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Research Article

The Effect of the CORE Learning Model (Connecting, Organizing, Reflecting, Extending) with Lumio by Smart Media on High School Students' Critical Thinking Abilities and Physics Learning Outcomes

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Abstract: Physics learning requires higher-order thinking skills, particularly critical thinking and conceptual understanding. However, students' critical thinking skills and physics learning outcomes at the senior high school level are still relatively low due to teacher-centered instruction and the limited use of innovative learning models and media. This study aimed to examine the effect of the CORE (Connecting, Organizing, Reflecting, Extending) learning model assisted by Lumio by Smart media on students' critical thinking skills and physics learning outcomes. This research employed a true experimental design with a post-test only control group design conducted at SMAN 4 Jember in the 2025/2026 academic year. The samples consisted of two classes, with class XI Umum 2 as the experimental class and class XI Teknik 3 as the control class. Data were collected through tests and analyzed using the Mann–Whitney U test. The results showed significance values of 0.027 ≤ 0,05 for critical thinking skills which means H0 is rejected and Ha is accepted and 0.020 ≤ 0,05 for physics learning outcomes which means H0 is rejected and Ha is accepted. Therefore, it can be concluded that the CORE learning model assisted by Lumio by Smart media has a significant effect on students' critical thinking skills and physics learning outcomes.

Keywords: CORE Learning Model; Critical Thinking; Lumio by Smart; Physics Learning Outcomes; True Experimental Design.

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1. Introduction

Rapid technological developments have brought significant changes to various areas of life, including education (Tamyiz et al., 2025). This situation indirectly necessitates mastery of various competencies aligned with 21st-century characteristics, including the ability to think critically, solve problems effectively, collaborate, and generate innovation (Ledoh et al., 2025). These competencies have an important role in the physics learning process (Amelia and Chusni, 2024). Physics is often perceived by students as a complex and abstract subject (Lusiani, 2024), resulting in low learning participation and difficulty in understanding the material. In line with this, learning strategies need to be designed systematically so that they can stimulate critical thinking skills and simultaneously improve student learning outcomes.

The results of observations conducted in several high schools in Jember Regency by Zahro et al. (2024) revealed that students had demonstrated the ability to interpret, evaluate,

and draw conclusions, but still experienced limitations in the analysis aspect. The gap in the quality of education in the field of physics is evident in 2019 data from the Education and Training Center (Puspendik), which shows that the average National Examination score in Jember Regency (46.11) lags behind the average score in East Java Province of 48.98. This reality is also reflected at Jember State Senior High School 4, where student learning outcomes often fall short of the required minimum completion standards.

By paying attention to the problem of low critical thinking skills of students and the achievement of learning outcomes that are not optimal, it is necessary to apply appropriate learning models and media to create an active, meaningful, and contextual learning process (Sari & Emiliannur, 2025). The CORE model is presented as a relevant pedagogical approach in developing critical reasoning through structured cognitive processes. The theoretical basis of this model is based on the principle of constructivism, where learning success is no longer seen as a passive transfer of information, but rather an active process in which students construct their own understanding through in-depth interaction and reflection (Khairunnisa & Amidi, 2022).

The use of technology to support the CORE model has been identified as an effective alternative for strengthening students' critical reasoning skills (Yulianto et al., 2024). Validation of this approach was found in a study by Hardianto et al. (2024), which showed that media integration into the CORE stages significantly contributed to maximizing learning outcomes. Lumio by Smart is a technology-based learning media developed to support innovative and interactive learning processes, thus potentially improving the quality of learning in the classroom (Anggraeni & Prihandono, 2025). In line with this, a study conducted by Silvia et al. (2024) confirmed that in the realm of physics education, this platform has a high level of feasibility for implementation in school environments.

Several previous studies have shown that the CORE model and Lumio by Smart media both contribute significantly to improving critical thinking skills and student learning outcomes. Sudane et al. (2023) and Anita et al. (2023) demonstrated the effectiveness of the CORE model in strengthening critical reasoning and physics academic achievement, while Choir et al. (2024) and Jannah (2023) emphasized the role of Lumio by Smart in increasing participation and critical thinking skills. However, research integrating these two variables is still limited, so further studies are needed to comprehensively explore their potential synergy.

