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Enhancing Physics Learning Outcomes through a Reflective Learning Model Supported by Logic Inference Worksheets: A Classroom Action Research Study

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Abstract: Improving conceptual understanding and reasoning skills in physics requires instructional strategies that go beyond procedural learning. Reflective learning models offer promising frameworks for fostering student engagement, critical thinking, and metacognition. However, the integration of structured reflection with logic-based instructional tools remains underexplored, particularly in middle school physics contexts. This study aims to examine the effectiveness of a reflective learning model supported by logic inference worksheets (LKS) in enhancing student learning outcomes in physics. A classroom action research design was implemented in two cycles at SMPN 18 Mataram, involving 21 students from Class VIII B. Each cycle included the phases of planning, action, observation, and reflection. Data were collected using observation sheets, validated learning outcome tests, and student reflection logs. Instructional improvements were made between cycles based on reflective evaluations. Quantitative results indicated an increase in the average score from 75.15 (Cycle I) to 79.48 (Cycle II), with classical completeness improving from 61.90% to 85.71%. A paired sample t-test confirmed the statistical significance of the gain ($t(20) = 4.16$, $p < 0.001$). Qualitative findings revealed improvements in students' logical reasoning, metacognitive behavior, and classroom engagement. Students demonstrated greater ability to justify answers, articulate reasoning, and collaborate during inference tasks. These outcomes highlight the pedagogical potential of integrating reflective structures and logic-based worksheets in science instruction. The study contributes to reflective pedagogy by offering an evidence-based, adaptable instructional model for developing higher-order thinking skills in physics education.

Keywords: Reflective Learning Model; Logic Inference Worksheets; Physics Education; Classroom Action Research; Higher-Order Thinking Skills

INTRODUCTION

Education is a fundamental driver of national development, and its quality directly influences the caliber of human resources that will shape the future. In line with this, the Indonesian government continues to implement various reforms aimed at improving the national education system. Among these efforts are updates to regulations such as Government Regulation No. 19 of 2005 concerning National Education Standards, emphasizing competence-oriented learning and a shift from product-based to process-based education. In science education, particularly physics, this shift requires innovative approaches that foster not only content mastery but also critical thinking, metacognition, and problem-solving skills.

Recent discourse in science education emphasizes that effective learning should not be limited to the transmission of knowledge but should involve active participation,

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reflection, and personal engagement with the learning content. Reflective learning models have emerged as an effective pedagogical approach to meet these goals. These models enable students to review and analyze their learning experiences, promoting deeper cognitive processing, stronger conceptual understanding, and greater learner autonomy. According to Suprijono (2010), reflective learning trains students to think critically and definitively, forming conclusions based on thoughtful evaluation of experiences. Reflection, as Huda (2013) elaborates, provides individuals with opportunities to articulate what they have done and how they have learned, thus enhancing their capacity to internalize content meaningfully.

The benefits of reflective learning are supported by a growing body of empirical research. Rapanta and Pisano (2021) found that structured reflection, particularly in online settings, enhances student engagement and self-awareness, significantly improving academic performance in science-related courses. Chen et al. (2023) further advocated for the inclusion of metacognitive strategies in early science education, showing that reflective inquiry not only fosters conceptual understanding among students but also contributes to professional development among educators. In secondary education, Holley and Park (2020) emphasized that reflective and constructivist teaching practices facilitate integration of disciplinary knowledge with environmental and societal themes, making science more relatable and meaningful. These findings are reinforced by Möller et al. (2021) and Rees et al. (2023), who identified that structured reflection fosters critical thinking, enabling students to engage with complex scientific phenomena more effectively.

Despite growing interest in reflective learning, limited attention has been paid to its integration with logic inference worksheets (LKS) in the context of middle school physics instruction. Much of the literature on reflective practice focuses either on higher education or on generic applications across various subjects. For instance, Woldt and Nenad (2021) examined reflective writing in dental education, demonstrating its positive effects on critical thinking and motivation. Likewise, Nur et al. (2020) explored the role of feedback in promoting reflection within collaborative learning environments. However, these studies stop short of evaluating the role of logic inference-based worksheets in physics classrooms, especially at the junior secondary level. This represents a notable research gap: How effective is the reflective learning model when combined with logic inference worksheets in improving physics learning outcomes at the middle school level?

