Vol. 01, No. 1, June 2026, pp. 37~44
ISSN: XXXX-XXXX

Problem Based Learning for Improving Science Learning Outcomes Among Fifth-Grade Elementary Students

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Article Info

Article history:

Received April 27, 2026
Revised May 20, 2026
Accepted June 30, 2026

Keywords:

Problem-Based Learning;
Science Learning Outcomes;
Primary Science Education;
Elementary Education;
Classroom Action Research.

ABSTRACT

Improving science learning outcomes remains a significant challenge in primary education, particularly because classroom instruction is often dominated by teacher-centered approaches that provide limited opportunities for students to actively construct knowledge and solve authentic problems. This study aimed to improve fifth-grade students' science learning outcomes through the implementation of the Problem-Based Learning (PBL) model. The study employed a Classroom Action Research design based on the Kemmis and McTaggart model, consisting of three iterative cycles of planning, action, observation, and reflection. The research was conducted at MI Nurul Huda Bandung, Indonesia, involving 24 fifth-grade students. Data were collected through classroom observations, achievement tests, and documentation and were analyzed using descriptive qualitative and quantitative approaches. The findings demonstrated consistent improvements in both the learning process and students' science learning outcomes across the intervention cycles. Teacher activity increased from 70% in Cycle I to 90% in Cycle III, while student learning activity improved from 65% to 85%. The mean science achievement score increased from 70.25 in Cycle I to 72.50 in Cycle II and reached 82.26 in Cycle III. Likewise, the percentage of students achieving the Minimum Mastery Criterion improved from 70.83% to 87.50%. These findings indicate that Problem-Based Learning effectively enhances students' engagement and science learning outcomes by promoting collaborative inquiry and authentic problem-solving. This study contributes to the growing body of evidence supporting Problem-Based Learning as an effective student-centered instructional approach for primary science education, particularly in Islamic primary school contexts, while providing practical guidance for teachers seeking to improve science learning through inquiry-oriented classroom practices.

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1 INTRODUCTION

Science education plays a fundamental role in developing students' scientific literacy, critical thinking, problem-solving ability, and decision-making skills from an early age. In primary education, science learning is expected not only to facilitate students' acquisition of scientific concepts but also to enable them to investigate natural phenomena, apply scientific knowledge to everyday life, and develop inquiry skills through meaningful learning experiences. Consequently, effective science instruction should promote active participation and student-centered learning rather than relying solely on knowledge transmission.

Despite continuous curriculum reforms emphasizing active learning, classroom practices in many elementary schools remain predominantly teacher-centered. Students frequently receive information passively through lectures and memorization, limiting opportunities to investigate problems, collaborate with peers, and construct knowledge independently. Such instructional practices often result in low classroom participation, superficial conceptual understanding, and unsatisfactory learning outcomes. Recent international reports have also emphasized that improving learning engagement and higher-order thinking remains one of the major priorities in primary education worldwide [1], [2].

Problem-Based Learning (PBL) has been recognized as one of the most effective student-centered instructional models for promoting meaningful learning. PBL engages students in solving authentic problems through investigation, collaboration, discussion, and reflection, enabling them to actively construct knowledge while developing scientific reasoning and problem-solving skills. Previous studies have demonstrated that PBL significantly improves students' academic achievement, conceptual understanding, motivation, and classroom engagement across various educational settings [3]–[6]. In science education, authentic problem-solving activities encourage learners to connect scientific concepts with real-life situations, thereby fostering deeper understanding and long-term knowledge retention.

However, previous studies have primarily investigated the effectiveness of PBL using quasi-experimental or experimental research designs at secondary schools and higher education institutions. Empirical evidence examining the implementation of PBL through iterative classroom improvement in primary science education, particularly within Islamic primary schools (Madrasah Ibtidaiyah), remains relatively limited. Furthermore, many previous investigations have focused on cognitive achievement or critical thinking separately, while fewer studies have explored how continuous instructional refinement through Classroom Action Research contributes to improving elementary students' science learning outcomes. This limitation highlights the need for further research that examines PBL implementation within authentic classroom contexts. [7]–[10].

A preliminary observation conducted in Grade V of MI Nurul Huda Bandung revealed several instructional challenges. Science learning remained predominantly teacher-centered, with students showing limited participation during classroom activities. Most students were reluctant to ask questions, express opinions, or participate actively in discussions. Moreover, students tended to memorize scientific concepts without being able to apply them to everyday situations, resulting in relatively low learning achievement. Classroom interaction among students was also limited, creating a learning environment that was less engaging and less supportive of active knowledge construction. These findings indicate the necessity of implementing a more student-centered instructional approach to improve science learning outcomes.

