



IMPLEMENTATION OF THE CLIS-STEM MODEL SUPPORTED BY SCIENCE EDUCATION KITS TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS

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ABSTRACT

Many elementary learners still encounter difficulties in analyzing evidence, formulating reasoned judgments, and solving science-related problems, indicating the need for instructional approaches that promote deeper engagement in learning. This study aims to evaluate the effectiveness of integrating the Children Learning in Science (CLIS) model, the Science, Technology, Engineering, and Mathematics (STEM) approach, and science education kits in enhancing critical thinking skills related to energy conversion. A quasi-experimental design with a pretest-posttest control group was employed, involving 46 fourth-grade students from an elementary school. Data were analyzed using normality and homogeneity tests, paired-sample t-tests, independent-sample t-tests, Cohen's d, and N-Gain scores. Critical thinking skills were measured using a test instrument developed based on Facione's indicators. Results showed that the experimental group receiving CLIS-STEM instruction supported by science education kits achieved significantly higher posttest scores than the control group, $t(44) = 2.989$, $p = .005$, 95% CI [5.88, 30.21], with a large effect size (Cohen's $d = 0.88$). The mean N-Gain score of 0.5755 further indicated a moderate level of improvement. These findings demonstrate that CLIS-STEM learning supported by science education kits is effective, with a substantial practical impact, in fostering critical thinking skills among primary school students.

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1. INTRODUCTION

Changes in the global education system represent a turning point in terms of the educational process itself. More precisely, a new approach to education is now shifting from being teacher-oriented to becoming learner-oriented. The aforementioned change implies that learners are not only expected to gain knowledge but also acquire 21st century skills, including critical thinking, creativity, communication, and collaboration (Alindra, Nuraeni, et al., 2025; Jegstad et al., 2025). Among these competencies, critical thinking plays a pivotal role in enabling students to evaluate information, construct evidence-based arguments, and make informed decisions when addressing various problems (Arifin et al., 2025). However, PISA data show that problem-solving and reasoning skills among Indonesian students are underdeveloped compared to the OECD average (OECD, 2023). Consequently, it becomes necessary to orient the school-based educational system towards developing higher-order thinking skills, including the capability of analyzing and critically solving any problems encountered in the learning process (Kusuma et al., 2024). Critical thinking skills represent a significant prerequisite since students need to learn how to observe a certain phenomenon, analyze its peculiarities, interpret the observed issues, and make decisions based on their findings and personal experience (Sarwanto et al., 2021).

Conceptually, critical thinking is viewed as a rational mental activity in understanding and simultaneously testing the truth of information (Kusuma et al., 2024). Facione (2011) maps this ability into six main, mutually integrated indicators. The first aspect is interpretation, which relates to the ability to grasp and explain the meaning of data or events. The second aspect is analysis, which focuses on the ability to break down and detect logical relationships among pieces of information. The third aspect is evaluation, which serves to test the validity and credibility of an argument. The fourth aspect is inference, which involves the ability to formulate logical conclusions based on available evidence. The fifth aspect is explanation, which refers to the ability to present a line of reasoning in a coherent and systematic manner. The final aspect is self-regulation, which involves the awareness to reflect on, monitor, and refine one's own thinking process independently.

Within the scope of IPAS learning, mastery of all these indicators is crucial for students' success in substantively grasping concepts and relating them to the realities they face daily (Amalia et al., 2021). However, research indicates that students' mastery of critical thinking skills, in particular, has not yet developed optimally. This challenge is linked to traditional educational practices that still view the teacher as the primary source of information and place excessive emphasis on theoretical methods or rote memorization of material. This low level of critical thinking is further exacerbated by students' passive engagement in the classroom (Anggraeni et al., 2022). Students tend to merely passively absorb material without being given sufficient space to explore, analyze problems, or test the validity of the concepts they are learning (Amelia, 2025). As a result, students often face difficulties when they need to logically analyze an argument or draw conclusions from a problem. This one-way communication pattern ultimately limits students' opportunities to practice and sharpen their higher-order thinking skills (Indriani, 2025). In fact, elementary school teachers hold a highly strategic position as key drivers in instilling sustainability values (Alindra, Rahmania, et al., 2025). Therefore, restructuring learning methods through educational innovation is absolutely necessary to enhance students' active engagement while providing meaningful and real-life-relevant learning innovations.

