The Effect of Integrating Self-Assessment into the Discovery Learning Model on Students' Critical Thinking Skills in Linear Motion

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Abstract *- This study aimed to examine the effect of integrating self-assessment into the Discovery Learning (DL) model on students' critical thinking skills in linear motion at a public senior high school in Malang Regency. This study employed a quantitative approach with a quasi-experimental design involving 68 students. The research instrument was a critical thinking skills test that had been subjected to validity and reliability testing. The collected data were analyzed using normality and homogeneity tests, an independent-samples t-test, and normalized gain (N-gain) analysis. The results showed that the mean posttest score of the experimental class (Class X-6) was 11.00, while that of the control class (Class X-8) was 8.41. The independent-samples t-test yielded a significance value of 0.00 ($p < 0.05$), indicating a statistically significant difference between the two classes. Furthermore, the experimental class achieved an average N-gain score of 0.58, which was categorized as moderate, whereas the control class obtained an average N-gain score of 0.27, which was categorized as low. These findings indicate that integrating self-assessment into the Discovery Learning model has a positive effect on students' critical thinking skills in linear motion.*

Keywords: *Critical Thinking Skills; Discovery Learning; Linear Motion; Self-Assessment*

INTRODUCTION

Critical thinking skills are among the essential twenty-first-century competencies that should be fostered in physics learning. These skills enable students to analyze information, evaluate arguments, and solve problems logically based on scientific evidence (Alruwaili, 2024). However, numerous studies have reported that Indonesian students' critical thinking skills remain relatively low, particularly in physics learning, which requires high levels of analytical reasoning and problem-solving abilities (Anggraeni & Rohmi, 2024). Consequently, students tend to memorize formulas without developing a comprehensive understanding of the underlying physical concepts (Khoiriyyah et al., 2022).

One of the physics topics that requires strong critical thinking skills is linear motion. This topic represents a fundamental concept in kinematics that examines the relationships among position, displacement, velocity, acceleration, and time (Roihannah, 2025). Nevertheless, previous studies have indicated that students continue to experience difficulties in understanding the concepts of linear motion, particularly in distinguishing distance from displacement, speed from velocity, and interpreting motion graphs (Handayani et al., 2022). Therefore, an instructional approach that facilitates students' critical thinking in understanding concepts and solving physics problems is required.

One strategy that can be employed to improve students' critical thinking skills is the implementation of self-assessment. Self-assessment is a process that enables students to evaluate their own understanding, abilities, and learning processes (Adawiyah, 2024). Through self-assessment, students are able to identify their strengths and

weaknesses, reflect on their thinking processes, and independently improve their learning strategies (Panadero et al., 2016). Furthermore, self-assessment promotes students' metacognitive awareness and encourages greater responsibility for their own learning (Lesmana & Rokhyati, 2020). Previous studies have demonstrated that self-assessment supports the development of critical thinking skills by engaging students in reflection, evaluation, and assessment of both their answers and their reasoning processes (Sarya et al., 2024).

To optimize the implementation of self-assessment, an instructional model that actively engages students throughout the learning process is required. One such model is Discovery Learning (DL). This model encourages students to construct concepts independently through activities involving observation, information gathering, data processing, and conclusion drawing (Yuliati & Susianna, 2022). Students' active engagement in learning through the Discovery Learning model has been shown to support the development of critical thinking skills (Susanti et al., 2025). Therefore, integrating self-assessment into Discovery Learning has the potential to help students reflect more effectively on both their conceptual understanding and thinking processes.

Although numerous studies have investigated either self-assessment or Discovery Learning independently, research integrating self-assessment into Discovery Learning instruction for the topic of linear motion remains limited. Most previous studies have primarily focused on the effects of Discovery Learning on students' critical thinking skills or learning outcomes without incorporating reflective strategies such as self-assessment (Astutik & Mahardika, 2020). In fact, integrating self-assessment into Discovery Learning has the potential to enhance students' engagement throughout the learning process while simultaneously promoting the development of critical thinking skills more effectively (Purmanah et al., 2017). Therefore, this study was conducted to examine the effect of implementing self-assessment through the Discovery Learning model on students' critical thinking skills in the topic of linear motion.

RESEARCH METHODS

This study employed a quantitative approach using a quasi-experimental method with a nonequivalent control group design. The research was conducted during the first semester of the 2025/2026 academic year at a public senior high school in Malang Regency, Indonesia. The study involved two groups: an experimental group that received instruction using the Discovery Learning (DL) model integrated with self-assessment and a control group that received instruction using the Discovery Learning model without self-assessment.