This gap is particularly concerning given the limitations of traditional worksheet-based learning. Conventional worksheets often prioritize factual recall and algorithmic procedures, which limit students' ability to engage in critical inquiry and self-assessment. According to Syukri et al. (2023), such worksheets do not challenge students to reflect on their problem-solving processes or understanding, thereby encouraging rote memorization over conceptual comprehension. Walanda et al. (2023) further noted that conventional LKS fail to promote collaboration or dialogue, two key components of 21st-century learning skills. Without reflective elements, students often become passive recipients of knowledge, lacking the motivation and autonomy needed for deep learning (Setiyani et al., 2023).

To address these limitations, scholars have proposed incorporating reflective components into worksheet design. Utami et al. (2023), for example, suggested that worksheets should include structured opportunities for students to discuss, compare, and reflect on their learning experiences. Such designs not only promote metacognition but also encourage active engagement with scientific content. Additionally, integrating logic inference tasks into worksheets can further enhance students' reasoning abilities. These tasks require learners to draw conclusions from data, apply theoretical principles, and justify their problem-solving approaches—skills that are essential in scientific inquiry.

The role of logical inference in science education has been increasingly emphasized in recent studies. Maghribi and Aristiawan (2023) demonstrated that students engaged in logic-based debate models showed significant improvements in scientific thinking, particularly in their ability to articulate and defend conceptual claims. Similarly, Shuhaiber et al. (2021) found that logical reasoning abilities—both inductive and deductive—positively correlate with student achievement in physics, suggesting that inference skills are instrumental in mastering complex scientific concepts. By fostering logical inference, educators not only enhance students' critical thinking but also bridge the gap between abstract theories and real-world applications.

From a theoretical standpoint, reflective learning models are rooted in constructivist learning theory, which posits that knowledge is actively constructed through experience and reflection rather than passively absorbed. As Ahmedi et al. (2023) explain, students learn more effectively when they are encouraged to connect new information with prior experiences and to reflect on the learning process itself. Subaedah et al. (2023) argue that reflection is critical to developing metacognitive skills, which are essential for regulating learning strategies and assessing one's own progress. Reflective learning also thrives in collaborative environments, where students can engage in dialogue, share perspectives, and co-construct understanding (Kesler et al., 2021). Ngah et al. (2019) added that this environment fosters intrinsic motivation and learner autonomy—qualities that are central to lifelong learning.

Integrating logic inference worksheets into reflective learning models can strengthen this constructivist framework. Such worksheets differ from traditional LKS by prompting students to think analytically, reason through problems, and validate their conclusions with evidence. While the empirical literature on logic inference-based LKS is still emerging, related studies provide encouraging results. Melawati et al. (2022) showed that problem-based learning worksheets significantly improved students' problem-solving abilities and learning outcomes. Zuhra et al. (2021) reported that guided inquiry worksheets enhanced conceptual understanding in science, while Hatiti et al. (2021) found that HOTS-oriented blended learning LKS yielded superior cognitive performance compared to traditional methods. Chutami and Suhartini (2021) further confirmed that LKS are effective in linking theoretical knowledge with hands-on learning, especially in science education.

Although the current literature lacks direct studies on logic inference-based LKS, the cumulative findings suggest that such instructional tools, when paired with reflective pedagogy, can yield meaningful improvements in science learning. These worksheets not only reinforce core content but also cultivate reasoning, autonomy, and self-regulated learning—attributes essential to developing scientifically literate citizens.

Therefore, this study aims to investigate the effectiveness of a reflective learning model supported by logic inference worksheets in improving physics learning outcomes among junior secondary students. The study is premised on the notion that reflection and logical reasoning, when integrated into learning activities, foster deeper engagement, better understanding, and improved academic performance. In doing so, this research addresses a critical gap in the literature and contributes to the advancement of instructional practices that align with national education reform goals.

METHOD

This study employed a Classroom Action Research (CAR) design, which aims to improve the quality of instructional practices and student learning outcomes through iterative, reflective cycles. CAR is especially effective in educational contexts where real-time feedback and practice-based interventions are essential for enhancing classroom engagement and achievement. The research was conducted over the even semester at SMPN 18 Mataram, involving Class VIII B as the study subject. The CAR approach consisted of two full cycles, each containing four key phases: planning, action, observation, and reflection.

