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The Influence of Self-Assessment on Cognitive Learning Outcomes of High School Students in the Topic of Linear Motion Kinematics

Khusaini*, Hilma Azza Sania[2], Nuril Munfaridah[3]
Department of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Indonesia
* *e-mail: khusaini.fmipa@um.ac.id*

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Abstract: Linear motion kinematics is one of the fundamental prerequisites for further knowledge acquisition, but students often face difficulties in comprehending this topic, which consequently impacts their cognitive learning outcomes. This research aims to investigate the influence of self-assessment on the cognitive learning outcomes of high school students in the subject of linear motion kinematics. This study used a quantitative approach with a group post-test design. Sampling was conducted through random sampling, with 33 students from Class X IPA A assigned as the experimental group and 32 students from Class X IPA B as the control group. The research instruments include a multiple-choice test sheet consisting of 12 questions and a self-assessment sheet. Data analysis commenced with prerequisite testing, revealing non-normally distributed data, thus necessitating the application of the Mann-Whitney test for analysis. The research findings revealed a significant difference between the experimental and control groups regarding cognitive learning outcomes. The self-assessment conducted by some students is not entirely in line with their cognitive learning outcomes, as evidenced when students respond as very understanding in self-assessment but then, when working on confirmation questions with the same indicators, they provide less accurate answers. Therefore, it is important to enhance the implementation of self-assessment in schools. Furthermore, future researchers should consider developing self-assessment tools for other different physics topics.

Keywords: Self-Assessment, Cognitive Learning Outcomes, Linear Motion Kinematics

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INTRODUCTION

Linear motion is one of the subtopics of motion in kinematics. Linear motion is an essential topic taught in the first year of high school physics education and serves as a fundamental prerequisite for subsequent topics (Yusro & Sasono, 2016; Yusuf et al., 2017). In addition, the kinematic phenomenon of straight movement is often found in daily activity (Sukadi & Angraeni, 2019). Some examples of the application of linear motion in everyday life include car braking events, increasing speed in cars, and the deceleration process when a car comes to a stop (Hermawan, 2018).

Students often experience difficulties when studying linear motion. This assertion in line with Nasir (2020) stated that 36.6% of students showed difficulty in understanding kinematical matter in linear motion. Furthermore, Adhitama (2018) also explained that 21.03% of 10th-grade students have a low level of comprehension regarding the topic of linear motion. These studies suggested that students struggle with comprehending linear motion material.

One of the reasons for students' low comprehension is their difficulty in understanding the kinematic quantities associated with linear motion. Magfira (2021) explained that students had difficulty in distinguishing between the magnitude of movement and distance, as well as the magnitude of speed and velocity. The next reason is that students do not understand the graphical analysis of the kinematical matter of linear motion (Aminah & Haryoto, 2018). The findings are also supported by Parmalo et al. (2016) who stated that students had a relatively low ability in interpreting graphs. The use of graphics in the concepts of physics can help to obtain a lot of information as well as physical concepts more easily understood (Andriyani et al., 2019).

The student's difficulty in understanding kinematic material influences his cognitive learning outcomes in the kinematical matter of linear motion. This statement is supported by Asriyanti and Purwati (2020), which revealed that students' learning difficulties affected their cognitive learning outcomes. The learning outcomes achieved by the students vary according to their learning styles and individual capabilities (Azrai et al., 2017). There are cognitive learning outcomes that can be used to see the student's level of achievement in understanding the material (Harefa, 2020). Cognitive learning outcomes can be enhanced by using one type of assessment, self-assessment because assessment is one of the important elements in learning that has the purpose of seeing, evaluating, and concluding the level of competence of students during the learning process (Halimah & Adiyono, 2022). Furthermore, it is explained that assessment is designed to track and detect students' mistakes and weaknesses during learning activities, making it a target for improvement to enhance students' cognitive learning outcomes.

Self-assessment is an activity in which students assess themselves. Self-assessment provides students with an opportunity to evaluate their level of competence, thereby enabling them to identify areas for improvement based on the gaps between their current understanding and the expected understanding to enhance cognitive learning outcomes (Hairida, 2018; Lisnawati & Siregar, 2018; Nadzra et al., 2018). Self-assessment helps students to actively participate and cultivate their self-confidence (Adachi et al., 2018; Hignasari & Supriadi, 2020; Lanthony et al., 2018). Self-assessment also aids in identifying one's strengths and weaknesses (Lisnawati & Siregar, 2018; Sukarni, 2022). Thus, the presence of self-assessment encourages students to enhance their learning motivation (Rahardjo, 2019).