In response to this need, the Children Learning in Science (CLIS) model offers a suitable instructional approach for fostering students' critical thinking skills in classroom learning. Drawing on constructivist principles, the CLIS model views learning as a process through which students actively generate meaning from observation, experience, and environmental interaction. (Amrah et al., 2023). This learning model facilitates students in articulating their initial ideas, conducting independent investigations, testing the validity of their ideas through direct experiments, and restructuring their conceptual understanding based on new findings (Nazilaturrahma et al., 2024). The uniqueness of the CLIS learning model lies in its focus on students-led knowledge acquisition, tracking initial understanding, correcting conceptual errors (misconceptions), and independent mastery of the material. In its implementation, the CLIS learning model operates sequentially through five strategic stages, beginning with the orientation stage, followed by the exploration of initial perceptions, moving to the reconstruction of ideas, continuing with the application of updated concepts, and concluding with an in-depth evaluation of the shifts in understanding that have occurred (Safahi et al., 2021). It is through this structured sequence of phases that students' critical thinking dynamics are intensively stimulated to achieve optimal result (Nurya et al., 2021).

The effectiveness of the CLIS learning model in promoting critical thinking has been documented in various studies. For instance, Rahmawati (2025) found that students demonstrated stronger critical thinking performance following engagement in CLIS-oriented learning experiences centered on experimentation and scientific exploration. In line with these findings, according to the research by (Hilda et al., 2025) the CLIS learning model facilitates students in achieving optimal understanding of the material because it positions students as the primary agents in absorbing the presented content. Nevertheless, the majority of previous studies on the CLIS learning model remain focused solely on the mastery of cognitive content and have not yet integrated it with modern, adaptive learning approaches aligned with 21st-century competencies, such as the STEM approach. By integrating interdisciplinary knowledge with real-world problem solving, STEM-oriented learning contributes significantly to the development of critical thinking and analytical skills required for future competitiveness among young learners (Nuraeni et al., 2024). STEM (Science, Technology, Engineering, and Mathematics) is an educational methodology which involves incorporating these scientific fields into solving problems in a contextual manner (Mailana & Dafit, 2023). The purpose of STEM education is to promote students' critical thinking abilities, creativity, collaborative synergy, and analytical skills in dealing with different types of problems. One of the important foundations of STEM education is the use of the Engineering Design Process (EDP), which encompasses a number of steps such as constraint identification, solution conceptualization, prototyping, experimenting, analysis, and redesigning (Safitri et al., 2024). In using EDP, students are enabled to break down the problem into simpler parts, analyze the effectiveness of solutions, draw inferences from actual situations, and critically assess the whole process and learning experience (Souysaart et al., 2026).

According to Rahmawati et al (2025), there exists a study which emphasizes the utilization of appropriate STEM learning as a means of enhancing the critical thinking ability of students through creation of a learning ecosystem focused on solving problems in the world outside. With respect to this notion, the conceptualization of engineering design process stages within the STEM domain is greatly associated with the framework of critical thinking skills provided by Facione (2011) focusing on analysis, evaluation, inference, and self-regulation domains. The development

and testing of solutions in STEM framework also enhances the development of critical explanation and interpretation abilities among students through group discussions and result dissemination (Sapphira & Sari, 2024). From this perspective, it can be said that there is an immense need for application of STEM framework to optimize critical thinking skills among children. Referring to previous research, the application of the Children's Learning in Science (CLIS) model is generally practiced independently or partially within the scope of science education (Rahmawati et al., 2022). On the other hand, the utilization of the STEM approach has so far been more frequently integrated with other learning models (Lestari et al., 2024). This indicates that the combination of the CLIS learning model with the STEM approach in the elementary school setting remains largely unexplored. Furthermore, the use of the science educational kit as a supporting tool in STEM learning is still minimal, particularly regarding energy transformation topics.