Research Design

In line with best practices in CAR (Yusron et al., 2023; Utami et al., 2023), the research process was structured into two complete cycles, enabling continuous refinement of teaching strategies based on observed outcomes. Each cycle was designed as follows:

1. **Planning**: In this phase, the researchers prepared instructional tools including Lesson Plans (RPP) and Logic Inference Worksheets (LKS). The materials were designed to integrate reflection and logical reasoning tasks to support students' critical thinking in physics.
2. **Action (Implementation)**: Lessons were conducted using the reflective learning model supported by LKS. This involved student-centered activities that emphasized inquiry, reasoning, and articulation of ideas based on physics content.
3. **Observation**: Researchers used structured observation sheets to record student engagement, participation, and teacher performance during the learning process. Observations focused on both individual and group activities to capture a holistic view of instructional effectiveness.
4. **Reflection**: At the end of each cycle, reflective sessions were held to evaluate the success of the intervention and determine necessary adjustments. These sessions involved both researcher reflections and informal feedback from students and fellow teachers, as recommended by Teresa & Febria (2023) and Rudyanto & Destia (2023).

The iterative structure of CAR enabled the identification of both instructional strengths and challenges, allowing for real-time adjustments and continuous improvement across the two cycles (Wijaya et al., 2021; Saroinsong & Takaendengan, 2022).

Participants and Sample

The study involved 21 students from Class VIII B at SMPN 18 Mataram. The selection was purposive, based on classroom availability and the school's willingness to participate in the intervention. All students completed the activities and assessments in both cycles, ensuring consistency and minimizing sample attrition.

Instruments and Materials

The instruments used in this study consisted of two categories:

Instructional Instruments

1. **Lesson Plan (RPP)**: Developed based on the 2013 Curriculum, incorporating constructivist and reflective learning principles.
2. **Student Worksheets (LKS – Logic Inference)**: Custom-designed to support deductive and inductive reasoning in physics problem-solving. These worksheets included guided inquiry tasks, data interpretation prompts, and reflective questions.

The LKS validation process included expert judgment by two senior physics educators and one curriculum expert, in line with recommendations from Camuyong (2023). The assessment used a checklist that evaluated content accuracy, construct validity, clarity of instructions, and cognitive challenge level. Revisions were made based on expert suggestions before classroom implementation.

Data Collection Instruments:

1. **Observation Sheets**: Used to assess both teacher implementation fidelity and student behavioral engagement across each cycle.
2. **Learning Outcome Tests**: A set of multiple-choice tests aligned with the instructional content and learning objectives. The items were developed following Bloom's taxonomy to ensure coverage of higher-order thinking skills.

Validity and Reliability

The validity of the test instruments was assessed through content validation, where items were matched against instructional indicators. This ensured alignment between learning goals and assessment tools (Sadeghi et al., 2019; Morowatisharifabad et al., 2020). In addition, student feedback was informally collected to confirm the clarity and relevance of the worksheet instructions (Staynova et al., 2019). To establish reliability, a pilot test was conducted with a separate class of similar level. The internal consistency of the test items was analyzed using Cronbach's Alpha, yielding a reliability coefficient above the minimum acceptable threshold (0.70), indicating a high degree of consistency.

Data Analysis Techniques

This study employed both quantitative descriptive analysis and inferential statistical methods to evaluate the impact of the intervention.

1. The main metric for learning improvement was the gain score, calculated as the difference between the students' post-test and pre-test scores across the two cycles. This allowed for straightforward quantification of progress.
2. To determine whether the improvement was statistically significant, a paired sample t-test was applied using pre-test and post-test scores of each cycle (Huang et al., 2022; Ceylan et al., 2023). The significance level (α) was set at 0.05. The paired t-test is particularly appropriate for small sample studies where assumptions of normality are approximately met (Stellefson et al., 2020).
3. If data did not meet normality assumptions, a non-parametric Wilcoxon signed-rank test was planned as an alternative (Sulistianingtyas & Suhardjanto, 2023).