Based on the background and identified research gaps, it can be concluded that there is an urgency to conduct research that examines the application of the CORE learning model supported by Lumio by Smart on critical thinking skills and student learning outcomes. Therefore, this research was conducted with the title "The Effect of the CORE Learning Model (Connecting, Organizing, Reflecting, Extending) Assisted by Lumio by Smart Media on Critical Thinking Skills and Physics Learning Outcomes of High School Students".

2. Literature Review

Learning is viewed as an interactive process that occurs between teachers and students within a systematically structured learning environment to achieve predetermined learning objectives. Physics, as a branch of science, studies various natural phenomena related to human life, encompassing concepts, principles, laws, and scientific theories (Erlangga, 2022). Physics learning can be defined as a learning process that examines phenomena through the application of physics concepts, principles, and theories using a scientific approach (Sari et al., 2021).

2.1 Learning Physics

Learning is viewed as an interactive process that occurs between teachers and students within a systematically structured learning environment to achieve predetermined learning objectives. Physics, as a branch of science, studies various natural phenomena related to human life, encompassing concepts, principles, laws, and scientific theories (Erlangga, 2022). Physics learning can be defined as a learning process that examines phenomena through the application of physics concepts, principles, and theories using a scientific approach (Sari et al., 2021).

2.2 Constructivist Learning Theory

In the school environment, various learning theories can be used as references, including constructivist learning theory (Arafah et al., 2023). Constructivist learning theory views students as individuals who play an active role in the learning process, where knowledge is

not only transferred but also independently constructed through learning experiences and interactions with the surrounding environment (Nurhayati et al., 2024). The development of constructivist learning theory was influenced by the thinking of several educational figures, including Jean Piaget, Jerome Bruner, John Dewey, Lev Vygotsky, and David Ausubel (Budiyanti et al., 2023).

2.3 The CORE Learning Model

The development of the CORE learning model is based on constructivist learning theory, which views students as active participants in the knowledge construction process (Khairunnisa & Amidi, 2022). The implementation of the CORE learning model aims to foster active student participation in learning and optimally develop critical thinking and problem-solving skills (Nofita et al., 2024). In line with its underlying principles, the CORE learning model is structured into four main stages: Connecting, Organizing, Reflecting, and Extending. According to Shoimin & Aris (2014), the stages of this learning model are listed in Table 2.1 below:

Table 1. The CORE Learning Model.

Stages	Activity
Phase 1: *Connecting*	Teachers link students' prior knowledge to new concepts through trigger questions or contextual phenomena.
Phase 2: *Organizing*	Students group and organize new information obtained to build a structured understanding of concepts.
Fase 3: *Reflecting*	Students review learning outcomes to assess understanding and correct conceptual errors.
Fase 4: *Extending*	Students create simple digital posters in groups to develop their existing understanding.

(Shoimin & Aris, 2014)

2.4 Lumio by Smart

Lumio by Smart is a web-based digital learning media that can be accessed online via various devices, such as smartphones and PCs and is used as a supporting media in implementing the learning process (Suryandani and Asih, 2024). Hanif and Armiati (2025) stated that the use of Lumio by Smart media can support learning activities that focus on student learning activities (student-centered learning). This media is equipped with various features, such as creating learning activities, formative assessment, interactive learning, educational games, and integration with PhET Simulation, YouTube, and Desmos (Suryandani & Asih, 2024).

2.5 Critical Thingking Skills

Critical thinking skills are viewed as an essential asset in the educational ecosystem, equipping students with strong reasoning capabilities (Kusumawati et al., 2022). The urgency of these skills is closely related to the demands of 21st-century competencies, where students are expected to be skilled problem solvers in various situations (Yulianti et al., 2022). Facione (2015) stated that critical thinking indicators consist of interpretation, analysis, and evaluation, which are then strengthened by explanation and self-regulation skills.

2.6 Learning Outcomes

Learning outcomes can be defined as multidimensional changes in students as a logical consequence of the learning activities they have completed. Based on the taxonomy developed by Benjamin S. Bloom (Jafar, 2021), learning success is mapped into three main domains: cognitive, affective, and psychomotor. According to Anderson and Krathwohl (in Saraswati and Agustika, 2020), learning outcomes are classified into six categories in the cognitive domain, namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). Meanwhile, Bloom (1956) stated that the cognitive domain includes knowledge, understanding, application, analysis, synthesis, and evaluation.