Table 1. *Non-Equivalent Control Group Design*

Group	Pre-test	Treatment	Post-test
Experimental	Yes	DL + *Self Assessment*	Yes
Control	Yes	DL	Yes

Source: (Sugiyono, 2023)

The population consisted of all tenth-grade students at the selected school. The research sample was selected using purposive sampling, considering the academic abilities and characteristics of the classes. Two classes were selected, each consisting of 34 students. Class X-6 served as the experimental group, while Class X-8 served as the control group.

The instructional intervention was conducted over nine learning sessions, with

each session lasting 45 minutes, over an approximately three-week period. The instruction covered Uniform Linear Motion and Uniformly Accelerated Linear Motion. The learning activities followed the six stages of the Discovery Learning model: stimulation, problem identification, data collection, data processing, verification, and conclusion drawing. During these stages, students engaged in learning activities involving individual and group worksheets (LKPD) and group investigations using PhET simulations.

In the experimental group, self-assessment was integrated into the worksheet-based learning activities as a structured reflection component. Students completed individual worksheets and group worksheets related to Uniform Linear Motion and Uniformly Accelerated Linear Motion. After completing the relevant worksheets, students filled out the corresponding self-assessment sheets to evaluate their answers, reasoning processes, and understanding of the physics concepts addressed in the activities. The self-assessment sheets were completed individually or in groups, depending on the type of worksheet and learning activity. Students then discussed their self-assessment results with their group members or the teacher. These discussions provided opportunities for students to explain their evaluations, compare their reasoning, clarify their responses, and reflect on aspects of their work that might require further attention. Thus, self-assessment functioned as a reflective follow-up to the worksheet activities within the Discovery Learning sequence. The control group followed the same Discovery Learning model and completed comparable learning activities without the additional self-assessment sheets.

In addition to the critical thinking test, four self-assessment forms were used: individual and group forms for Uniform Linear Motion and individual and group forms for Uniformly Accelerated Linear Motion. Each form consisted of ten statements with dichotomous response options (“Yes” and “No”), which students selected based on their own evaluation after completing the relevant worksheet. The statements addressed aspects of critical thinking based on Ennis’s (1996) framework: elementary clarification, basic support, inference, advanced clarification, and strategies and tactics. The items covered problem identification and reasoning, evaluation of information and experimental data, evidence-based conclusions, understanding of physics concepts and assumptions, problem-solving strategies, and collaboration during group activities.

After completing the self-assessment sheets, students discussed their evaluations with their group members or the teacher. These discussions allowed students to explain their self-assessment responses, compare their reasoning with others, and clarify their understanding of linear motion in relation to the work completed on the worksheets. Through this discussion process, students had opportunities to reflect on their learning and recognize aspects of their answers, reasoning, or conceptual understanding that might require further attention. The self-assessment discussions were intended to support students’ awareness of their own learning processes; they were not treated as a separate measure of critical thinking performance.

The research data were obtained from pretest and posttest scores and the self-assessment sheets completed by students in the experimental group. Data analysis began with the Shapiro–Wilk normality test and Levene's homogeneity test to examine the

statistical assumptions. The Independent Samples t-test was then used to determine whether a statistically significant difference existed between the posttest scores of the experimental and control groups. Furthermore, the improvement in critical thinking skills was analyzed using the normalized gain (N-Gain) score, categorized as low ($g \leq 0.30$), moderate ($0.30 < g \leq 0.70$), or high ($g > 0.70$).

RESULTS AND DISCUSSION

Results

Descriptive Statistics of the Pretest and Posttest

The pretest data were used to determine students' initial competencies before the instructional treatment, whereas the posttest data were used to evaluate students' critical thinking skills after the learning process. Class X-6 served as the experimental group, which received instruction integrating self-assessment into the Discovery Learning model. Meanwhile, Class X-8 served as the control group and received instruction using the Discovery Learning model only.

Table 2. Descriptive Statistics

Data	Class	N	Mean	SD
Pretest	X-6	34	6,06	1,96
	X-8	34	6,12	1,85
Posttest	X-6	34	11,00	2,33
	X-8	34	8,41	2,59

As presented in Table 2, the experimental class obtained a mean pretest score of 6.06, whereas the control class achieved a mean score of 6.12. The difference between the two classes was only 0.06 points, indicating that both groups possessed relatively comparable initial critical thinking skills before the instructional treatment. This condition is important because it demonstrates that the two classes had similar baseline critical thinking abilities. Therefore, any differences observed at the end of the study are more likely attributable to the instructional treatment rather than to differences in students' initial abilities.