Data analysis was carried out using spreadsheet-based statistical tools and supported by manual interpretation to capture nuances that may not be evident from numerical data alone.

Reflection Phase

The reflection process played a central role in this research. Following each implementation cycle, the researcher and collaborating teacher engaged in structured reflection discussions. These sessions examined quantitative test results, observational records, and subjective feedback to identify:

1. Aspects of instructional design that supported learning success
2. Challenges faced by students in engaging with the LKS
3. Adjustments needed in worksheet complexity or instructional pacing

This continuous improvement loop not only enhanced instructional quality but also served as a mechanism for teacher professional development (Zheng & Huan, 2022; Rudyanto & Destia, 2023).

RESULTS AND DISCUSSION

Overview of Student Learning Outcomes

The study aimed to improve students' learning outcomes in physics by applying a reflective learning model supported by logic inference worksheets (LKS). Data was collected over two Classroom Action Research (CAR) cycles. Each cycle culminated in a written evaluation aligned with the core competencies of the curriculum. The average scores and classical completeness rates were used as primary indicators of student performance. Table 1 summarizes the average scores and the percentage of students achieving the Minimum Mastery Criteria (KKM), set at 75, for each cycle.

Table 1. Physics Learning Outcomes Across Two Cycles

Cycle	Average Score	Classical Completeness (%)
I	75.15	61.90
II	79.48	85.71

Based on Table 1, in Cycle I, the average student score was 75.15, with only 13 of the 21 students (61.90%) achieving scores at or above the KKM. In Cycle II, student performance improved considerably: the average score rose to 79.48, and the number of students meeting or exceeding the KKM increased to 18, raising classical completeness to 85.71%.

A bar chart comparison was used to visually represent these results. Figure 1 illustrates the improvement in both average score and completeness, making the impact of the reflective learning model more accessible for evaluation.

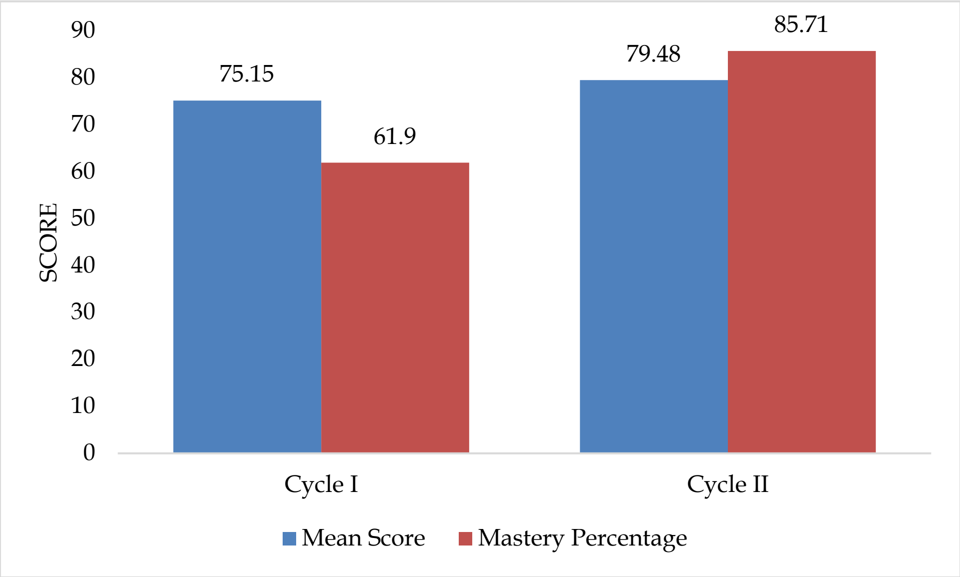

Figure 1. The improvement of average score and completeness

Paired Sample t-Test Result

To assess whether the improvement in students' physics learning outcomes from Cycle I to Cycle II was statistically significant, a paired sample t-test was conducted. This test compared the average scores of the same 21 students after each intervention cycle.

The null hypothesis (H_0) was that there is no difference in student performance between Cycle I and Cycle II. The alternative hypothesis (H_1) was that there is a significant difference in mean scores, indicating that the reflective learning model with logic inference worksheets positively affected student outcomes.

