Effectiveness of Ethno-Inquiry-Interactive Physics Multimedia Using the Gopa Game to Improving Students' Numeracy Literacy

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Abstract - *This study aims to analyze the effectiveness of ethno-inquiry-based interactive physics multimedia through the traditional Gopa game in improving students' numeracy in parabolic motion material for grade XI of high school. This study used a quasi-experimental method with a pretest-posttest control group design involving two classes, namely the experimental class that used ethno-inquiry-based interactive multimedia through the Gopa game and the control class that used conventional learning. The research instrument included a numeracy literacy test. Data were analyzed using an independent t-test and N-Gain test calculations to measure the level of effectiveness. The results showed that there was a significant difference between the numeracy and cultural literacy results of students in the experimental and control classes. With an Independent Sample t-test on the posttest score, there was a significant difference between the experimental and control classes with a p-value of 0.029 (p <0.05). The average posttest score of the experimental class (74.92) was higher than the control class (64.67). These results indicate that the use of ethno-inquiry-based interactive multimedia in the Gopa game has a positive influence on improving students' numeracy literacy. The average gain in numeracy literacy scores in the experimental and control classes was in the moderate category, meaning that the effectiveness of using ethno-inquiry-based interactive physics multimedia through the Gopa game on parabolic motion material was categorized as moderate or quite effective.*

Keywords*: Etno-Inquiry; Gopa Game; Interactive Multimedia in Physics; Numeracy Literacy.*

INTRODUCTION

Education in Indonesia continues to face challenges in improving students' numeracy literacy skills, particularly in science subjects like physics. The 2022 PISA results showed a decline in Indonesian students' numeracy literacy scores to 366, compared to 379 in 2018 (Hamdu et al., 2023; Moruk & Sulisworo, 2024; Setiawan et al., 2024). This decline reflects students' difficulties in applying basic mathematical concepts, including measurement, data interpretation, and quantitative reasoning, which are essential skills in solving physics problems (Dai et al., 2025; Komarudin et al., 2024).

One physics topic that requires significant numeracy skills is parabolic motion. Understanding parabolic motion involves interpreting mathematical relationships between variables such as displacement, velocity, time, and angle, as well as analyzing graphs and equations. Students are required to calculate trajectories, determine maximum heights and ranges, and interpret motion data quantitatively. Weak numeracy skills often lead to misunderstandings and low achievement in this topic, as students struggle to connect mathematical representations with physical phenomena.

In addition to challenges in numeracy, physics learning in Indonesia often lacks cultural contextualization. Physics concepts are often taught abstractly without linking them to students' local cultural experiences, resulting in low engagement and meaningful understanding (Putri & Nisa', 2025; Suminar

et al., 2025). Integrating local wisdom into physics learning can make abstract concepts more concrete, contextual, and relevant to students' daily lives (Bin Amiruddin & Suliyanah, 2023; Sholahuddin & Admoko, 2021).

One learning approach that addresses both of these issues is the Ethno-Inquiry learning model, which combines inquiry-based learning with local cultural context. This model encourages students to actively investigate physical phenomena while connecting scientific concepts to traditional practices and local wisdom (Prayogi et al., 2023; Verawati et al., 2023). This study used the traditional game Gopa from the Bima (Mbojo) community. Gopa involves throwing objects (inci) into a patterned box, creating projectile trajectories that can be directly linked to the concept of parabolic motion. Through this activity, students can observe, measure, and analyze the motion paths, thereby strengthening their numeracy skills such as measurement, data analysis, and quantitative reasoning.

To support this learning process, interactive multimedia was used. Interactive multimedia integrates text, images, animation, audio, and video, enabling students to actively engage with the learning content (Inawan et al., 2022; Yulianci et al., 2017). In physics learning, multimedia facilitates the visualization of abstract concepts, supports exploration and experimentation, and enhances students' understanding of the relationship between mathematics and physics (Alarcon, 2025; Nyirahabimana et al., 2023). Ethno-inquiry-based interactive multimedia allows students to explore parabolic motion through a culturally familiar context while practicing numeracy skills in a meaningful way.

This research also aligns with Indonesia's Asta Cita (Goals 4 and 8). Asta Cita 4 emphasizes strengthening human resource development through quality education and science, while Asta Cita 8 highlights alignment with local culture and wisdom. By integrating the Gopa game into physics multimedia, this research supports the quality of education and cultural preservation.