The posttest results indicated that the mean score of the experimental class increased to 11.00, whereas the control class achieved a mean score of 8.41. These findings suggest that students' critical thinking skills improved after the learning process in both groups. However, the improvement observed in the experimental class was substantially greater than that of the control class. Compared with the pretest scores, the experimental class improved by 4.94 points, increasing from 6.06 to 11.00. In contrast, the control class improved by only 2.29 points, increasing from 6.12 to 8.41.

Normality Test

The distribution of the pretest and posttest data for both the experimental and control groups was examined using the normality test. The Shapiro–Wilk test was employed because the sample size in each class was fewer than 50 students. A significance value greater than 0.05 indicates that the data are normally distributed.

Table 3. Normality Test

Data	Class	Shapiro-Wilk Sig.	Criterion	Interpretation
Pretest	X-6	0,612	> 0,05	Normal
	X-8	0,099	> 0,05	Normal
Posttest	X-6	0,146	> 0,05	Normal
	X-8	0,308	> 0,05	Normal

As shown in Table 3, all pretest and posttest data produced Shapiro–Wilk significance values greater than 0.05. These findings indicate that the data from both the experimental and control groups were normally distributed. Therefore, the data satisfied the assumption of normality and were appropriate for subsequent parametric statistical analyses.

Homogeneity Test dan Independent Sample t-Test

Before conducting the hypothesis test, the equality of variances between the experimental and control groups was examined using Levene's test. A significance value greater than 0.05 indicates that the data are homogeneous.

Table 4. Homogeneity Test

Data	Class	Mean	Levene Statistic	Sig.	t hitung	Sig. (2-tailed)
Pretest	X-6	6,06	0,04	0,84	-0,12	0,89
	X-8	6,12				
Posttest	X-6	11,00	0,65	0,42	4,32	0,00
	X-8	8,41				

As presented in Table 4, the significance values obtained from Levene's test were 0.84 for the pretest data and 0.42 for the posttest data. Since both values exceeded 0.05, the variances of the experimental and control groups were considered homogeneous. Consequently, the assumption of homogeneity was satisfied, allowing the analysis to proceed using the Independent Samples t-test.

The Independent Samples t-test was conducted to determine whether significant differences existed in students' initial and final critical thinking skills between the experimental and control groups. Students' initial abilities were examined using the pretest scores, whereas their final abilities were evaluated using the posttest scores.

Based on Table 4, the pretest analysis produced a significance value of 0.89, which was greater than 0.05. This result indicates that there was no statistically significant difference in students' initial critical thinking skills between the experimental and control groups. Therefore, both groups possessed comparable baseline abilities before the instructional treatment.

In contrast, the posttest analysis yielded a significance value of 0.00, which was lower than 0.05. This finding indicates a statistically significant difference in students' critical thinking skills between the experimental and control groups after the instructional treatment. Furthermore, the experimental group achieved a higher mean posttest score (11.00) than the control group (8.41). These findings suggest that integrating self-assessment into the Discovery Learning model was more effective in improving students' critical thinking skills than implementing the Discovery Learning model alone.

Self-Assessment Result

Self-assessment was employed to examine the extent to which students were able to evaluate their learning processes, conceptual understanding, conclusion-making abilities, and problem-solving strategies throughout the learning activities. The self-assessment data were analyzed descriptively based on the frequency and percentage of "Yes" and "No" responses obtained from both individual and group activities in the topics of Uniform Linear

Motion and Uniformly Accelerated Linear Motion.