Table 2. Summary of Paired Sample t-Test Results

Test	N	t	df	p
Pair 1	21	4.16	20	0.000

The results reveal that the computed t-value was approximately 4.16, with an associated p-value less than 0.001. Given that $p < 0.05$, the difference in scores between Cycle I and Cycle II is statistically significant. Therefore, we reject the null hypothesis and conclude that the reflective learning model, when supported with logic inference worksheets, significantly improved student performance in physics.

This finding is meaningful in the context of small-sample educational studies. As Huang et al. (2022) and Stellefson et al. (2020) emphasize, the paired sample t-test is a reliable method for detecting instructional effectiveness in within-subject designs. In this study, the effect size implied by the 4.33-point gain on a 100-point scale is both statistically and pedagogically substantial.

Importantly, the improvement reflects more than surface-level score enhancement. Given that instruction in Cycle II involved enriched reflective prompts, peer interactions, and logic inference scaffolding, it is likely that students developed deeper conceptual understanding and stronger reasoning skills—as evidenced by their higher scores and more elaborate written responses. This aligns with the findings of Acar and Azaklı (2023), who assert that structured reflection significantly strengthens logical thinking capabilities.

Furthermore, this result supports the broader claim that instructional designs integrating metacognition and logic—such as Argument Driven Inquiry (Fuadah et al., 2023) and reflective modeling (Atiyah & Priatna, 2023)—yield measurable gains in academic achievement. In the present study, the statistical improvement thus serves as an empirical validation of the theoretical and pedagogical premises underlying reflective learning models.

The significant improvement in post-test scores across cycles, as demonstrated by the paired t-test, confirms that the intervention positively influenced students' learning outcomes in physics. This quantitative result complements the qualitative findings discussed in subsequent sections, including enhanced student engagement and reasoning depth. Together, these outcomes reinforce the value of integrating structured reflection and logical inference into science education.

Analysis of Cycle I: Identification of Barriers

The implementation of the reflective learning model with logic inference worksheets (LKS) in Cycle I revealed key pedagogical challenges. Although the average student score slightly exceeded the Minimum Mastery Criteria (KKM) at 75.15, only 61.90% of students reached the classical completeness threshold, indicating limited success. These outcomes pointed to instructional gaps that hindered student engagement and deep learning.

A major barrier was students' unfamiliarity with reflective learning. While the LKS were designed to promote metacognition, many students approached them as procedural tasks. Responses to inference questions were often superficial, lacking justification or conceptual depth. This behavior suggested that students had not yet developed the ability to reflect meaningfully on their learning. As noted by Coleman et al. (2021), reflection must be explicitly taught and scaffolded to enable students to examine their thought processes critically.

Classroom observations also revealed low student participation. Learners who struggled with physics concepts rarely asked questions or engaged in reflection. Many completed tasks without connecting new material to prior knowledge, indicating a lingering dependence on teacher-centered instruction. This passive stance limited students' ability to benefit from the reflective approach.

The structure of the LKS contributed to these limitations. While inference tasks were present, they lacked guiding prompts to help students unpack and analyze problems. For instance, questions like "draw conclusions based on the data" were not supported by follow-ups such as "what evidence supports your answer?" or "how does this relate to physical principles?" Without such scaffolds, students often reverted to guessing. This supports Ahmed and Zaky's (2021) claim that students need clear reflective cues to engage actively with learning tasks.

In addition, the teacher's instruction in Cycle I did not adequately account for students' varying levels of readiness. All students received the same tasks and instructional support, assuming homogeneity in skill and understanding. However, feedback revealed that some students required repeated modeling or concrete examples, while others needed peer collaboration opportunities that were not sufficiently provided. Yuliana et al. (2022) emphasize that reflective instruction should be adaptable to diverse learner profiles to promote equitable learning outcomes.

Teacher feedback was another area for growth. In Cycle I, feedback focused mostly on the correctness of answers, rather than probing students' reasoning. As Ribeiro et al. (2019) suggest, such feedback is vital to nurturing critical thinking and metacognitive development. Without it, students lacked direction in how to improve their thinking.