Beyond pedagogical models and strategies, the presence of learning instruments or media plays an equally crucial role in sparking students' active participation during the learning process (Sastradewi & Agung, 2022). Optimizing concrete and interactive teaching aids can simplify students' understanding of abstract theoretical concepts while fostering their interest in the subject matter. These tools provide students with the opportunity to test various alternative solutions and evaluate their effectiveness directly, thereby positively impacting the sharpening of their logic and analytical reasoning (Angelia et al., 2022). Furthermore, learning media oriented toward exploratory activities have proven effective in encouraging students' active engagement during the learning process, which ultimately leads to an improvement in students' critical thinking skills (Rochmawati & Muslim, 2022). Epistemological synergy between the CLIS teaching model, the STEM concept, and science educational kits ensures optimal conditions for cultivating students' critical thinking skills, especially with regard to energy transformation. Students, according to the CLIS method, become active subjects of acquiring knowledge in terms of going through the stages of orientation, eliciting ideas, restructuring, applying, and reviewing those ideas (Hilda et al., 2025). Combining this technique with elements of STEM makes the whole process much more challenging because students are not only supposed to grasp certain scientific facts and theories, but also think about ways in which they can be applied, design technological instruments, and do engineering tasks along with solving mathematical problems related to the gathered data (Mintii, 2023). At this point, science kits play the role of catalysts for students' cognition. Kits connect abstract theories and the real world by creating a tangible object that needs to be manipulated and analyzed in order to prove or deny the hypothesis formulated by students based on prior knowledge. Since this manipulation leads to cognitive conflicts between students' assumptions and real-life facts, they start analyzing variables, testing the accuracy of the experiment result, and making conclusions – processes which help in developing to achieve through conventional, one-way, rote-learning methods.

The application of the findings from this study is not limited to the confines of the learning environment but is strategically significant in terms of policy formulation, curriculum improvement, and professional development of teachers in the new era of 21st century education. Successful implementation of the CLIS model, STEM concept, and use of science educational kits in this study can be used as an adaptive approach in other institutions as well, especially those where the objective is to produce students who can think critically, as required by the new curriculum. The outcomes of this study will also have practical applications in terms of providing insights to the authorities regarding resource allocation for procurement of affordable but quality

science educational materials along with improving teacher training programs to include not just expertise in content but also pedagogical approaches for developing higher-order cognitive skills. By documenting in detail implementation challenges, such as teachers' readiness to manage dynamic classrooms or limited instructional time, this study also offers practical recommendations and mitigation strategies that can be adopted by schools with limited resources. Ultimately, this research contributes to a paradigm shift in science education from a transmissive to a transformative approach, aiming to cultivate a younger generation that does not merely memorize facts about energy transformations but also possesses intellectual resilience, analytical acuity, and innovative capacity to confront and solve complex scientific and technological problems in the real world.

To date, limited research has empirically examined the integration of the CLIS model with the STEM approach supported by science education kits in improving elementary students' critical thinking skills, particularly on the topic of energy conversion. Beyond simply combining three existing components, this integration introduces a distinct pedagogical mechanism. CLIS positions students as active knowledge-constructors, STEM extends this into applied problem-solving, while the science education kits act as a cognitive catalyst that triggers conflict between students' prior assumptions and observed phenomena driving the analytical and inferential processes central to critical thinking. This synergistic mechanism positions the present study as one of the first attempts to operationalize this integration within an elementary school setting. This study therefore aims to fill this gap by evaluating the effectiveness of the CLIS-STEM model supported by science education kits in enhancing fourth-grade students' critical thinking skills related to energy conversation.

2. METHOD

In order to find out the contribution of the learning model in developing critical thinking among students, quasi-experimental design was used in this research. Quasi-experimental design is used when random allocation of the participants is not possible because of the field conditions but, at the same time, it helps in examining the causal relationships between the variables in question (Anantasia & Rindrayani, 2025). The pretest-posttest control group approach was implemented to assess the impact of the intervention. Individuals were separated into an experimental group that received the intervention and a control group that acted as a reference for comparison. This particular design was chosen to facilitate an unbiased evaluation of the initial outcomes (pretest) before the intervention and the concluding outcomes (posttest) following the intervention for both groups. Specific information about this research design is shown in Table 1.

