should examine guided discovery learning across different educational settings, mathematical topics, and intervention periods. Further studies could also investigate its integration with other instructional approaches and its effects on a broader range of higher-order thinking skills.

Overall, guided discovery learning offers an effective and meaningful approach to fostering mathematical reflective thinking by actively engaging students in analyzing, evaluating, and reflecting on problem-solving processes.

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