Instructional Enhancements in Cycle II

The instructional adjustments in Cycle II were informed by the shortcomings observed in Cycle I. The teaching team redesigned components of the reflective learning model—particularly the logic inference worksheets (LKS)—to strengthen metacognitive scaffolding, increase student engagement, and promote deeper conceptual understanding in physics.

A key enhancement was the revision of LKS design. While Cycle I worksheets focused on logic-based problem-solving, they lacked prompts that encouraged students to reflect on their reasoning. In Cycle II, each worksheet task was followed by structured prompts such as "What reasoning did you use?", "How confident are you?", and "What concept did you apply?". These cues were designed to activate metacognitive thinking, drawing on reflective pedagogy principles (Atiyah & Priatna, 2023; Coleman et al., 2021).

The teacher's role also evolved from delivering content to facilitating reflective dialogue. During LKS activities, the teacher moved among student groups, asked open-ended questions, and guided discussions to clarify misconceptions. This approach not only supported reflection but served as a form of formative assessment, consistent with the recommendations of Ahmed and Zaky (2021) on dialogic instruction to stimulate higher-order thinking.

To further enrich reflective practice, peer-assisted reflection was introduced. After completing LKS tasks, students discussed their answers in small groups, allowing them to compare reasoning strategies and evaluate different perspectives. These collaborative sessions promoted dialogic thinking and helped students refine their ideas—an approach supported by Kesler et al. (2021) and Yuliana et al. (2022), who emphasize the cognitive benefits of social reflection in science learning.

The classroom setting was also adapted to encourage interaction. Desks were arranged into clusters, and class time was allocated for whole-group reflection at the end of each session. These environmental changes supported the continuous feedback loop essential in Classroom Action Research (Sudiatama et al., 2023; Utami et al., 2023).

Recognizing differences in student readiness, Cycle II also featured tiered worksheet tasks: basic inference for recall, intermediate tasks for justification, and advanced applications involving real-world physics scenarios. This differentiation allowed all students to engage meaningfully, regardless of their prior achievement, and reflects inquiry-based scaffolding principles (Fuadah et al., 2023; Camuyong, 2023).

Finally, students completed reflection logs after each lesson, guided by questions on learning gains, challenges, and conceptual connections. Analysis of these logs helped the teacher identify misconceptions and plan targeted instruction. This practice, aligned with Ribeiro et al. (2019), enhanced both conceptual clarity and student agency.

Improvement in Logical Inference and Critical Thinking

The implementation of the reflective learning model supported by logic inference worksheets (LKS) in Cycle II resulted in notable improvements in students' logical reasoning and critical thinking skills. Compared to Cycle I, students' written responses displayed greater depth and clarity, with more frequent justifications grounded in scientific principles. For example, when addressing Newton's Third Law, several students were able to explain action-reaction forces using both conceptual reasoning and prior experimental evidence. This shift indicates a transition from procedural learning to reasoning-based engagement, aligned with Debrenti and Bordás (2023), who emphasize that structured logic tasks enhance deductive thinking and argumentation.

Metacognitive behaviors also increased. Students began using reflective language to evaluate their understanding, indicating the development of selfmonitoring processes. Statements like "I thought this force was greater, but after comparing the data, I realized…" exemplify the reflective adjustments students made—an outcome in line with the reflection-on-action framework discussed by Coleman et al. (2021).

The LKS design in Cycle II, which included direct, comparative, and predictive inference tasks, played a crucial role in fostering this growth. These layered tasks supported students in developing fluency in scientific reasoning by prompting them to analyze, evaluate, and synthesize information. Activities that required students to judge between conflicting explanations further encouraged evidence-based thinking and scientific argumentation—core competencies in modern STEM education, as highlighted by Fuadah et al. (2023).

Beyond individual cognition, these improvements extended into classroom discourse. Students engaged more confidently in reflective dialogues and peer-review discussions, demonstrating increased willingness to question, debate, and construct shared understanding. The transformation from teacher-led questioning to student-driven discussion mirrors findings by Maghribi and Aristiawan (2023), who showed that logic-based group tasks enhance scientific communication and independent reasoning.

These skills are not limited to physics. As Acar and Azaklı (2023) and Atiyah and Priatna (2023) argue, logical reasoning and argumentation are foundational across disciplines and essential for 21st-century problem-solving. Post-test analyses confirmed that inference-based questions showed the most improvement between cycles, suggesting strong gains in analytical thinking.