Table 1. Pretest–Posttest Control Group Design

Group	Pre-test	Treatment	Posttest
Experimental	O1	X	O2
Control	O3	-	O4

Where, O1 and O3 is Pretest, O2 and O4 is Posttest, and X is intervened with the CLIS learning model integrated with STEM using science educational kits.

Based on Table 1, the study was carried out in the 2025/2026 academic year targeting fourth-grade students at a government elementary school in Purwakarta District. Fourth-grade students at the elementary school were set as the population for this study. Students were selected through purposive sampling based on school administrative availability and feasible scheduling, resulting in two intact fourth-grade classes designated as the experimental and control groups. Baseline comparability between the two groups was confirmed by an independent-sample t-test on pretest scores, which showed no statistically significant difference between the control ($M = 55.87$, $SD = 20.39$) and experimental ($M = 54.70$, $SD = 18.09$) groups, $t(44) = 0.207$, $p = .837$. The research participants were divided into two groups where the experimental group had 23 learners and control group comprised 23 learners too. In teaching the experimental group, Children Learning in Science model (CLIS) integrating STEM approach together with use of science education kits while cooperative learning model was applied to the control group. The lessons delivered involved concepts under energy transformations in the fourth-grade IPAS program.

The study employed tests and documentation as the primary sources of data collection. Information regarding students' critical thinking development was obtained from measurements conducted prior to and following the intervention. The test instrument was designed with reference to Facione's (2011) critical thinking framework, encompassing the dimensions of interpretation, analysis, evaluation, inference, explanation, and self-regulation. This model was adapted into an instrument framework that would match the curriculum of energy conversions, as well as the intellectual capabilities of young children at an elementary level. The assessment tool used had twelve multiple-choice questions, where each question had four answers choices. Before implementation, the 24 items trial instrument was administered to 21 students for item analysis. Item validity was assessed using product-moment item-total correlation, with coefficients ranging from 0.065 to 0.745; 16 items were valid, while 8 were excluded. Reliability using the split-half method with Spearman-Brown correction yielded a coefficient of 0.75, categorized as high according to Guilford's criteria. The difficulty index ranged from 19.05% to 80.95%, consisting of 8 easy, 12 moderate, and 4 difficult items, while discrimination power ranged from 0% to 83.33%. Based on these criteria, 16 items were retained, from which 12 were selected for the final instrument, with two items representing each of the six critical-thinking indicators.

Furthermore, data collected was analyzed quantitatively through both descriptive and inferential statistical methods. Through the descriptive statistical method, the mean value of the students' critical thinking skills was determined using the N-gain score formula. N-gain analysis was conducted to evaluate the magnitude of improvement in learners' performance level following the instruction. The effectiveness of the intervention was subsequently determined through between-group comparison, taking baseline differences into account. The findings of N-gain scores were subsequently grouped into three groups high, moderate, and low. The criteria for the classification were based on those set forth by Richard G. Hake (1999) in Table 2.

Table 2. N-Gain Categories

N-Gain (%)	Effectiveness Category
≥ 0.7	High
0.3–0.7	Moderate
<0.3	Low

(Source: Hake, 1999)

Based on Table 2, data normality and homogeneity assessments were initially conducted as essential preliminary evaluations needed to apply parametric statistics before testing hypotheses. Once it was verified that the data satisfied the necessary statistical criteria, the analysis proceeded with both paired-samples and independent-samples t-tests. The paired-samples t-test was used to investigate the differences between the scores from the pretest and posttest within each group, whereas the independent-samples t-test was utilized to assess whether there were noTable differences in critical thinking skills between the two groups after the intervention. In this research, statistical data processing was carried out using SPSS version 25 software on the Windows operating system. Descriptive methods were applied for analyzing documentation data to reinforce the findings.