Self-assessment is a way to gauge students' self-abilities. Tamaela's study (2022) explains that there is an improvement in high-order thinking skills in the lower category after students are provided with self-assessment. This research indicates that self-assessment can enhance the process but needs to be supported by appropriate teaching strategies. Lisnawati & Siregar's research (2018) states that self-assessment can enhance learning outcomes through thorough planning, starting from the planning phase to the actual assessment. However, the self-assessment conducted does not yet have reinforcement related to the honesty of students in completing it. Research by Shofiyah (2013) demonstrates that students' learning outcomes are better when self-assessment is implemented compared to when it is not. The assessments made by students reveal that they do not yet know their strengths and weaknesses, leading to their lack of confidence in self-assessment. This is because self-assessment is a novel concept, and students are not accustomed to evaluating themselves. Based on the analysis of previous research, self-assessment needs to be implemented to improve learning outcomes. Therefore, this research provides self-assessment to examine its impact on students' cognitive learning outcomes in the topic of linear motion kinematics. Additionally, to assess the alignment between the self-assessment conducted and students' abilities, students are also given confirmation questions with the same indicators as those in the self-assessment. Subsequently, students are provided with feedback on topics they have not understood to encourage improvement. Consequently, this research aims to determine the influence of self-assessment on students' cognitive learning outcomes in the topic of linear motion kinematics.

METHOD

This research employed a quantitative research method. Quantitative research is used to research certain populations or samples, sampling techniques are generally carried out randomly, data collection using research instruments, and data analysis are quantitative/statistical with the aim of testing predetermined hypotheses (Sugiyono, 2015). The researcher chose this method to investigate the influence of self-assessment on students' cognitive learning outcomes.

Research Design & Procedures

This study utilized a Two Group Posttest Only Design, where two classes were subjected to posttests. Before the posttest, the experimental class received treatment in the form of self-assessment during the learning activities, while the control class underwent the same learning activities without the self-assessment treatment. The use of this design aligns with the research objective, which is to determine the impact of self-assessment on the cognitive learning outcomes of 10th-grade students in the topic of linear motion kinematics. The research design pattern in this study is illustrated in Table 1.

Table 1. Research Design

Class	**Treament (X)**	***Posttest***
Control		O_1
Experiment	X	O_2

(Sugiyono, 2013)

Note:
O_1 : Posttest Scores (no treatment provided)
O_2 : Posttest Scores (after treatment)
X : Self-assessment Treatment

Population and Sample

This research was conducted at SMA Negeri 1 Singosari. The research sample was selected using a random sampling method, indicating specific criteria in the sample selection process. The criteria of the sampling students are the students learned the linear motion kinematics material before. The sample for this research consisted of 33 students from class X IPA A as the experimental group and 32 students from class X IPA B as the control group. The experimental group received a posttest after the treatment, while the control group did the posttest without the treatment. The treatment provided consists of self-assessment and confirmation questions with the same indicators, followed by feedback based on the self-assessment results to assess the achievement of students' cognitive learning outcomes.

Data Collection and Instrument

The instruments used in this study include a test sheet and a self-assessment sheet. The test instrument consists of 12 post-test questions that are aligned with the learning objectives in the cognitive domain (Bloom, 2019). The self-assessment instrument contains a set of questions designed to assess students' understanding of linear motion kinematics, as demonstrated by their performance on confirmation questions with the same indicators as the questions provided. This serves as evidence to determine the alignment or misalignment of students' self-assessments with their actual abilities. Self-assessment is conducted after the instruction to assess the extent of students' understanding of linear motion kinematics. The cognitive indicators in the test instrument are presented in Table 2.

Table 2. Cognitive Indicators in the Test Instrument

No	Cognitive Level	Question Indicators
1	C3	Calculate the distance travelled with known constant velocity.
2	C4	Analyze the velocities of two objects moving in the same direction along a straight path.
3	C4	Analyze consecutive average velocity and consecutive average speed.
4	C4	Analyze the acceleration of two objects with different velocities and times.
5	C2	Explain the conditions for uniform linear motion.
6	C5	Evaluate the graph depicting the relationship between velocity and time indicating uniform linear motion.
7	C1	Identify examples of accelerated motion with a constant force.
8	C4	Analyze the motion of objects based on the tick marks of a ticker timer, exhibiting uniformly changing linear motion.
9	C6	Plot a graph of velocity (v) versus time (t) for uniformly decelerated motion.
10	C3	Calculate the velocity of an object experiencing free fall.
11	C2	Explain the acceleration and velocity of an object when moving vertically upward and then returning to its initial position.
12	C3	Calculate the maximum height reached by an object in vertical upward motion.