Impact on Student Engagement

The implementation of the reflective learning model supported by logic inference worksheets (LKS) in Cycle II led to a significant increase in student engagement across behavioral, emotional, cognitive, and social dimensions. Engagement was assessed through classroom observations, student reflection logs, and participation trends, revealing a comprehensive transformation in how students interacted with content, peers, and the learning process.

Behaviorally, students transitioned from passive task compliance in Cycle I to active participation in Cycle II. They began initiating questions, contributing voluntarily to discussions, and engaging more enthusiastically in LKS tasks. Observers noted that students sustained focus during group work and moved between tasks with minimal distraction—an indicator of improved attentiveness and intrinsic motivation. This shift supports the view of Suraworachet et al. (2023) that structured reflection and feedback mechanisms foster greater student agency.

Emotionally, students demonstrated higher confidence in approaching complex tasks. Reflection logs revealed a stronger sense of academic self-efficacy, as students expressed newfound comfort in explaining their reasoning. One reflection noted: "Now, I understand how to think through the problem and explain why my answer makes sense." This increase in confidence encouraged participation in peer discussions, especially among students who were previously hesitant to speak. As Ribeiro et al. (2019) and Ahmed and Zaky (2021) emphasize, this type of growth in self-belief is a key motivator that sustains engagement.

In terms of cognitive engagement, students exhibited enhanced metacognitive behavior. Through reflection prompts and LKS-guided tasks, they began identifying knowledge gaps, reworking incorrect answers, and making connections to prior lessons. This level of self-regulation aligns with findings by Wulff et al. (2023), who argue that structured reflection nurtures students' ability to assess and direct their own learning. When students noticed that their reflections were addressed in classroom discussions and lesson adaptations, their motivation to engage deepened further.

Peer engagement was another area of improvement. Small-group discussions became more dynamic, with students actively comparing reasoning, challenging each other's conclusions, and collaboratively constructing understanding. These dialogic interactions supported cognitive development and reinforced classroom cohesion. As Kesler et al. (2021) highlight, reflection in social contexts deepens learning by exposing students to diverse perspectives and refining thought through mutual feedback.

Cumulatively, these changes fostered a cultural shift in the classroom. The teacher moved from content deliverer to facilitator, while students assumed greater responsibility for their learning. Mistakes were reframed as learning opportunities, and resilience in problem-solving increased. These developments reflect a constructivist, student-centered environment consistent with the transformative effects observed by Ryan et al. (2022).

However, not all students responded equally. Some continued to struggle with participation, underscoring the need for differentiated support. Moreover, this study did not measure the longevity of engagement post-intervention. Future research should explore how reflective engagement practices can be sustained over time and across subjects to ensure their lasting impact.

Implications for Reflective Learning in Physics

This study provides strong evidence for the pedagogical value of integrating reflective learning models with logic inference-based instructional tools in junior secondary physics education. Beyond improving learning outcomes, the approach supports deeper conceptual understanding, promotes student-centered inquiry, and aligns with the broader goals of equitable and reflective science instruction.

One major implication lies in how this model bridges conceptual understanding. Physics is often perceived as abstract and difficult due to its mathematical nature. Traditional teaching methods that focus on memorization often fail to support meaningful comprehension. In this study, the reflective learning model, supported by structured logic inference worksheets (LKS), enabled students to think critically about how and why physics concepts work, rather than just applying formulas. The use of inference tasks helped students justify conclusions with evidence and interpret physical phenomena in more sophisticated ways—findings that align with Fuadah et al. (2023) and Debrenti and Bordás (2023).

This model also helped cultivate scientific habits of mind, including curiosity, skepticism, and evidence-based reasoning. Rather than simply receiving information, students began to engage in hypothesis formulation, questioning, and independent analysis—behaviors indicative of authentic scientific inquiry. As observed in the classroom and supported by Maghribi and Aristiawan (2023), the use of logic-driven debate and structured reasoning tasks fosters analytical thinking and prepares students to apply science to real-world challenges.