3. Proposed Method

Overall, this study was designed using a quantitative approach with a true experimental design in the form of a posttest-only control group design, involving one experimental class and one control class. The study was conducted at SMA Negeri 4 Jember with a population of all grade XI students in the 2025/2026 academic year, while the sample was determined through a cluster random sampling technique based on the results of the homogeneity test. The research model used was the application of the CORE (Connecting, Organizing, Reflecting, Extending) learning model assisted by Lumio by Smart media as the independent variable, with critical thinking skills and physics learning outcomes as the dependent variables. Data collection techniques included tests (multiple choice and essay), observation, semi-structured interviews, and documentation to strengthen the data. The research instrument has undergone validity and reliability tests with the results indicating that the instrument is suitable for use in data collection. Data analysis was carried out through a normality test as a prerequisite, then continued with the Mann–Whitney U test according to the characteristics of the data distribution, with decision making based on a significance level of 0.05 as referring to statistical analysis procedures commonly used in quantitative research. Details of the stages of the research procedure are presented visually in Figure 3.1 below.

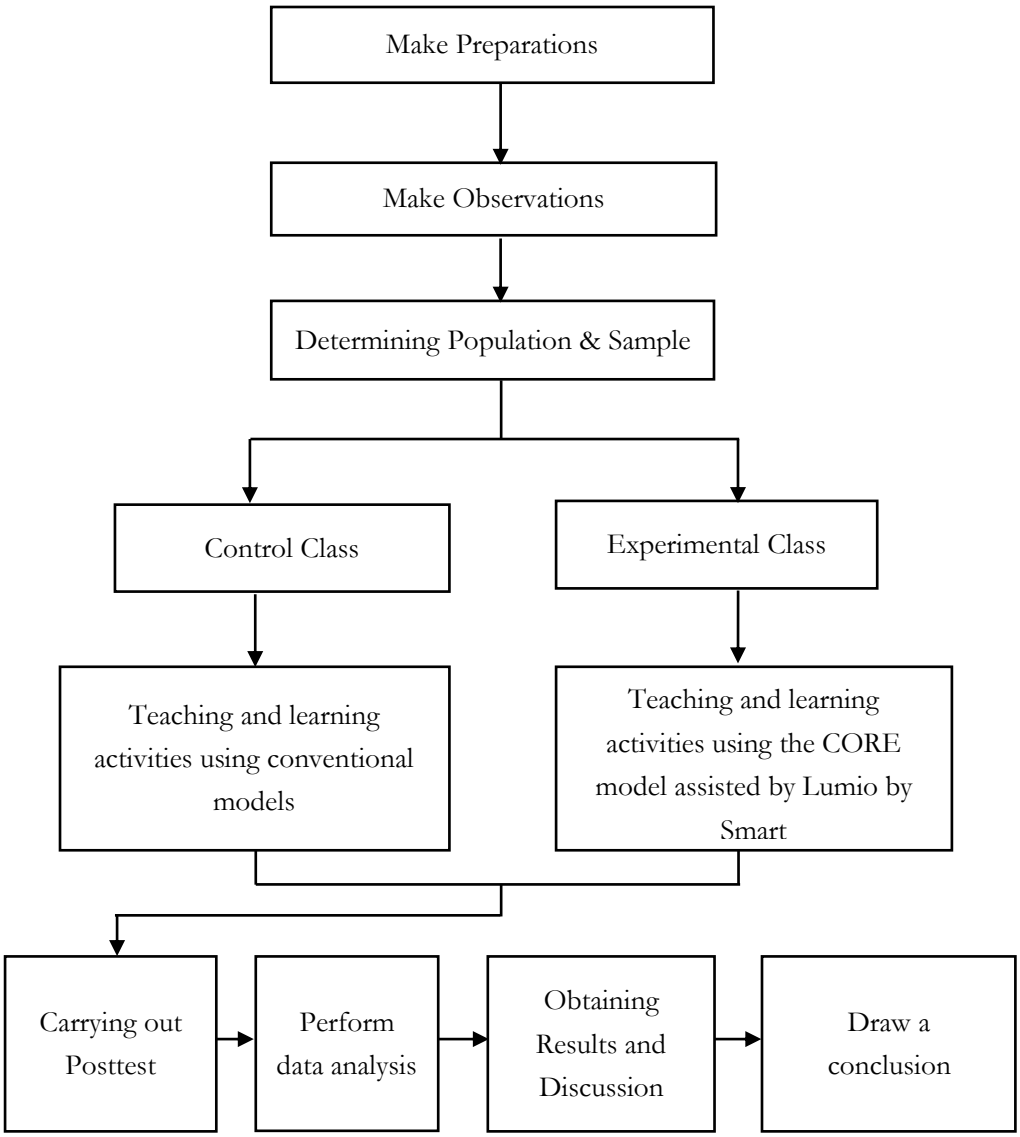

Figure 1. Details of the stages of the research procedure.