3. RESULTS AND DISCUSSION

The implementation of the CLIS model combined with STEM-focused education and science learning kits has led to several significant outcomes regarding the enhancement of students' critical thinking abilities related to energy transformations. The research indicated a substantial improvement in the critical thinking skills of the group that participated in the experiments after they finished the course. This was highlighted by the noTable difference observed between the scores in their pre- and post-tests. Furthermore, a comparative analysis revealed marked disparities in critical thinking skill achievements between the experimental group and the control group. This conclusion was backed by data obtained from normality and homogeneity tests, paired-samples t-tests, independent-samples t-tests, and N-gain analysis. As a result, the findings demonstrate the effectiveness of utilizing the CLIS model along with STEM educational activities and science kits as a means of fostering critical thinking skills in elementary school students.

The normality assessment was conducted to verify that the data distribution for this research met the requirements of a normal distribution. The Shapiro-Wilk test approach was utilized for the analysis because the sample included fewer than 50 students. A detailed summary of the normality test results for both pretest and posttest data is shown in Table 3.

Table 3. Result of the Normality Test for Pretest and Posttest Data

Group	Data	Sig. Shapiro-Wilk	Description
Control	Pretest	0.062	Normal
	Posttest	0.179	Normal
Experimental	Pretest	0.236	Normal
	Posttest	0.092	Normal

(Source: SPSS Version 25 Data Analysis Result)

Based on Table 3, according to the outcomes of the normality test shown in Table 3, it can be clearly observed that the significance values (p-values) recorded by all the data groups were higher than the stipulated threshold of 0.05. This shows that the pre-test and post-test data collected from both the experimental and control classes were normally distributed and thus could meet the necessary prerequisites for testing via parametric analysis. Once it had been determined that the collected research data met the requirements of normality, the next procedural step would be that of homogeneity testing. The purpose was to determine if the variances in the experimental and control groups were equal before moving on to the actual process of hypothesis testing.

Table 4. Homogeneity Test Result

Based on Mean	Levene's Statistic	df1	df2	Sig.	Notes
Control	3.335	1	44	0.075	Homogeneous

(Source: SPSS Version 25 Data Analysis Result)

Based on Table 4, considering the numbers that have been provided in Table 4, the result of homogeneity test obtained a significance value of 0.075. From the result that have been presented, it can be noted that there is a significance value that is not 0.05. This means that the variance for the numbers considered in the research is indeed homogeneous, meeting the most significant condition prior to conducting a parametric test. As is shown from the result of the test for normality and the test for homogeneity, all values meet the conditions required for application of the parametric test. Based on this information, data analysis in the subsequent stage included application of a paired sample t-test for finding out whether there was any improvement in the critical thinking skills of students.

Table 5. Result of the Paired-Sample t-Test for the Experimental Class

Group	Data	Mean	t	Sig. (2-tailed)	Notes
Control	Pretest	55.87	-21.939	0.000	There is a significant difference
	Posttest	59.87			
Experiment	Pretest	54.70	-12.290	0.000	There is a significant difference
	Posttest	77.91			

(Source: SPSS Version 25 Data Analysis Result)

Based on Table 5, it is clear from the data available in the Table that while the pre-test average score for the control group was 55.87, it changed to 59.87 in the post-test. In case of the experimental group, however, while its pre-test average score was 54.70, its post-test score increased to 77.91. The paired-sample t-test showed statistically significant pretest-posttest improvement in both groups ($p = 0.000$). However, the magnitude differed considerably: the control group's mean score rose by only 4.00 points (55.87 to 59.87), while the experimental group's rose by 23.21 points (54.70 to 77.91). This suggests that beyond the general learning gain seen in both classes, the experimental group showed a notably larger increase, consistent with an additional effect of the CLIS-STEM intervention, as confirmed by the between-group comparison. While both groups made gains in terms of critical thinking ability, the gains of those in the experimental group were greater compared to the control group participants. The difference in

pretest and posttest scores suggests significant improvements in mean performance of students undergoing CLIS learning through STEM. This shows that the application of the CLIS method had a positive influence on the development of critical thinking skills among the participants. An independent samples t-test was used to investigate the differences between the two groups after intervention. The test results are shown in the following Table 6.