Problem-Based Learning was selected because its instructional stages encourage students to identify authentic problems, investigate relevant information, collaborate with peers, develop alternative solutions, and communicate their findings through reflective discussion. Such learning experiences are expected to increase students' engagement while simultaneously improving conceptual understanding and academic achievement in science. Within the framework of Classroom Action Research, continuous cycles of planning, action, observation, and reflection also enable teachers to systematically refine instructional practices based on students' learning needs. [11], [15]

Although numerous studies have confirmed the effectiveness of Problem-Based Learning in improving students' academic achievement and higher-order thinking skills, three important gaps remain. First, most studies have employed quasi-experimental designs rather than examining continuous instructional improvement through Classroom Action Research. Second, empirical evidence focusing on primary science education, particularly within Islamic primary schools, remains limited. Third, relatively few studies have investigated how iterative implementation of Problem-Based Learning influences students' science learning outcomes in authentic elementary classroom settings.

This study contributes to the growing body of literature on Problem-Based Learning by providing empirical evidence from an Islamic primary school context, which remains underrepresented in international primary education research. Unlike previous studies that primarily evaluated Problem-Based Learning using experimental designs, this study demonstrates how iterative classroom interventions based on Problem-Based Learning progressively improve science learning outcomes among elementary students in an Islamic primary school context. This contextual and methodological perspective constitutes the novelty of the present study.Accordingly, this study aimed to examine the implementation of the Problem-Based Learning model in improving the science learning outcomes of fifth-grade students at MI Nurul Huda Bandung through Classroom Action Research.

2 RESEARCH METHOD

Research Design

This study employed a Classroom Action Research (CAR) design using the cyclical model proposed by Kemmis and McTaggart, consisting of four stages: planning, action, observation, and reflection. Classroom Action Research was selected because it enables teachers to improve instructional practices through continuous planning, implementation, observation, and reflective evaluation. The study was conducted through three action cycles, each designed to improve students' science learning outcomes through the implementation of the Problem-Based Learning model [16], [17].

Participants and Research Setting

The research was conducted at MI Nurul Huda Bandung, Indonesia, involving 24 fifth-grade students. The participants were selected because preliminary classroom observations indicated relatively low science learning outcomes and limited student participation during classroom instruction. The study focused on improving students' learning outcomes in science through the implementation of Problem-Based Learning.

Research Procedure

The research followed the Kemmis and McTaggart action research cycle consisting of four sequential stages: planning, action, observation, and reflection. During the planning stage, lesson plans, learning materials, observation sheets, and achievement tests were prepared. The action stage involved implementing science learning using the Problem-Based Learning model. Classroom activities were systematically observed using observation sheets to evaluate teacher performance and students' learning activities. Reflection was conducted at the end of each cycle to identify strengths and weaknesses of the instructional process and to determine improvements for the subsequent cycle [18], [19].

Research Instruments

The study employed observation sheets, achievement tests, and documentation as research instruments. Observation sheets were used to assess teacher performance and students' learning activities during the implementation of Problem-Based Learning. Achievement tests were administered at the end of each cycle to measure students' science learning outcomes, while documentation supported classroom observations and verified the implementation of the instructional process.

Table 1. Research Instruments

Instrument	Purpose	Data Type
Observation sheet	Assess teacher performance	Qualitative
Observation sheet	Assess students' learning activities	Qualitative
Achievement test	Measure science learning outcomes	Quantitative
Documentation	Support classroom observation	Qualitative

Data Analysis

The collected data were analyzed using both qualitative and quantitative approaches. Qualitative data obtained from classroom observations were analyzed descriptively through data reduction, data presentation, and conclusion drawing to evaluate the implementation of the instructional intervention. Quantitative data obtained from students' achievement tests were analyzed descriptively by calculating mean scores and the percentage of students achieving the predetermined Minimum Mastery Criterion (MMC). Improvements in students' learning outcomes were compared across the preliminary stage, Cycle I, Cycle II, and Cycle III to evaluate the effectiveness of the Problem-Based Learning implementation

3 RESULTS AND DISCUSSION

3.1 Initial Condition of Students' Science Learning Outcomes

Prior to implementing the Problem-Based Learning (PBL) model, a preliminary observation was conducted to identify the existing conditions of science learning in the fifth-grade classroom. The observation revealed that classroom instruction remained predominantly teacher-centered, with students demonstrating limited participation during learning activities. Most students were passive, rarely asked questions, expressed opinions infrequently, and experienced difficulties in solving contextual science problems. Students generally memorized scientific concepts without being able to apply them to everyday situations, resulting in relatively low learning achievement. The classroom atmosphere was also less interactive, as communication between the teacher and students as well as among students themselves was limited.

The preliminary evaluation further confirmed these classroom observations. Students' science learning outcomes were below the expected level, indicating that many students had not yet achieved the predetermined Minimum Mastery Criterion (MMC) of 70. These findings suggested that the existing instructional approach had not adequately facilitated students' conceptual understanding and active engagement in science learning. Consequently, a more student-centered instructional strategy was required to improve both classroom participation and academic achievement.

To address these challenges, the Problem-Based Learning model was implemented through Classroom Action Research. This instructional model was expected to provide students with opportunities to investigate authentic problems, collaborate with peers, and construct scientific knowledge actively through inquiry-based learning. The preliminary findings therefore served as the baseline for evaluating students' learning progress throughout the three intervention cycles.