Therefore, this study aims to develop ethno-inquiry-based interactive physics multimedia using the Gopa game to improve students' numeracy literacy. This multimedia was developed using the Articulate Storyline application. The research question guiding this study is: How can ethno-inquiry-based interactive physics multimedia through the Gopa game improve students' numeracy literacy?

RESEARCH METHODS

This study employed a quasi-experimental pretest–posttest design with a control group (non-randomized control group design). Both groups (experimental and control) were given pretests and posttests to measure numeracy and cultural literacy. The experimental group received an Ethno-Inquiry based Interactive Physics Multimedia treatment using the Gopa game, while the control group received conventional learning. The study sample consisted of eleventh-grade students from high school, grades A and B, using a random sampling technique.

The research instruments consisted of a numeracy literacy test in the form of five essay questions corresponding to numeracy literacy indicators, as well as a cultural literacy questionnaire using a validated Likert scale. The data were analyzed in several stages. First, prerequisite tests were conducted, including a normality test (Shapiro–Wilk) and a homogeneity of variance test (Levene's Test) to ensure the data distribution met parametric assumptions. Next, the main analysis was

conducted using an independent t-test to compare the differences in the average posttest scores for numeracy literacy between the experimental and control classes. This test was chosen because it is suitable for determining the differences in learning outcomes between two unpaired groups.

RESULTS AND DISCUSSION

Results

Interactive physics multimedia based on ethno-inquiry through gopa game on parabolic motion material is declared feasible to use both from the feasibility of the material and the feasibility of the media. So that interactive physics multimedia based on ethno-inquiry is applied in the learning process in the experimental class. The application of interactive physics multimedia based on ethno-inquiry through Gopa game improves numeracy literacy and cultural literacy. Before the application was carried out in class XI A as the experimental class, a pretest or initial ability test of numeracy literacy was given totaling 5 questions and a cultural literacy questionnaire totaling 10 questions. After that, treatment was given, namely applying interactive physics multimedia based on ethno-inquiry through Gopa Game on parabolic motion material and at the end of the meeting a posttest was given. As a comparison class, the control class, namely class XI B, was also given a pretest and posttest with different treatment, namely using conventional teaching by a physics teacher.

Numeracy Literacy

1) Comparison of pretest and posttest scores for the experimental class and control class.

A comparison of the average pretest and posttest scores for the experimental class and control class can be seen in table 1 and figure 2.

Table 1. Comparison of pretest and posttest scores of the experimental class and the control class

Comparison of Scores	Pretest score		Postest score	
	X	Y	X	Y
Highest Score	50	40	100	97,5
Lowest Score	0	5	35	45
Average	17,33	16.73	74,91	64,67
Completed	0	0	17	9
Incomplete	30	30	13	21
Number of student	30	30	30	30

Description: X: Exsperimen class; Y: Control class.

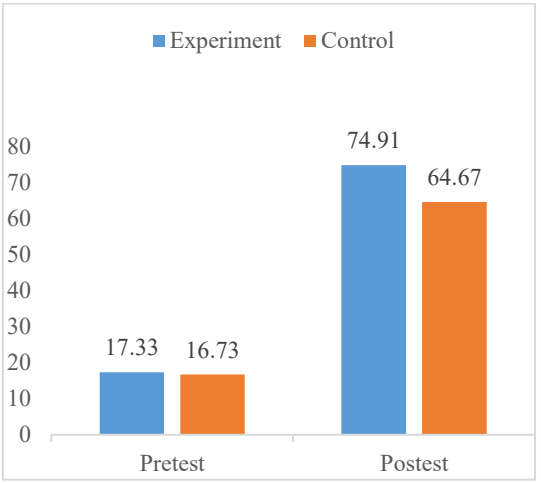

Figure 3. Comparison of the average pretest-post test scores of the experimental and control classes

Based on table 1 and figure 1, there was a significant increase in student learning outcomes after using ethno-inquiry-based interactive physics multimedia through the Gopa game. The average pretest score of the experimental class was 17.33, increasing to 74.91 in the posttest, while the control class increased from 16.73 to 64.67. The number of students who completed the test was also greater in the experimental class (17 students) than in the control class (9 students). This increase indicates that the application of ethno-inquiry-based interactive multimedia is effective in improving understanding of the concept of parabolic motion, as well as being able to foster numeracy literacy and cultural awareness of students through the context of the traditional Gopa game.