Each item in the test underwent validity and reliability testing again to determine the accuracy of an instrument to be used in the research. Validity testing was conducted in two ways: expert validity by faculty members in the Department of Physics at the State University of Malang and empirical validity by students through instrument trials in classes other than the research subjects. Out of the 12 items tested for expert content validation, a result of 94% was obtained, indicating validity. Meanwhile, the validity test using IBM SPSS Statistic 26.0 yielded validity results ranging from 0.000 to 0.050, indicating validity. Following the validity testing, the item reliability test was conducted, also calculated using IBM SPSS Statistic 26.0 with the Cronbach Alpha formula, resulting in a value of 0.764. Thus, the instrument can be considered reliable with a high level of reliability. After conducting the validity and reliability tests, items that meet the validity criteria and have high-reliability coefficients can be used in measuring cognitive learning outcomes.

Data Analysis

The data analysis process of the research began with preliminary tests to determine whether parametric or non-parametric tests should be employed. These preliminary tests include tests for normality and homogeneity. The normality test is used to assess the distribution of data within a variable using the one-sample Kolmogorov-Smirnov test in IBM SPSS Statistic 26.0, with a significance level of 5%. The results indicate that the post-test data for both the control class (p-value < 0.050) and the experimental class (p-value < 0.050) do not follow a normal distribution. Subsequently, the homogeneity test is used to investigate whether the data originate from sources with similar characteristics, employing the Levene test in IBM SPSS Statistic 26.0. The homogeneity test results for the post-test data from both classes show that the p-value is ≥ 0.050. Consequently, it can be concluded that the posttest data in both classes are homogeneous. Since the data is found not to be normally distributed, non-parametric testing is employed, specifically the Mann-Whitney U test, with the assistance of IBM SPSS Statistic 26.0.

RESULT AND DISCUSSION

The results of this research were obtained from the analysis of several data sets to assess students' cognitive learning outcomes. The analysis of cognitive learning outcomes was derived from the posttest and self-assessment sheets that were aligned with the cognitive learning outcome indicators.

Results

The Influence of Self-Assessment on Cognitive Learning Outcomes

Based on the data processing results, a descriptive statistical overview was obtained as shown in Table 3.

Table 3. Descriptive Analysis

Statistic	Control Class	Experiment Class
N	32	33
Mean	64,6	83,6
Median	66,6	83
Mode	75	83
Std. Deviation	14,2	10,3
Minimum	25	67
Maximum	83	100

The cognitive learning outcomes of students between the control and experimental groups at each cognitive level are presented in Table 4.

Table 4. Cognitive Learning Outcomes of Control and Experiment Classes

Class	Cognitive Level					
	C1	C2	C3	C4	C5	C6
Control	88	45	57	75	84	41
Experiment	91	64	90	80	100	94

After conducting the prerequisite test, it was found that the data did not follow a normal distribution. Therefore, the post-test data for both the control and experimental groups did not meet the prerequisites for parametric t-test analysis. Consequently, the research data was analyzed using non-parametric analysis, specifically the Mann-Whitney U test. The results showed that the Mean Rank, or the average ranking for each group in the experimental class, was 44.64 which was higher than the mean ranking for the control class, which was 21.00. Furthermore, the Mann-Whitney U test results indicated that the value of U was 144, and the value of W was 672. When converted to a Z-score, it amounted to -5.133, resulting in a p-value of < 0.050. It can be concluded that there is a significant difference in cognitive learning outcomes between the experimental and control classes.