4. Results and Discussion

This research took place at SMA Negeri 4 Jember during the odd semester of the 2025/2026 academic year for grade XI students. The main focus of this section is to describe the empirical data obtained from the implementation of the Connecting, Organizing,

Reflecting, and Extending (CORE) learning model with the integration of Lumio by Smart media. To determine the class, a homogeneity test was conducted, as shown in Table 4.1 below.

Table 2. Homogeneity Test Results.

Test of Homogenity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	1.404	5	209	.224

The homogeneity test results in Table 4.1 show a significance value of 0.224 (> 0.05), so the data is stated to have homogeneous variance. Based on these results, the sample was determined using the cluster random sampling technique, with class XI General 2 as the experimental class and class XI Engineering 3 as the control class.

Critical thinking skills in this study were measured through a post-test administered to both the experimental and control classes. The instrument consisted of six descriptive questions structured based on critical thinking indicators in the static fluid material. The results from both classes are then presented in Table 4.2 to demonstrate the comparative effectiveness of the learning models in improving students' critical thinking skills.

Table 3. Students' Critical Thinking Ability Data.

	Control Class	Experiment Class
Number of Students	36	35
Lowest Score	42	50
Highest Score	88	96
Average	64,23	72,26

Based on Table 4.2, the experimental class performed better than the control class. The experimental class's score range (50–96) was higher than the control class's (42–88), with an average of 72.26 exceeding the control class's average of 64.23. This finding indicates that the CORE learning model assisted by Lumio by Smart is more effective in improving students' critical thinking skills.

The collected post-test data on students' critical thinking skills were then analyzed using the Kolmogorov-Smirnov (KS) normality test. This test was conducted to determine whether the students' critical thinking skills data met the assumptions of a normal distribution. A summary of the results of the normality test is presented in Table 4.3.

Table 4. Results Of Normality Test Using K-S.

One-Sample Kolmogorov-Smirnov Test			
		Control Class	Experiment Class
N		36	35
Normal Parameters[a,b]	Mean	64.23	72.26
	Std. Deviation	16.103	13.890
Test Statistic		.173	.205
Asymp. Sig (2-tailed)		.008[c]	.001[c]

Based on the output of Table 4.3, the Kolmogorov-Smirnov test yielded significance values of 0.008 for the control class and 0.001 for the experimental class, respectively. In accordance with the provision that data is considered to deviate from a normal distribution if the p-value is <0.05, the evaluation results indicate that the critical thinking ability data in both classes are not normally distributed. This finding serves as the basis for researchers to use non-parametric statistical methods in the next stage of hypothesis testing.

Because the critical thinking ability data did not meet the requirements for a normal distribution, the analysis to test the research hypothesis was conducted using the Mann-Whitney U test. The use of this non-parametric method aims to ensure the accuracy of statistical conclusions even though the data is not normally distributed. The output of the data processing, which includes the significance value to determine whether the hypothesis is accepted or rejected, is presented in Table 4.4.

Table 5. Results Of Hypothesis Testing Using Mann-Whitney U.

Test Statistics[a]	
	Results of students' critical thinking skills
Mann-Whitney U	439.500

Wilcoxon W	1106.500
Z	-2.207
Asymp.Sig. (2-tailed)	.027

Based on the data in Table 4.4, the Mann–Whitney U test shows a significance value (Sig. 2-tailed) of 0.027. With a significance value smaller than 0.05, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. This indicates that there is a significant difference in critical thinking skills between students in the experimental class and the control class. Thus, it can be concluded that the application of the CORE learning model assisted by Lumio by Smart media has a significant influence on students' critical thinking skills.

Further analysis was conducted to compare students' mastery of physics material in the experimental and control classes based on post-test scores. A description of the distribution of scores and statistics of learning outcomes for both groups is presented in Table 4.5 to facilitate comparison.

Table 6. Physics Learning Outcome Data.