2) Results of Data Analysis of Pretest and Posttest Scores for the Experimental and Control Classes

a. Normality Test

A normality test was conducted using the Shapiro-Wilk method on the pretest and posttest scores for both the experimental and control classes. The results of the normality test can be seen in Table 2.

Table 2. Results of the normality test for pretest and posttest data for the experimental and control classes.

Group	N	Statistik W	Sig (p)	Deskription
Pretest X		0,897	0,007	Absorbal
Postest X		0,937	0,075	Normal
Pretest Y	30	0,875	0,002	Absorlbal
Postest Y		0,979	0,797	Normal

Description: X: Experiment; Y: Control

Based on these findings, the experimental pretest group and the control class were not normally distributed, so the pretest difference analysis was carried out using the non-parametric Mann-Whitney U test. Thus, both groups had equivalent baseline abilities before the treatment was given.

b. Homogeneity Test

The homogeneity of variance test was conducted using Levene's Test on posttest scores. The results showed a p-value of 0.224 > 0.05, indicating that the posttest data in the experimental and control classes had homogeneous variances. Thus, the requirements for using parametric tests were met, allowing analysis of differences in post-treatment learning outcomes using an Independent Samples t-test.

c. Independent Samples t-test

An Independent Samples t-test on posttest scores showed a significant difference between the experimental and control classes with a p-value of 0.029 ($p < 0.05$). The average posttest score for the experimental class (74.92) was higher than that of the control class (64.67). These results indicate that the use of ethno-inquiry-based interactive multimedia in the Gopa game has a positive impact on improving students' numeracy literacy.

This difference can be explained by the characteristics of ethno-inquiry-based interactive multimedia, which integrates the local cultural context (the traditional Gopa game) with an inquiry approach. Through this multimedia, students not only practice solving numeracy problems but also connect mathematical knowledge with real-life experiences in traditional games.

d. N-Gain Test

To determine the effectiveness of the treatment, an N-Gain analysis was conducted for the control and experimental classes.

Table 6. N-Gain test results

Group	N-Gain	Category
X	0,69	Medium
Y	0,57	Medium

Information: X: Experiment; Y: Control

Nevertheless, the difference in average N-Gain values still indicates a tendency for learning with ethno-inquiry-based interactive multimedia to be more effective than conventional learning. Although the difference in N-Gain was not statistically significant, the trend of higher improvement in the experimental class confirms the effectiveness of the learning intervention.

e. Analysis results based on indicators of numeracy literacy.

Analysis of students' numeracy literacy is not only carried out as a whole, but also reviewed in more detail based on numeracy literacy indicators. This approach is important in order to obtain a more in-depth picture of which aspects of numeracy literacy have experienced significant improvements after learning treatment.

Each numeracy literacy indicator represents a specific skill, from the ability to interpret graphs and tables, to calculate physical quantities, to using formulas in real-life contexts. By analyzing the achievements on each indicator, students' strengths and weaknesses can be identified, as well as the extent to which interactive multimedia based on ethno-inquiry through the traditional game Gopa is able to contribute to increasing numeracy literacy.

Therefore, in this section, the results of the N-Gain analysis based on numeracy literacy indicators for the control and experimental classes are presented, complete with categorization. This analysis is expected to provide a more comprehensive understanding of the effectiveness of the learning treatment that has been implemented. The results of the N gain test on the pretest and posttest scores in the experimental class and control class can be seen in table 3 and table 4.

Table 3. Numeracy Literacy Analysis Results from Pretest and Posttest scores for the control class

Numeracy Literacy Indicators	Control Class		N-Gain	Category
	postest (%)	pretest (%)		
Interpreting graphs	83,33	29,16	0,76	High
Calculating physical quantities	68,33	17,5	0,62	Medium
Using formulas in real-life contexts	85,83	8,33	0,85	High
Creating mathematical representations of physics problems	36,94	4,16	0,34	Low
Analyzing solutions and making decisions based on numerical data	72,5	23,33	0,64	Medium

Table 4. Numeracy Literacy Analysis Results from Pretest and Posttest scores for the exsperiment class