Table 6. Result of the Independents-Samples t-Test

Group	Data	Mean	Sig. (2-tailed)	Notes
Control	Posttest	59.87	0.005	There is a significant difference
Experimental	Posttest	77.91		

(Source: SPSS Version 25 Data Analysis Result)

Based on Table 6, the outcome from the independent sample t-test was recorded as 0.005. This significance level of 0.005 was lower than the predetermined threshold of 0.05, resulting in the null hypothesis being dismissed. Thus, there is a no difference between the experimental group and the control group. Additionally, it was observed that students who participated in the CLIS learning program combined with STEM demonstrated superior critical thinking results compared to their peers in the control group. The combination of the CLIS learning program, STEM, and science educational kits enhances the students' critical thinking skills. According to the findings, students in the experimental group outperformed those in the control group regarding their critical thinking abilities. To evaluate the degree of learning improvement for each group, an N-gain analysis was performed. The results are presented in the Table 7.

Table 7. Result of the N-Gain Test of Students' Critical Thinking Skills

Variable	N	Min.	Max.	Mean	Std. Deviation
N-Gain Score	23	0.21	1.00	0.5755	0.26197
N-Gain Percents	23	21.43	100.00	57.5506	26.19666

(Source: SPSS Version 25 Data Analysis Result)

Based on Table 7, from the calculations of the N-Gain scores as provided in Table 7, the mean N-Gain score computed is 0.5755 or 57.55% which is classified as moderate according to Hake's criteria. This result indicates that the implementation of CLIS in the teaching-learning process was moderately effective in improving students' critical thinking skills. Therefore, from this N-Gain analysis result, the findings are consistent with the findings from the statistical analysis in which it has been concluded that the use of CLIS along with STEM assisted by science media kit enhances critical thinking skills of students. Data analysis was conducted in greater depth by examining not only the overall scores but also each aspect of critical thinking ability based on Facione's (2011) categories. This further analysis aimed to examine the level of improvement in each indicator so that the aspects showing the most significant development, as well as those showing relatively lower improvement, could be identified following the application of the treatment in the experimental group. The development of each of these indicators is presented systematically in Figure 1.

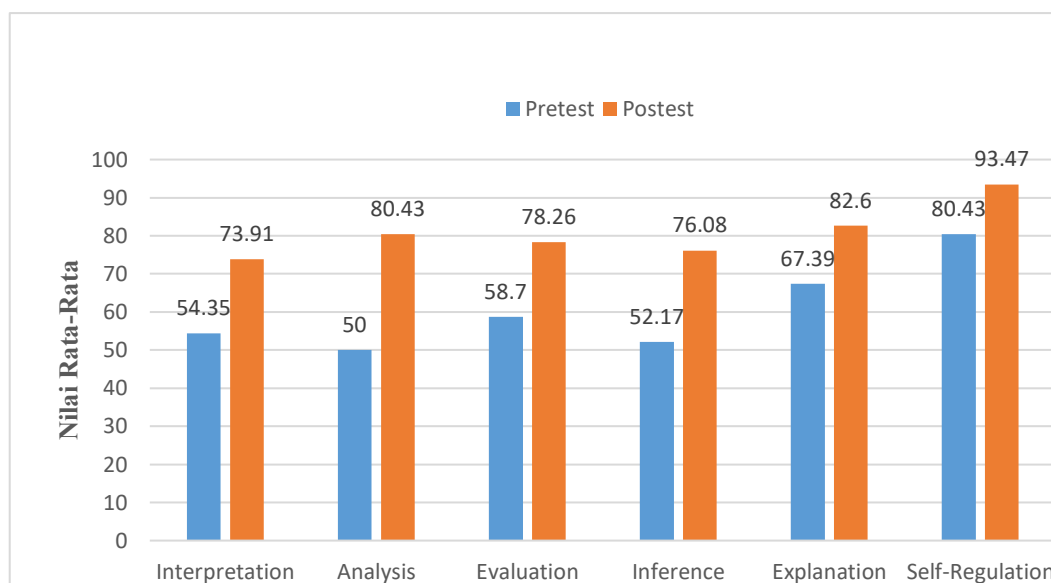


Figure 1. Mean Pretest and Posttest Scores of Critical Thinking Skills Based on Indicators According to Facione