	Control Class	**Experiment Class**
Number of Students	36	35
Lowest Score	30	50
Highest Score	100	100
Average	73,89	84,86

Based on Table 4.5, the post-test results show that the control class, consisting of 36 students, had a score range between 30 as the lowest score and 100 as the highest score. On the other hand, the experimental class, consisting of 35 students, obtained a minimum score of 50 with the same maximum score, namely 100. The measurement results showed a real difference in achievement, where the control class achieved an average score of 73.89, while the experimental class managed to achieve 84.86. These results confirm that the physics learning outcomes in the group that implemented the innovative model were of better quality than the group with the conventional method.

As a prerequisite before conducting the hypothesis test, the students' physics learning outcomes were first validated through a normality test. This step is crucial to verify whether the data distribution follows the assumption of a normal distribution. In this study, the test was conducted using the Kolmogorov-Smirnov method. A summary of the statistical outputs for the normality test is presented in detail in Table 4.6.

Table 7. Results Of The Normality Test Of Physics Learning Outcome Data.

One-Sample Kolmogorov-Smirnov Test			
		Control Class	Experiment Class
N		36	35
Normal Parameters[a,b]	Mean	73.89	84.86
	Std. Deviation	19.752	15.410
Test Statistic		.161	.231
Asymp. Sig (2-tailed)		.019[c]	.000[c]

Based on the statistical output in Table 4.6, the significance value obtained for the control class of 0.019 and the experimental class of 0.000 indicates that both classes do not meet the criteria for normal distribution. This is based on the test provisions where data is considered to deviate from the normal distribution if the significance value is less than 0.05. Thus, the results of this analysis confirm that the distribution of student physics learning outcomes data in both research groups is not normal.

Based on the findings of the Kolmogorov-Smirnov test, which confirmed that the distribution of student physics learning outcomes data deviated from the assumption of a normal distribution, the hypothesis testing procedure was switched to using non-parametric statistics. The instrument applied in this phase was the Mann-Whitney U test. This step was taken to ensure the validity of the comparative analysis between two independent groups in conditions where the data was not normally distributed. The summary of the statistical outputs from the test is presented systematically in Table 4.7.

Table 8. Results Of Physics Learning Outcomes Data.

Test Statistics[a]	
	physics learning outcomes
Mann-Whitney U	431.500
Wilcoxon W	1097.500
Z	-2.239
Asymp.Sig. (2-tailed)	.020

Referring to Table 4.7, the results of the Mann–Whitney U test produced a significance value (Sig. 2-tailed) of 0.020, so it is below the significance level of 0.05. Referring to the decision-making criteria, this value indicates that the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted. Thus, it can be stated that there is a significant difference in the average physics learning outcomes between the experimental class and the control class. The results of this study show that the application of the CORE learning model combined with Lumio by Smart media significantly affects student learning outcomes.

This subchapter discusses the research results based on the statistical data analysis conducted. The discussion focuses on interpreting the statistical test results to explain the effect of implementing the CORE learning model with the aid of Lumio by Smart on high school students' critical thinking skills and physics learning outcomes. This analysis is linked to the results of normality and hypothesis tests, as well as the characteristics of the learning model and the function of the learning media in supporting the learning process.

To support the implementation of the CORE learning model, Lumio by Smart was used as an interactive learning medium. Before being used in the learning process, the media was first tested for validity to ensure its suitability for use. The results of the validity test are listed in Appendix 26, showing a score of 92.5% with an average score of 92.5%. Based on these results, Lumio by Smart was declared valid and categorized as very good. This aligns with the validation criteria proposed by Hidayah et al. (2023), which state that learning media with a feasibility percentage between 81% and 100% are considered very good and suitable for use in learning activities.

The CORE (Connecting, Organizing, Reflecting, Extending) learning model applied to the experimental class was implemented through four systematic learning stages. Theore model is not theoretically rooted in just one constructivist figure, but rather a synthesis of several constructivist approaches. The Connecting stage represents Piaget's cognitive constructivism, Organizing reinforces Bruner's ideas about knowledge structure, Reflecting aligns with Dewey's reflective concept, and Extending reflects Vygotsky's social constructivism. Thus, the CORE model has a strong theoretical foundation because it integrates cognitive, reflective, and social aspects in the knowledge construction process (Nubhan et al., 2022).