The study further underscores the importance of building a constructivist classroom culture. Through reflection logs, peer discussion, and inference-based tasks, students assumed more responsibility for their learning and began to co-construct understanding through dialogue. This shift reflects the principles of constructivism as described by Ahmedi et al. (2023) and Subaedah et al. (2023), where knowledge is actively built through interaction and metacognitive engagement. The teacher's transition from content transmitter to reflective facilitator contributed to a classroom climate that embraced critical thinking, valued questioning, and supported learning from mistakes.

Another key implication is the model's potential to support equitable learning. The LKS were designed with a tiered structure—progressing from basic to advanced inference tasks—which allowed students at different skill levels to participate meaningfully. This form of scaffolded reflection ensures that all learners, regardless of prior achievement, have access to complex reasoning experiences. As supported by

Sadeghi et al. (2019) and Camuyong (2023), differentiated tools enhance both fairness and effectiveness in diverse classrooms.

Importantly, the model's benefits are not limited to physics. Reflective and logic-based learning practices are transferable to other disciplines such as biology, mathematics, and social science. Ubaidillah et al. (2023) affirm the cross-disciplinary potential of these strategies, suggesting that they may be widely applied in interdisciplinary STEM education and project-based learning.

Finally, the study carries implications for teacher professional development. Effective implementation of reflective learning requires training in designing reflective tools, facilitating metacognitive dialogue, and using student reflections to adapt instruction. As demonstrated in this CAR, the teacher's instructional responsiveness improved through structured reflection and ongoing evaluation—echoing the recommendations of Zheng and Huan (2022) and Rudyanto & Destia (2023).

CONCLUSION

This classroom action research has demonstrated that the implementation of a reflective learning model, when supported by logic inference worksheets (LKS), can significantly improve both learning outcomes and engagement among junior high school students studying physics. The intervention, applied in two structured cycles, showed a clear increase in the average student score and classical completeness, with statistical analysis confirming the significance of these gains. More importantly, the quality of student reasoning, metacognitive awareness, and classroom interaction improved markedly in Cycle II compared to Cycle I.

The findings underscore that reflection, when scaffolded through structured worksheets and facilitated by thoughtful instruction, fosters deeper conceptual understanding, encourages scientific thinking, and promotes critical engagement with physics content. Logical inference tasks embedded within the LKS challenged students to articulate reasoning, evaluate evidence, and reflect on learning processes, resulting in stronger academic performance and a transformation in classroom dynamics. These results affirm the theoretical foundations of constructivist pedagogy and metacognitive learning, offering practical insights into how they can be operationalized in real classroom settings.

Beyond cognitive achievement, the model cultivated student confidence, autonomy, and collaborative learning behaviors. The teacher's role evolved into that of a facilitator of inquiry and reflection, further enhancing the overall learning environment. This study thus confirms the efficacy and value of integrating reflection and logic in secondary science education and demonstrates the iterative power of Classroom Action Research as a framework for continuous pedagogical improvement.

RECOMMENDATION

Based on the findings of this study, several recommendations can be proposed for educators, researchers, and policymakers. First, physics educators are encouraged to adopt reflective learning models supported by structured logic inference tasks as part of their instructional strategies. To maximize their effectiveness, these models should include clear reflection prompts, collaborative opportunities, and differentiated tasks that cater to varying student readiness levels. Training and support should be provided to help teachers design, implement, and evaluate reflective learning materials in alignment with curriculum objectives. Second, schools and teacher education institutions should integrate reflective pedagogy and logic-based instruction into professional development programs. This includes equipping teachers with the tools to facilitate metacognitive dialogue, analyze student reflections for instructional planning, and use classroom research data for continual refinement of practice. Third, future research should explore the long-term impact of reflective and logic-based instruction on student learning retention, particularly through delayed post-tests and follow-up evaluations across subjects. It is also recommended that the model be piloted in other disciplines, such as biology, chemistry, and mathematics, to examine its broader applicability and effectiveness in cultivating cross-disciplinary reasoning and inquiry skills. Finally, education policymakers should support the development and dissemination of reflective learning frameworks, especially in science education reforms aiming to build 21st-century skills. Emphasizing reflection, reasoning, and engagement not only enhances student achievement but also prepares learners to be critical thinkers and informed citizens in an increasingly complex world.

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