Based on Figure 1, findings from the analysis of mean levels of critical thinking ability of the experimental group according to the categorization made by Facione (2011) show that there was a positive increment for all aspects of the indicators after the pre-test and post-test using CLIS model with STEM approach and education kits for sciences. The increment was equally distributed to all aspects of interpretation, analysis, evaluation, inference, explanation, and self-regulation. In the interpretation aspect, the average score rose from around 54 on the pretest to 73 on the posttest. The analysis aspect recorded growth from around 49 to 79, while the evaluation aspect jumped from around 58 to 77. Next, the average score in the inference aspect increased from around 52 to 75, while the explanation aspect surged from around 67 to 82. The most significant improvement was observed in the self-regulation aspect, where the score range of 80 on the pretest soared to 93 on the posttest. Overall, these data demonstrate that the integration of the CLIS learning model with STEM, supported by science educational kits, effectively enhances students' critical thinking skills across all dimensions as defined by Facione (2011).

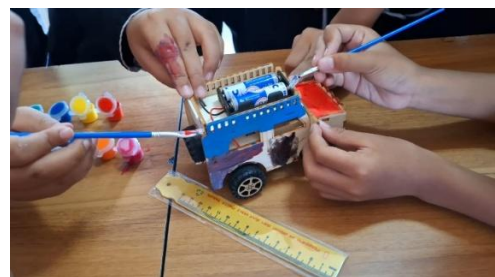
The result of this study indicates that the integration of CLIS and STEM, supported by science learning tools, has an effective influence on improving students' critical thinking skills regarding the theme of energy conversion. This finding suggests that learning activities that position students as the primary actors through data exploration, discussion forums, experiments, and problem-solving are capable of maximally supporting the strengthening of students' critical thinking skills. These research findings reinforce the constructivist theory proposed by (Mulyani & Agusminarti, 2026) study, which emphasizes that knowledge construction is built through the engagement of the five senses in learning and active interaction with the surrounding ecosystem. This is due to the characteristics of the CLIS approach, which encourages students to formulate initial concepts, test their understanding through observation tasks, and then reconstruct those concepts based on direct observation (Mulyani & Agusminarti, 2026). This enhancement process is further solidified by the implementation of the STEM approach, as students are confronted with real-world problems in daily life that compel them to analyze an issue, design alternative solutions,

test the resulting products, and draw conclusions based on field evidence. Specifically, the Engineering Design Process embedded in the STEM approach requires students to identify constraints, conceptualize solutions, and test prototypes, stages that correspond directly to the analysis, evaluation, and inference indicators of facione's framework. This close alignment explains why the experimental group's largest gains occurred in these dimensions, as the iterative design-test-redesign cycle repeatedly demands that students analyze evidence, evaluate the validity of their solutions, and infer logical conclusions from experimental outcomes.

Additionally, the use of science educational kits provides a more realistic and concrete learning visualization, thereby simplifying students' understanding of energy conversion concepts. The science educational kits used in this experiment consist of energy conversion demonstration tools that students can assemble, connect, and simulate independently. These educational tools include an electric motor-powered boat model, a simple lighting setup, a mini electric vehicle, and an electric motor-powered fan model. The visualizations or documentation of the use of these science educational kits in the activity are shown in Figure 2.



(a)



(b)



(c)

Figure 2. Science Educational Kits

Based on Figure 2, through the optimization of these science kits, students do not merely absorb the concept of energy conversion theoretically, but can directly observe the transformation of electrical energy into kinetic (motion) energy or light energy. Students' active involvement in constructing, testing, and investigating how the kits work provides an educational experience that is both *hands-on* and *minds-on*. These activities encourage students to make in-depth observations, formulate problems, design alternative solutions, test the resulting products, and draw conclusions from their findings. This process stimulates students to absorb the material more effectively while developing critical thinking skills, particularly in the areas of analysis, evaluation, inference, and