The influence of self-assessment in learning can be determined from the post-test scores in the experimental and control classes. The post-test results between the two classes on the topic of Linear Motion indicate a difference in cognitive learning outcomes. The experimental class received treatment in the form of self-assessment, while the control class did not receive this treatment. The following is a bar chart comparing cognitive learning outcomes for each question indicator:

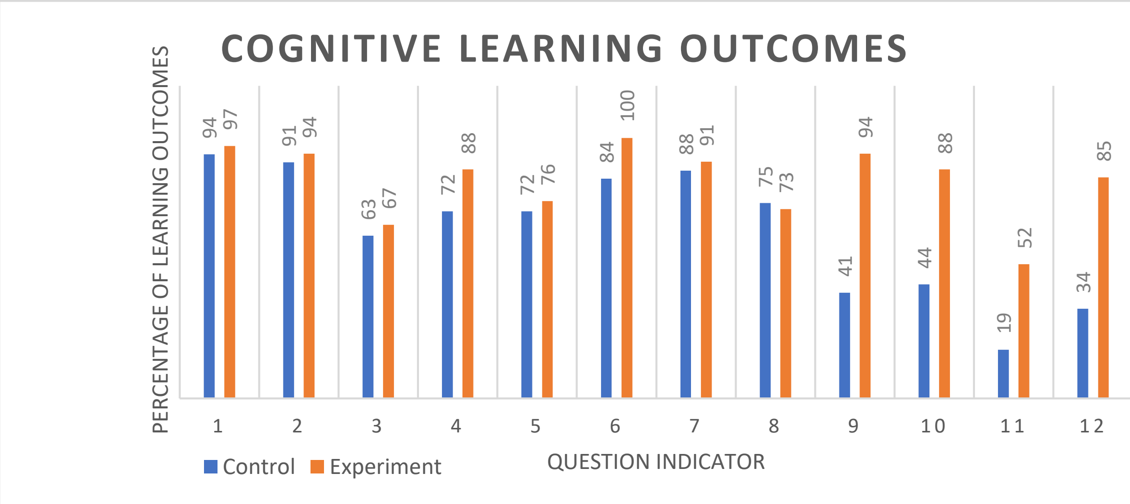
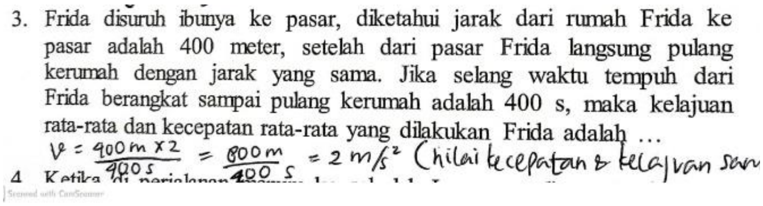


Figure 1. Comparison Diagram of Posttest Results for the Control and Experimental Classes in Terms of Students' Cognitive Learning Outcomes

Figure 1 shows that the post-test results in the experimental class are higher in each of their indicators compared to the control class. The most significant difference in the number of correct answers between the experimental and control classes is found in question number nine. This is evidenced by the fact that students in the experimental class answered correctly with appropriate reasoning, whereas in the control class, students answered incorrectly with less suitable reasoning. The smallest difference in the number of correct answers between the experimental and control classes is observed in question number eight. This is supported by the consistency in answers between the experimental and control classes, indicating that students' cognitive learning outcomes tend to be similar in that particular indicator.

Alignment of Self-Assessment with Cognitive Learning Outcomes

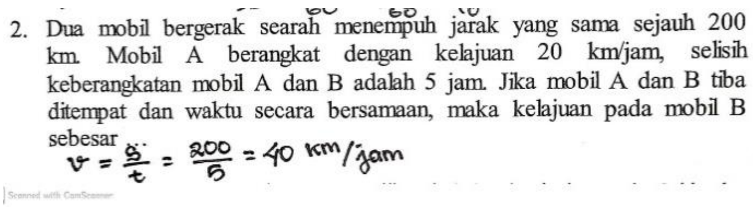
Self-assessment is carried out after the learning process, serving as preparation for upcoming exams. This allows teachers to gauge the extent of students' understanding of linear motion kinematics material. However, the self-assessment conducted by some students does not entirely match their cognitive learning outcomes. The inconsistencies are as follows:


3. Frida disuruh ibunya ke pasar, diketahui jarak dari rumah Frida ke pasar adalah 400 meter, setelah dari pasar Frida langsung pulang kerumah dengan jarak yang sama. Jika selang waktu tempuh dari Frida berangkat sampai pulang kerumah adalah 400 s, maka kelajuan rata-rata dan kecepatan rata-rata yang dilakukan Frida adalah …

$v = \frac{400 m \times 2}{400 s} = \frac{800 m}{400 s} = 2 m/s^2$ (nilai kecepatan & kelajuan sam

Figure 2. Confirmation Question Responses for Self-Assessment Question No. 3

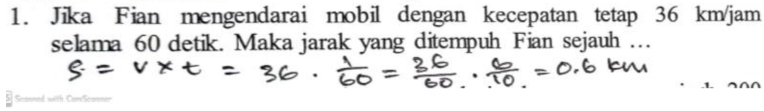
Figure 2 presents responses to the self-assessment question regarding indicator question No. 3, which reads, "How well do you understand analyzing consecutive average velocity and consecutive average speed?" Six students responded as "very knowledgeable," but some students mistakenly believed that velocity and speed are the same. Additionally, some students had a reversed understanding of the concepts of velocity and speed.