Numeracy Literacy Indicators	Exsperiment Class		N-Gain	Category
	postest (%)	pretest (%)		
Interpreting graphs	77,5	32,5	0,67	Medium
Calculating physical quantities	89,16	21,67	0,86	High
Using formulas in real-life contexts	82,5	20	0,78	High
Creating mathematical representations of physics problems	62,77	0,56	0,63	Medium
Analyzing solutions and making decisions based on numerical data	73,33	20,83	0,66	Medium

The results showed that both the control and experimental classes experienced improvements in numeracy literacy after the learning process. However, the experimental class's performance was more evenly distributed and superior in indicators requiring higher-order thinking skills. The control class showed high improvements in interpreting graphs (0.76) and using formulas in real-life contexts (0.85), but remained low in creating mathematical representations (0.34). Conversely, the experimental class excelled in calculating physical quantities (0.86), creating mathematical representations (0.63), and analyzing solutions based on numerical data (0.66). This demonstrates that ethno-inquiry-based interactive multimedia through the traditional Gopa game is more effective in fostering conceptual understanding, representation skills, and decision-making.

The following percentage comparison presentation allows us to see the differences in students' numeracy literacy more proportionally and objectively. It also makes it easier to assess

the extent to which the treatment in the experimental class provided benefits compared to learning in the control class. A comparison of posttest and pretest scores between the experimental and control classes can be seen in Figures 5 and 6.

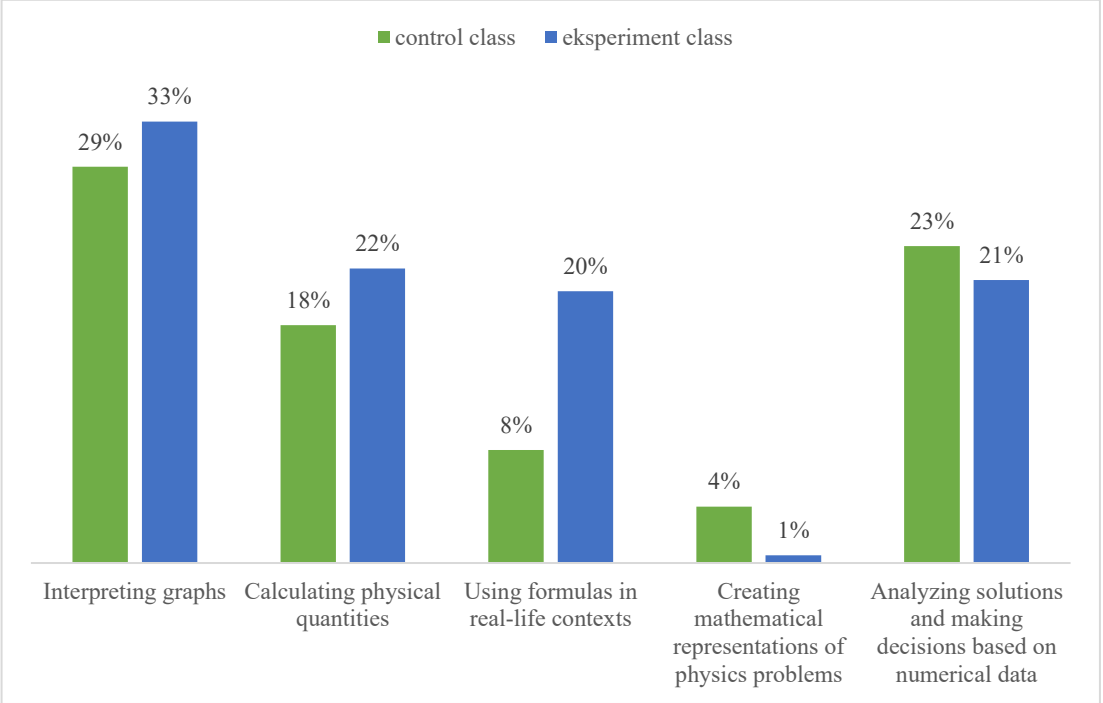

Figure 5. Comparison of the percentage of pretest scores for the experimental class and control class on the Numeracy literacy indicator