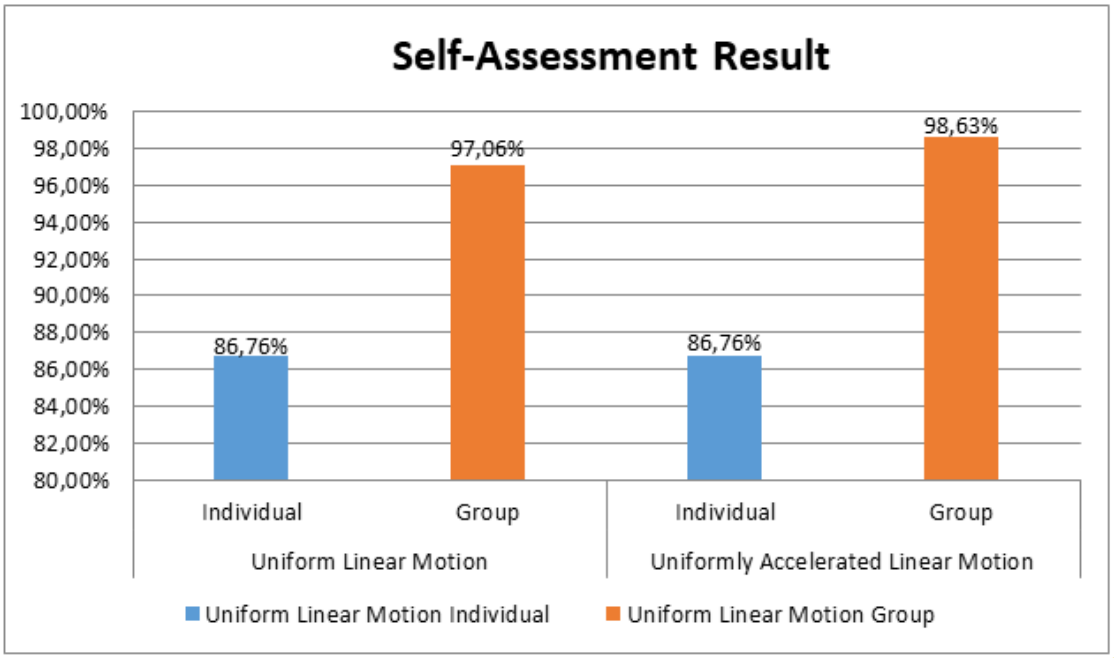


Figure 1. Self-Assessment Result Chart

Based on Figure 1, all self-assessment activities obtained more than 85% "Yes" responses, indicating a very positive category. For the Uniform Linear Motion topic, individual self-assessment achieved a percentage of 86.76%, whereas group self-assessment reached 97.06%. Similarly, for the Uniformly Accelerated Linear Motion topic, individual self-assessment also obtained 86.76%, while group self-assessment achieved 98.53%. These findings indicate that students demonstrated highly positive responses toward the self-assessment process in both individual and collaborative learning activities.

The percentage obtained from group self-assessment was consistently higher than that of individual self-assessment. This finding suggests that students tended to be more active and confident when reflecting on their understanding and solving problems collaboratively. Through group discussions, students were able to compare ideas, re-evaluate their answers, and formulate conclusions based on observations and calculations. Nevertheless, the high percentage of positive responses in the individual self-assessment also indicates that most students were capable of evaluating their own understanding of both the Uniform Linear Motion and Uniformly Accelerated Linear Motion concepts.

N-Gain Analysis

The N-gain analysis was conducted to determine the improvement in students' critical thinking skills following the learning process. The calculation compares the difference between pretest and posttest scores while considering the maximum score that could be achieved by students. In this study, the maximum score was 15, corresponding to the total number of test items. The N-gain values were categorized into three levels: high ($g > 0.70$), moderate ($0.30 < g \leq 0.70$), and low ($g \leq 0.30$).

Based on the N-gain calculation, the experimental class (X-6) achieved an average N-gain score of 0.58, which falls within the moderate category. In contrast,

the control class (X-8) obtained an average N-gain score of 0.27, which is classified as low. These findings indicate that the improvement in students' critical thinking skills was greater in the experimental class than in the control class.

Regarding the distribution of N-gain categories, the experimental class consisted of 9 students in the high category, 24 students in the moderate category, and 1 student in the low category. Meanwhile, the control class included 2 students in the high category, 11 students in the moderate category, and 21 students in the low category. This distribution demonstrates that the majority of students in the experimental class experienced moderate to high improvements in critical thinking skills, whereas most students in the control class remained within the low improvement category.

Discussion

The findings of this study confirm the hypothesis that the implementation of self-assessment through the Discovery Learning model has a significant effect on students' critical thinking skills in the topic of linear motion. This is evidenced by the comparable pretest mean scores obtained by the experimental class (6.06) and the control class (6.12), indicating that both groups had relatively equivalent initial critical thinking abilities before the instructional treatment. Following the intervention, the mean posttest score of the experimental class increased to 11.00, whereas the control class achieved a mean score of 8.41. Furthermore, the Independent Samples t-test produced a significance value of 0.00 (< 0.05), indicating a statistically significant difference in critical thinking skills between the two groups. In addition, the experimental class achieved an average N-gain score of 0.58, which falls within the moderate category, whereas the control class obtained an average N-gain score of 0.27, categorized as low. These findings indicate that the implementation of self-assessment made a positive contribution to improving students' critical thinking skills.