2. Dua mobil bergerak searah menempuh jarak yang sama sejauh 200 km. Mobil A berangkat dengan kelajuan 20 km/jam, selisih keberangkatan mobil A dan B adalah 5 jam. Jika mobil A dan B tiba ditempat dan waktu secara bersamaan, maka kelajuan pada mobil B sebesar …

$v = \frac{s}{t} = \frac{200}{5} = 40$ km/jam

Figure 3. Confirmation Question Responses for Self-Assessment Question No. 2

Figure 3 displays responses to the self-assessment question concerning indicator question No. 2, which states, "How well do you understand analyzing the velocities of two objects moving in the same direction along a straight path?" Eight students responded as "very knowledgeable," but some students were not precise in formulating equations, resulting in less accurate answers.


1. Jika Fian mengendarai mobil dengan kecepatan tetap 36 km/jam selama 60 detik. Maka jarak yang ditempuh Fian sejauh …

$s = v \times t = 36 \cdot \frac{1}{60} = \frac{36}{60} \cdot \frac{6}{10} = 0.6$ km

Figure 4. Confirmation Question Responses for Self-Assessment Question No. 1

Figure 4 depicts responses to the self-assessment question related to indicator question No. 1, which reads, "How well do you understand calculating the distance travelled with a known constant velocity?" Seven students responded as "very knowledgeable," but some students were imprecise in converting the required units. Based on the self-assessment results obtained, the researcher could assess the level of understanding of each student.

Discussion

Tamaela's study (2022) explains that there is an improvement in high-order thinking skills in the low category after the implementation of self-assessment. Lisnawati and Siregar's research (2018) suggests that there is a lack of reinforcement regarding the honesty of students in completing self-assessments. Shofiyah's study (2013) indicates that students' self-assessment results reveal that they do not yet know their strengths and weaknesses, causing them to lack confidence in self-assessment. This is because self-assessment is a relatively new concept, and students are not accustomed to evaluating themselves. Therefore, to determine the honesty of students in self-assessment, confirmation questions with the same indicators as self-assessment are needed to ensure alignment between self-assessment and students' abilities. Additionally, students should receive feedback on sub-topics they haven't understood to encourage improvement.

Based on the analysis results, there is a significant difference in cognitive learning outcomes between the experimental and control classes for high school students in linear motion kinematics. However, the self-assessment results of some students do not entirely align with their level of understanding. It is possible that students do not fully comprehend their abilities when conducting self-assessment (Adawiyah & Haolani, 2021). Figure 1 illustrates the difference in the average cognitive learning outcomes between the group that received the self-assessment treatment and the group that did not, amounting to 19. The success of the self-assessment treatment can be attributed to student's ability to self-assess their understanding of the linear motion kinematics topic. This aligns with Andrade's (2019) research, which suggests that self-assessment is a self-assessment technique that informs the level of competence achievement, thus enhancing motivation and influencing learning outcomes.

The analysis also reveals differences in cognitive learning outcomes between groups with and without the self-assessment intervention. Trisno's (2014) study indicates that assessments given by students and teachers have a significant correlation, making self-assessment a reliable assessment technique. Research conducted by Wahyuningsih et al. (2016) suggested that self-assessment is suitable and receives positive responses from both students and teachers. Self-assessment in learning activities is highly beneficial, as its application can improve students' learning outcomes (Martínez et al., 2020).

One indicator that shows a significant difference in cognitive learning outcomes after the implementation of self-assessment is indicator number 9, which assesses the ability of students to graph velocity (v) versus time (t) for uniformly accelerated linear motion. Figure 1 indicates that the cognitive learning outcomes of students in the control group reached 37.14%, while in the experimental group that received the intervention, it reached 93.94%. The substantial difference in values can be attributed to the feedback provided by the researcher, which helped students gain a better understanding and, in turn, improved their cognitive learning outcomes. The feedback included explanations related to the topics that were not well understood based on the self-assessment and confirmation questions. Furthermore, feedback serves to enhance students' understanding and inform them of their current skill levels. According to Fernando et al.. (2017), providing positive feedback significantly influences students' comprehension development. Other studies also explain that students who receive feedback tend to achieve higher learning outcomes compared to those who do not (Sofyatiningrum et al.., 2019).