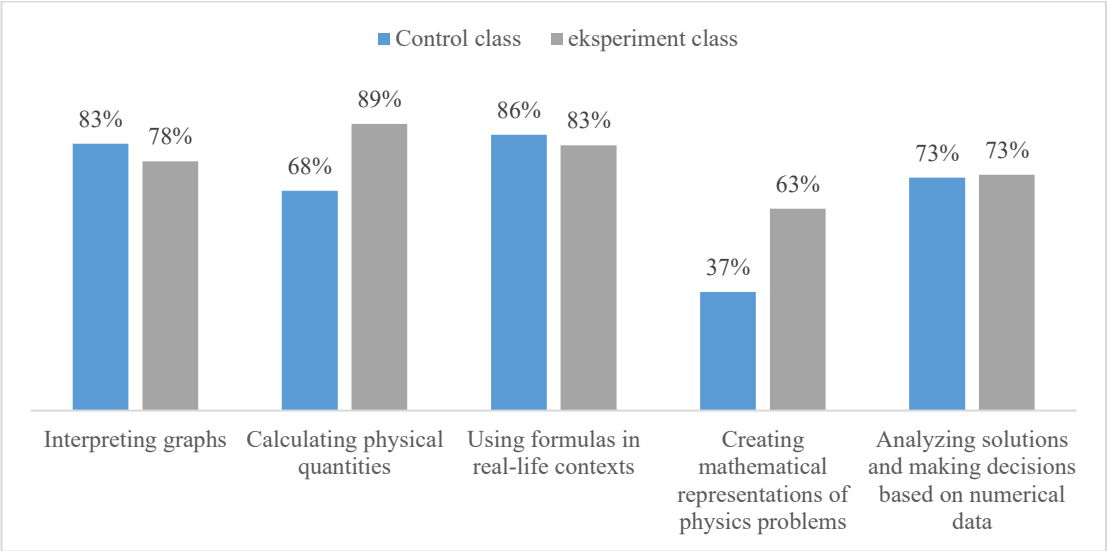

Figure 6. Comparison of the percentage of postest scores for the experimental class and control class on the Numeracy literacy indicator

Based on Figure 5, the comparative data of the percentage of numeracy literacy indicators, it can be seen that the experimental class showed higher results than the control class in most indicators. In the indicator of interpreting graphs, the experimental class obtained 32.5%, higher than the control class at 29.2%, indicating that the use of interactive multimedia helps students understand the relationship between physics variables visually. The indicator of calculating physics quantities also increased from 17.5% in the control to 21.7% in the experiment, indicating an increase in students' ability to perform numerical calculations based on physics concepts. The most significant increase occurred in the indicator of using formulas in real-life contexts, namely from 8.3% in the control to 20.0% in the experiment, indicating that the ethno-inquiry approach through the Gopa game is effective in linking physics concepts with everyday experiences and cultural contexts. Meanwhile, the indicator of analyzing solutions based on numerical data was relatively balanced between the two classes (23.3% in the control and 20.8% in the experiment), and in the indicator of making mathematical representations, the results of the experimental class (0.6%) were slightly lower than the control (4.2%). In general, the results of this percentage show that the pretest scores on numeracy literacy of students in both the control class and the experimental class are not much different, meaning that the pretest abilities of numeracy literacy are balanced or the same.

Based on Figure 6, the comparison of the percentage of numeracy literacy indicators between the control and experimental classes, there are variations in achievement for each indicator. In the indicator of interpreting graphs, the control class obtained 83%, slightly higher than the experimental class (78%), indicating that control students are more accustomed to reading visual data. However, in the indicator of calculating physical quantities, the experimental class showed a much higher result (89%) than the control (68%), indicating that the ethno-inquiry-based interactive multimedia approach is effective in training concept-based calculation skills. In the indicator of using formulas in real-life contexts, the results of the control class (86%) were slightly superior to the experimental (83%), indicating that control students are still quite good at applying formulas without cultural context. Conversely, a significant increase occurred in the indicator of creating mathematical representations of physics problems, where the experimental class achieved 63% compared to only 37% in the control, indicating that the ethno-inquiry approach is able to develop students' representational and conceptual thinking skills. As for the indicator of analyzing solutions and making decisions based on numerical data, both classes achieved the same result (73%), indicating that numerical analysis skills are relatively balanced. Overall, ethno-inquiry interactive multimedia-based learning has a positive influence, especially on indicators that require high-level thinking skills and the application of concepts in a local cultural context.