This study was conducted to determine the effect of implementing the CORE learning model, supported by Lumio by Smart, on high school students' critical thinking skills in physics. Critical thinking skills were measured using a test instrument developed based on critical thinking indicators. The instrument was developed based on Facione's (2015) theory, encompassing interpretation, analysis, evaluation, inference, explanation, and self-regulation. Before the instrument was used in data collection, a validity test was conducted using a validation sheet, which involved assessment by expert validators. The validity assessment included the suitability of the indicators to the measurement objectives, the accuracy of the material, the clarity of the language, and the construction of the test items. Based on the validity test results listed in Appendix 24, the assessment percentages were 88% and 75%, with an average score of 81.5%. These results indicate that the critical thinking skills instrument is valid and suitable for use in research.

The results presented in Table 4.2 indicate that class XI General 2, the experimental class, had a higher average critical thinking ability score than class XI Engineering 3, the control class. However, the difference in average scores between the two classes was not significant. This situation was triggered by the implementation of the Problem-Based Learning (PBL) model in the control class, which also adopted student-centered learning principles. As emphasized by Widyanto and Vienlentia (2022), instructional activities that prioritize active participation have been shown to stimulate the development of critical thinking processes. This finding aligns with a study by Bastian et al. (2022) which stated that the CORE model strengthens students' reasoning capacity in processing information and

formulating logical inferences. Furthermore, the characteristic of PBL, which utilizes real-world problems as a starting point for learning, plays a strategic role in honing students' problem-solving skills and learning independence.

The implementation of the CORE learning model in the learning process is supported by the use of Lumio by Smart, which has an interactive character. The synergy of interactive media in the instructional process provides space for students to be directly involved, so that the knowledge transfer process is no longer one-way. In line with the argument of Listiyoningrum et al. (2024), the integration of interactive technology plays a crucial role in triggering student cognitive engagement and stimulating the emergence of critical thinking skills. Furthermore, research conducted by Sari et al. (2022) also revealed that the use of Lumio by Smart in learning can improve students' critical thinking skills. Lumio by Smart's specific advantage lies in its ability to present virtual materials, experiments, and a variety of interactive quizzes. This gradually guides students to conduct more in-depth and structured analysis. A visual depiction of Lumio by Smart can be seen in Appendix 14.

The bar chart in Figure 4.1 confirms that the average critical thinking ability of students in the experimental class surpassed that of the control class in each indicator tested. Positive achievements in aspects ranging from interpretation to self-regulation demonstrate that the synergy between the CORE model and Lumio by Smart media can facilitate the development of comprehensive critical thinking skills. In the context of abstract physics material, this combination helps students reason more systematically. This advantage is a direct result of the CORE model's structure, which trains students to connect knowledge (Connecting), organize concepts (Organizing), evaluate thinking (Reflecting), and broaden understanding (Extending) to address new learning challenges.

The results of the normality test in Table 4.3 indicate that the students' critical thinking skills data were not normally distributed. Therefore, the hypothesis test was conducted using the Mann-Whitney U Test, as shown in Table 4.4. This test revealed that the CORE learning model, supported by Lumio by Smart, significantly impacted students' critical thinking skills. This is because each stage of the CORE model is interconnected with critical thinking indicators.

In the connecting stage, students are trained to interpret and relate prior knowledge to contextual problems, thereby strengthening the interpretation indicators. This process requires students to understand the meaning of information, relate it to existing experiences or concepts, and interpret the relationships between ideas logically. This aligns with the findings of Rendi et al. (2024), who emphasized the crucial role of logic in critical thinking. Logical reasoning helps individuals systematically understand and interpret information and examine the relationships between concepts in greater depth. This is supported by Nugraha et al. (2022), who stated that the connecting stage significantly contributes to improving critical thinking skills, particularly in the aspect of interpretation.

The organizing stage is the process where students organize their knowledge by analyzing the relationships between problems and concepts to formulate appropriate solution strategies (Riyanto & Abidi, 2024). Through this stage, students develop indicators of analysis and inference in critical thinking. Strengthening the role of this stage is supported by research by Ulpelina et al. (2024), which shows that CORE learning contributes to improving students' mathematical critical thinking skills, particularly in the aspect of analyzing conceptual relationships and drawing conclusions from the solutions obtained.