Figure 1 also reveals that there are indicators with minimal differences between the control and experimental groups, indicating that cognitive learning outcomes tend to be similar for those indicators. This phenomenon may be attributed to students in the experimental group retaining misconceptions even after receiving the intervention and feedback (Saputra et al.., 2013). Additionally, some students may remain passive during the feedback process. Research by Başer and Geban (2007) suggests that misconceptions tend to be consistent and difficult to correct, persisting even after appropriate teaching interventions.

Assessment is not solely conducted by students; researchers also evaluate students' self-assessment results and confirmation questions completed by students during self-assessment. This means that researchers can ascertain the honesty of students' self-assessments, which is substantiated by their responses to questions with indicators matching those in the self-assessment. This finding aligns with Lesmana and Rokhyati's (2020) research, which indicates that self-assessment is used to evaluate the honest assessment of the level of understanding and, subsequently, improve students' learning outcomes. According to Vasileiadou and Karadimitriou (2021), self-assessment is also employed to assess learning abilities, providing information to teachers to enhance students' abilities and improve their learning outcomes.

Students' self-assessments do not always align with their level of understanding. There is a possibility that students may not comprehend their abilities during self-assessment (Adawiyah & Haolani, 2021). This suggests the presence of misconceptions among students. Misconceptions refer to the disparity between students' concepts and those established by experts (Mukhlisa, 2021). Busyairi and Zuhdi's (2020) research explains that misconceptions result in individuals believing their concepts are correct, even when they contradict expert knowledge.

Furthermore, these misconceptions are evidenced by the self-assessment question regarding indicator question No. 3: "How well do you understand analyzing consecutive average velocity and consecutive average speed?" Six students responded as "very knowledgeable," but their answers were imprecise. These students believed that velocity and speed were the same and had a reversed understanding of the concepts of velocity and speed. This result aligns with Nasir's research, which indicates that 64.58% of students experience misconceptions regarding the subtopic of speed and velocity. Students struggle to differentiate between these two quantities and erroneously consider velocity and speed to be identical. Furthermore, Habellia et al. (2021) also suggest that students cannot distinguish between the concepts of velocity and speed, with many students believing that speed is the ratio of distance to time.

The self-assessment question for indicator question No. 2: "How well do you understand analyzing the velocities of two objects moving in the same direction along a straight path?" received responses from eight students who considered themselves "very knowledgeable." However, after being presented with a similar indicator question during the confirmation questions, it became evident that these students were imprecise in their responses. They lacked attention to detail in formulating equations, resulting in less accurate answers. Students believed they were very knowledgeable about this indicator because they had successfully solved similar problems. However, they inadvertently used incorrect equation formulations that did not match the given problems. Dali et al.. (2021) stated that students may not understand the equations used, leading to an inability to solve the problems presented. This situation aligns with Sari et al.'s (2018) findings, which suggest that 65.73% of students encounter difficulties and lack precision in determining which equations to use.

The self-assessment question for indicator question No. 1: "How well do you understand calculating the distance travelled with a known constant velocity?" received responses from seven students who considered themselves "very knowledgeable." However, their responses were imprecise. These students had difficulty and were confined to units in the problem, failing to convert units as required. Darsa's (2020) research suggests that students often struggle with unit conversions, leading to imprecise answers. Some students may even skip unit conversions and directly insert values into equations. Based on the self-assessment results obtained, the researcher can assess each student's level of understanding and provide feedback to enhance their learning outcomes. However, it is essential to note the possibility of discrepancies between self-assessment and students' cognitive learning outcomes.

CONCLUSION

Based on the results of the data analysis and discussions provided, it can be concluded that there is an influence of self-assessment with a significant difference between the experimental and control classes on the cognitive learning outcomes of high school students in the topic of linear motion kinematics. This is indicated by the average ranking of each group in the experimental class, which is 44.64, which is higher than the average ranking of the control class, which is 21.00. The Mann-Whitney test results show a p-value of < 0.050. However, it should be noted that not all students' self-assessments align perfectly with their actual level of understanding. Some students overestimated their comprehension, as evidenced by their inability to accurately answer questions with the same indicators as their self-assessment.

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