self-regulation. Furthermore, the use of science educational kits has proven effective in boosting students' interest in learning because they gain real-world learning experiences relevant to daily life. This is evident from the growth rate in each critical thinking variable. Efficiency in adopting the CLIS learning model based on STEM using the science educational kit is confirmed by the result obtained during the performance of an independent samples t-test, where there is a high degree of statistical significance when comparing the treatment class and the control group (significance $0.005 < 0.05$). The average score for the posttest in the treatment class achieved 77.91, surpassing the average score for the posttest in the control class, which was 59.87. The difference in result implies that a learning model based on students' activities has a higher degree of effectiveness in fostering critical thinking than other types of learning models. However, it can be stated that there has been an improvement in critical thinking abilities in the comparison class despite its lower degree of effectiveness than that of the treatment class. This has been due to knowledge transfer, memory of the previous pretest, and self-directed activities undertaken by the students.

The findings of Rahmawati and Pitra (2025) indicate that CLIS effectively contributes to the development of critical thinking skills through structured exploration and experimental activities. Furthermore, these findings reinforce the research by Lestari et al. (2024) which underscore that the STEM approach is highly effective in fostering critical thinking skills and problem-solving proficiency through contextual learning experiences. Therefore, this study not only reinforces previous research but also provides concrete evidence that the CLIS learning model, the STEM approach, and the use of science educational kits constitute a strategic formula that serves as an effective starting point for IPAS learning. The empirical validity resulting from the synergy between the CLIS model, the STEM approach, and these science educational kits provides a solid foundation for pedagogical transformation in Natural and Social Sciences (IPAS) education, particularly when students are confronted with abstract concepts such as energy transformation concepts that often lead to misconceptions if taught solely through verbal instruction. The success of this strategy is inseparable from how the educational kit functions, enabling students to visualize energy flow, energy transformation, and the law of conservation of energy through the manipulation of real objects, so that their cognitive processes move from the concrete to the abstract in a smoother and more structured manner.

In this context, the CLIS stages serve as a systematic framework ensuring that every student's interaction with the kit is not merely playful but guided by probing questions that demand in-depth analysis, evaluation of experimental result, and critical reflection on the gap between their initial predictions and the observed phenomena (Vistara et al., 2022). The integration of STEM elements further enriches this experience by encouraging students not only to understand "what" and "why" an energy change occurs, but also "how" to engineer simple, efficient solutions or tools to harness that energy, thereby honing their critical thinking skills through the cycle of design, testing, failure, and iterative improvement—the very essence of genuine engineering and scientific practice (Canovan & Walsh, 2026). In particular, the no increase in the self-regulation indicator can be attributed to the reflective component embedded in the STEM design cycle, in which students must continuously monitor and revise their own reasoning after each round of testing and failure, a process that mirrors the metacognitive awareness central to self-regulation as defined by Facione (2011). The long-term implications of adopting this learning model are highly strategic in efforts to prepare the younger generation to meet the demands of 21st century competencies, where

critical thinking, creativity, collaboration, and communication (4C) form the foundation of the future workplace and social life.

Several limitations should be acknowledged. The study was conducted in a single school using purposive sampling with a relatively small sample size and no random assignment, which limits generalizability and may introduce selection bias. The CLIS-STEM intervention was implemented as a bundled treatment, so the individual contribution of each component cannot be isolated, and since each class was taught by a different teacher, classroom-level effects cannot be fully ruled out. Additionally, the twelve-item multiple-choice instrument may not have sufficiently captured all six dimensions of critical thinking. Future studies should employ larger, randomly assigned samples across multiple schools and more extensive instruments to strengthen these findings.

4. CONCLUSION

The overall analysis reveals that the learning process based on the CLIS learning model integrated with STEM and using science educational kits does not only help the students acquire the energy transformation knowledge but also plays an important role in enhancing the students' critical thinking ability. Theoretically speaking, the result obtained in the study confirm the ideas associated with the constructivist theory that states that direct experience can contribute to better thinking abilities of the students. On the other hand, from the practical point of view, this learning process can be used as an example for the future implementation of science education that will help develop 21st century skills among the students at the elementary school level. Thus, the implementation of the CLIS learning model integrated with STEM using science educational kits can be treated as an example of innovation in science education.

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