Furthermore, the reflecting stage in learning provides students with the opportunity to review and reconstruct previously learned concepts (Rosdiana & Sopianingsih, 2025). During this stage, students also evaluate and refine their ideas, encouraging the emergence of new, more original ideas (Irfani et al., 2026). Furthermore, the reflecting stage is the process by which students restate their understanding coherently and logically, enabling them to explain concepts in their own words (Indrawati & Ardana, 2025). Thus, the reflecting stage supports the development of evaluation and explanation skills in critical thinking.

The extending stage is the stage where students develop and expand their learned knowledge by applying it to situations (Rahayu et al., 2022). According to Sari & Waluya (2023), during this stage, students apply concepts in new contexts, indirectly practicing self-regulation through reflection and drawing conclusions. They can expand their knowledge by providing sound reasons for these conclusions. So that at the extending stage students can practice critical thinking skills, especially inference and self-regulation skills.

Through synergy with the interactive Lumio by Smart platform, an optimal learning ecosystem has been created for the development of students' critical thinking. The CORE model serves as a methodological foundation that trains critical thinking skills systematically

through connecting, organizing, reflecting, and extending activities (Rosdiana & Sopianingsih, 2025). Furthermore, Lumio by Smart media acts as a catalyst, strengthening these cognitive processes through attractive content presentation that is responsive to students' learning dynamics (Rahmayani et al., 2025). In conclusion, the implementation of the CORE model, supported by Lumio by Smart, has been shown to have a significant positive impact on enhancing students' critical thinking skills, particularly in addressing complex challenges in physics.

The results of this study are consistent with various relevant literature highlighting the advantages of the CORE model. Ayudia and Mariani (2022) emphasized that this model is an effective instrument for honing students' critical thinking skills. Furthermore, data support from research by Nofita et al., (2024) shows that the implementation of the CORE model contributed 69% to the improvement of these abilities, supported by the results of the t-test at a significance level of 0.05. The accumulation of these findings states that the CORE model is an effective learning model in stimulating critical reasoning through its structured thinking stages. The consistency of these findings is also supported by research by Warid et al., (2023) which reported a significant effect of the implementation of the CORE model on students' critical thinking skills. This was validated through the results of the Mann-Whitney U test which showed an absolute significance value of 0.000. Based on the accumulation of empirical evidence from these various studies, it can be concluded that the CORE learning model assisted by Lumio by Smart is a strategy that can significantly improve students' critical thinking skills at the high school level.

Another aspect examined in this study is the effect of implementing the CORE learning model combined with Lumio by Smart on high school students' physics learning outcomes. Learning outcomes serve as a reflection of students' mastery of the learning material, which is mapped through a series of ability measurement activities (Fernando et al., 2024). This study documented these achievements using a post-test instrument distributed to both the control and experimental classes. Measurements were conducted using an objective test consisting of 10 multiple-choice questions structured based on the cognitive theory of Anderson & Krathwohl (2015), covering levels from understanding to evaluation. The determination of these cognitive levels was adjusted to the characteristics of the material and the target physics learning outcomes at the high school level.

The data in Table 4.5 shows that the majority of students in the experimental group achieved optimal learning mastery after being taught using the CORE model integrated with Lumio by Smart. This indicates that the implementation of this model has a positive impact on student learning outcomes. The significance of the differences in learning outcomes between the experimental and control groups can be seen in Table 4.7, which shows a statistically significant difference between the two groups.

The improvement in learning outcomes in the experimental class can be explained by the characteristics of the CORE learning model, which positions students as active participants in the learning process (Bohalima et al., 2025). In the connecting stage, the teacher presents contextual problems through the integration of learning videos and facilitates initial discussions using the Shout It Out feature in Lumio by Smart, encouraging students to connect physics material with their experiences and prior knowledge (Syari et al., 2024). This stage falls within the cognitive categories C1 (remembering) and C2 (understanding), helping students build more meaningful initial understanding and facilitating the process of remembering and understanding concepts (Habibah & Sunarmi, 2025). This aligns with Piaget's assimilation theory, which emphasizes that new information is more easily understood when integrated into students' existing knowledge structures, thus optimizing cognitive development (Ulya, 2024).

The organizing stage involves presenting core material using Lumio by Smart, randomly assigning students to groups, and integrating PhET simulations to observe physics phenomena. Students organize their observations and group discussions using the Graphic Organizers feature. This stage involves cognitive processes C3 and C4, where students begin to apply and analyze the information obtained. This is supported by research by Tia et al. (2024) which states that the application of the CORE model has a positive effect on students' ability to analyze and apply physics concepts. According to Sari and Nurhayati (2020), good concept organization in science learning has a significant effect on improving learning outcomes because students find it easier to understand the relationships between concepts and apply them in solving problems. Thus, the organizing stage plays a significant role in improving students' physics learning outcomes in this study.