Discussion

Interpretation of Key Findings

The findings of this study indicate that ethno-inquiry-based interactive physics multimedia through the Gopa game is effective in improving students' numeracy literacy skills. This is evidenced by the positive N-Gain scores obtained in both the experimental and control classes, with the experimental class showing higher and more equitable improvements across all numeracy literacy indicators.

The superior performance of the experimental class can be attributed to the differences in the learning treatments implemented. Students in the experimental class learned parabolic motion through

ethno-inquiry-based interactive multimedia integrated with the Gopa game, which provided dynamic visualizations and culturally contextualized learning experiences. This approach supported students in understanding the mathematical relationships in parabolic motion, such as interpreting trajectories, calculating physical quantities, and applying formulas in real-life contexts. In contrast, the control class relied on conventional, textbook-based experimental methods, which tend to emphasize procedural understanding with limited visualization and contextual engagement.

Further analysis of the numeracy literacy indicators showed that the experimental class achieved moderate to high improvements in interpreting graphs, calculating physical quantities, creating mathematical representations, and analyzing numerical data for decision-making. These results indicate that an ethno-inquiry approach promotes the development of balanced numeracy skills by encouraging students to actively explore, analyze, and represent physical phenomena within a meaningful cultural context.

Comparison with Previous Studies

The results of this study are consistent with previous research showing that inquiry-based and culturally integrated interactive multimedia can significantly improve students' numeracy literacy. Studies by Huda et al. (2024), Bina et al. (2025), Amanda et al. (2025), and Yuniria et al. (2025) also reported that interactive multimedia grounded in inquiry and local culture produced better numeracy outcomes compared to conventional teaching.

Furthermore, these findings align with those of Yulianci et al. (2021), who emphasized that interactive multimedia increases student engagement and supports higher-order thinking skills. Nurjumiati et al. (2022) also found that inquiry-based learning focused on numeracy literacy improved students' mathematical modeling and symbolic reasoning in physics. This study extends these findings by demonstrating that the integration of traditional games such as Gopa further strengthens students' understanding of parabolic motion by connecting abstract concepts with familiar cultural practices.

Pedagogical Implications

The findings of this study suggest several important pedagogical implications. First, physics teachers are encouraged to integrate local cultural elements, such as traditional games, into physics instruction to enhance contextual understanding and student engagement. The Gopa game proved to be an effective medium for illustrating parabolic motion while simultaneously strengthening numeracy skills.

Second, the use of ethno-inquiry-based interactive multimedia supports student-centered learning by encouraging exploration, visualization, and various forms of representation. This approach can help students develop not only computational skills but also the ability to interpret graphs, create mathematical representations, and make informed decisions based on numerical data.

In conclusion, these results suggest that curriculum designers and policymakers may consider incorporating ethno-inquiry-based multimedia learning resources into physics curricula as a strategy to improve numeracy literacy while preserving and valuing local cultural wisdom.

Study Limitations

Despite its positive results, this study has several limitations that need to be acknowledged. First, the sample size was

relatively small, which may limit the generalizability of the findings to a broader student population. Second, this study focused on a single physics topic, namely parabolic motion, so the effectiveness of ethno-inquiry-based interactive multimedia for other physics topics remains uncertain. Third, the intervention duration was relatively short, which may not fully capture the long-term impact of the learning approach on students' numeracy literacy.

Future research is recommended to involve larger and more diverse samples, apply the ethno-inquiry approach to a variety of physics topics, and implement a longer intervention period to test for sustained effects on numeracy literacy and other higher-order learning outcomes.

CONCLUSION

This study shows that the use of ethno-inquiry-based interactive physics multimedia through the Gopa game is quite effective in improving students' numeracy literacy, as indicated by the higher and more consistent abilities of the experimental class compared to the control class, especially in the ability to calculate physical quantities, apply formulas in real-life contexts, and represent physics problems mathematically. This finding confirms that inquiry-based learning is integrated with local culture and supported by interactive multimedia is able to make abstract physics concepts more contextual and easier to understand. Practically, physics teachers can implement this approach by integrating traditional games that are relevant to the learning context, using interactive multimedia to visualize mathematical concepts and relationships, and designing inquiry activities that encourage students to measure, analyze data, and reflect, so that students' numeracy literacy can develop more optimally in physics learning.

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