The improvement in students' critical thinking skills can be attributed to the opportunities provided by self-assessment for students to evaluate their own learning processes and conceptual understanding. In learning the topic of linear motion, students are required not only to obtain correct answers but also to understand the underlying reasoning, problem-solving procedures, and physics concepts that support those answers. Through self-assessment, students are able to identify concepts they have mastered as well as concepts that remain misunderstood. This process of self-evaluation encourages students to reflect more actively on their own thinking processes, thereby promoting deeper conceptual understanding. These findings are consistent with those reported by Gayatri et al. (2024), who stated that assessment is a systematic process used to determine students' learning achievement in the domains of knowledge, attitudes, and skills.

The implementation of self-assessment also facilitated the development of students' reflective abilities, which play an essential role in critical thinking. In the topic of linear motion, students encountered various forms of conceptual representation, including word problems, tables, graphs, and mathematical equations that require analytical reasoning. Through self-assessment, students were encouraged to review their responses, evaluate the validity of their reasoning, and identify errors in their problem-solving processes. These activities helped students develop more systematic and critical thinking habits before drawing conclusions. This finding is supported by Adawiyah and Haolani (2021), who

explained that self-assessment actively engages students in evaluating both the learning process and learning outcomes, thereby improving instructional quality and students' self-reflective abilities.

In addition to enhancing reflective skills, self-assessment also strengthened students' responsibility for their own learning. Throughout the instructional process, students did not rely solely on feedback provided by the teacher but instead actively evaluated their own level of understanding. Consequently, students became more aware of their learning strengths and weaknesses and were encouraged to improve the deficiencies they identified. This was reflected in students' efforts to re-examine their problem-solving procedures, evaluate the appropriateness of their reasoning, and verify the accuracy of the conclusions they reached. These findings are consistent with those reported by Sarya et al. (2024), who found that self-assessment enhances students' engagement in the learning process while simultaneously promoting greater learning responsibility. Likewise, Lesmana and Rokhyati (2020) argued that self-assessment enables students to recognize their current level of competence and determine more effective learning strategies.

The high self-assessment scores obtained throughout the learning activities indicate that most students were capable of evaluating their own learning processes effectively. This ability to conduct self-evaluation contributed to the improvement of critical thinking skills because students consciously reviewed their understanding before drawing conclusions. Therefore, self-assessment functions not only as an assessment strategy but also as a reflective learning tool that assists students in continuously improving both their thinking processes and conceptual understanding.

In this study, the Discovery Learning model served as a learning environment that supported the implementation of self-assessment. Learning activities involving observation, information gathering, data analysis, and conclusion drawing provided students with opportunities to evaluate their own thinking processes. Nevertheless, the primary finding of this study indicates that the improvement in students' critical thinking skills was mainly influenced by their active engagement in self-assessment. Therefore, the implementation of self-assessment can be considered an effective strategy for enhancing students' critical thinking skills in the topic of linear motion.

The findings of this study are supported by previous research demonstrating that self-assessment contributes positively to the development of students' critical thinking skills and learning awareness. The present findings further strengthen the evidence that integrating self-assessment into physics instruction enables students to reflect on their conceptual understanding, evaluate their mistakes, and develop the analytical reasoning required to solve physics problems. Therefore, the implementation of self-assessment through the Discovery Learning model has been demonstrated to exert a positive and significant effect on students' critical thinking skills in the topic of linear motion.

CONCLUSION

Based on the findings of this study, the implementation of self-assessment through the Discovery Learning (DL) model had a positive effect on students' critical thinking skills in the topic of linear motion. This finding was supported by the results of the Independent Samples t-test, which yielded a significance value of 0.00 (< 0.05), indicating a statistically significant difference in critical thinking skills between the experimental and control groups after the

instructional treatment. The experimental group achieved a higher mean posttest score (11.00) than the control group (8.41). Furthermore, the N-gain analysis revealed that the experimental group obtained an average score of 0.58, which was categorized as moderate, whereas the control group obtained an average score of 0.27, which was categorized as low. These findings indicate that the implementation of self-assessment enabled students to evaluate their conceptual understanding, identify learning deficiencies, and improve their critical thinking skills in understanding the concepts of linear motion.

Based on these findings, future studies are recommended to investigate the implementation of self-assessment in other physics topics and across different educational levels to obtain a broader understanding of its effectiveness in improving students' critical thinking skills. In addition, future research may incorporate other variables, such as metacognitive ability, learning motivation, or self-regulated learning, to provide a more comprehensive understanding of the effects of self-assessment.

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