In the reflecting stage, teachers utilize the Questioning & Reflection feature in Lumio by Smart to review student understanding through reflective questions. Students discuss their reflections in groups and receive feedback from the teacher. This stage falls within the C4 and C5 cognitive domains, helping students identify conceptual misconceptions and deepen their understanding, thus strengthening their knowledge. This is supported by research by Putri et al. (2021), which shows that reflection activities in CORE-based learning can improve learning outcomes because students can evaluate and refine their understanding independently. Therefore, the reflecting stage in this study contributes to deepening understanding of physics concepts, which has a direct impact on improved learning outcomes.

The extending stage is implemented by assigning students to apply learned physics concepts to new problems through the Response feature in Lumio by Smart and by creating digital mini-posters. This stage falls within the C5 cognitive category, which demands evaluative and application skills. This is in line with research by Nurfala et al. (2025), which states that this stage can improve students' ability to reevaluate the problem-solving process, compare various alternative solutions, and assess the effectiveness of applying concepts in different contexts. Furthermore, according to Rahayu et al. (2022), through this stage, students not only understand the concepts theoretically but are also able to apply their knowledge to solve real-life physics problems. Thus, the extending stage strengthens students' physics learning outcomes and their abilities in the evaluation process.

The effectiveness of the CORE model in boosting physics learning outcomes in this study is inseparable from the strategic role of Lumio by Smart as an interactive learning medium. The integration of interactive digital platforms has been proven to improve physics learning outcomes (Arsyad, 2020). The simultaneous improvement of affective and cognitive aspects positively contributed to strengthening student learning outcomes in the experimental class. In line with the results of this study, Sari et al. (2025) confirmed that the use of Lumio by Smart plays a crucial role in optimizing cognitive learning outcomes through interactive presentation of material.

Various studies have shown that the CORE (Connecting, Organizing, Reflecting, Extending) learning model significantly improves student learning outcomes. Susanto (2022) stated that the implementation of the CORE model with the support of interactive media has been shown to improve student learning outcomes. Similarly, Zebua et al. (2024) revealed that the CORE model is effective in boosting student learning outcomes and critical thinking skills, thus contributing to improving the quality of learning in schools. Furthermore, Yulianti (2026) concluded that the application of the CORE model in mathematics learning significantly improved students' conceptual understanding, thus impacting their learning outcomes. Thus, these findings reinforce the CORE learning model's significant effectiveness in improving learning outcomes through a systematic, active, and meaningful learning process.

Based on the description, it can be concluded that the improvement in students' physics learning outcomes in this study was influenced by the integration between the stages of the CORE model and the use of Lumio by Smart media. Each stage of CORE contributes to students' cognitive processes, while Lumio by Smart acts as a supporting tool that strengthens conceptual understanding through visualization, interactivity, and feedback. This finding is consistent with the results of previous studies which stated that the integration of the CORE learning model with Lumio by Smart media was able to significantly improve student learning outcomes. Thus, the integration of the CORE and Lumio by Smart models not only impacts the improvement in learning outcomes quantitatively, but also on the quality of the learning process which is more effective and oriented towards the development of higher-order thinking skills.

5. Conclusion

This study concludes that the implementation of the CORE (Connecting, Organizing, Reflecting, Extending) learning model assisted by Lumio by Smart has a significant positive effect on students' critical thinking skills and physics learning outcomes. The findings indicate that the structured stages of the CORE model effectively facilitate students' conceptual understanding, analytical ability, and knowledge application, while the integration of interactive digital media enhances engagement, visualization, and feedback during the learning process. These results support the research objectives and confirm the proposed hypothesis that the combined approach improves both cognitive skills and academic achievement.

The study contributes to the development of innovative, constructivist-based physics instruction by demonstrating the effectiveness of integrating structured learning stages with interactive technology. However, the research was limited to a specific sample and time frame, which may restrict the generalizability of the findings. Future studies are recommended to involve broader participants, longer implementation periods, and additional variables to further explore the impact of the CORE model assisted by digital media on various aspects of student learning.

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