Table 2. Initial Condition of Students' Science Learning

Indicator	Preliminary Findings
Learning approach	Predominantly teacher-centered
Student participation	Low
Classroom interaction	Limited
Ability to solve science problems	Low
Science learning outcomes	Below the Minimum Mastery Criterion (MMC)
Need for instructional improvement	High

3.2 Results of Cycle I

The first cycle represented the initial implementation of the Problem-Based Learning (PBL) model in science instruction. During this stage, students began participating in learning activities organized around authentic problems and collaborative group discussions. Although several students were still adapting to the new instructional approach, classroom interaction showed noticeable improvement compared with the preliminary condition. Students became more willing to participate in discussions, respond to teachers' questions, and engage in problem-solving activities, although active participation had not yet involved all members of the class.

The observation results also indicated positive changes in the implementation of the learning process. Teacher activity during Cycle I reached 70%, reflecting that most stages of the Problem-Based Learning model were implemented appropriately. Student learning activity reached 65%, indicating that learners had begun to adapt to collaborative and inquiry-oriented learning despite requiring further guidance during group discussions and problem analysis. These findings demonstrate that the initial implementation of PBL successfully encouraged greater classroom participation than the previous teacher-centered approach.

Students' science learning outcomes also improved during the first cycle. The average achievement score reached 70.25, exceeding the predetermined Minimum Mastery Criterion (MMC) of 70. Furthermore, 70.83% of students achieved learning mastery, indicating that most students had successfully met the expected competency level after the initial implementation of Problem-Based Learning. Nevertheless, approximately one-third of the students had not yet achieved mastery, suggesting that additional instructional improvements were necessary in the subsequent cycles to optimize learning outcomes.

Table 3. Results of Cycle I

Indicator	Cycle I
Teacher activity	70%
Student activity	65%
Mean learning outcome	70.25
Students achieving mastery	70.83%

The findings from Cycle I demonstrate that the initial application of Problem-Based Learning produced positive improvements in both classroom engagement and science learning outcomes. However, the results also revealed opportunities for refinement, particularly in increasing students' participation during collaborative problem-solving and strengthening conceptual understanding. These reflections informed the instructional modifications implemented in Cycle II.

3.3 Results of Cycle II

Cycle II was implemented following the reflection of Cycle I by addressing several instructional weaknesses identified during the initial intervention. Improvements focused on providing clearer problem orientation, strengthening teacher facilitation during group discussions, encouraging equal participation among group members, and guiding students to relate scientific concepts to authentic situations. These refinements were intended to increase students' engagement and improve the effectiveness of the Problem-Based Learning process.

Classroom observations demonstrated positive progress in the implementation of Problem-Based Learning. Teacher activity increased from 70% in Cycle I to 80% in Cycle II, indicating a more effective implementation of the planned instructional stages. Student learning activity also improved from 65% to 75%, reflecting greater participation in collaborative discussions, problem analysis, and presentation of group findings. Students appeared more confident in expressing ideas, responding to questions, and working together to solve science-related problems.

The improvement in classroom participation was accompanied by better science learning outcomes. The mean achievement score increased from 70.25 in Cycle I to 72.50 in Cycle II. Likewise, the percentage of students achieving the Minimum Mastery Criterion (MMC) increased from 70.83% to 75%. Although the expected level of class mastery had not yet been fully achieved, these findings indicate that the instructional improvements implemented during Cycle II positively influenced students' conceptual understanding and academic performance.

Table 4. Results of Cycle II

Indicator	Cycle I	Cycle II
Teacher activity	70%	80%
Student activity	65%	75%
Mean learning outcome	70.25	72.50
Students achieving mastery	70.83%	75.00%

The findings of Cycle II indicate that the refinements made after the first cycle successfully enhanced the quality of classroom instruction and students' participation in science learning. Nevertheless, several students still experienced difficulties in applying scientific concepts independently during problem-solving activities. Therefore, further instructional improvements were implemented in Cycle III to maximize learning outcomes and achieve the predetermined success indicators.

3.4 Results of Cycle III

Cycle III was conducted as the final stage of the Classroom Action Research after reflecting on the outcomes of Cycle II. Several instructional improvements were maintained, including more structured teacher facilitation, intensive guidance during collaborative problem-solving, and greater opportunities for students to present and evaluate alternative solutions. These improvements aimed to maximize students' participation and strengthen their conceptual understanding of science through the Problem-Based Learning model.

The classroom observation results demonstrated substantial improvements in the implementation of the learning process. Teacher activity increased from 80% in Cycle II to 90% in Cycle III, indicating that nearly all stages of the Problem-Based Learning model were implemented effectively. Likewise, student learning activity improved from 75% to 85%, reflecting higher levels of engagement during problem identification, group discussion, investigation, and classroom presentation. Students became more confident in communicating scientific ideas, collaborating with peers, and applying scientific concepts to solve contextual problems.

The improvement in classroom participation was accompanied by significant gains in students' science learning outcomes. The mean achievement score increased from 72.50 in Cycle II to 82.26 in Cycle III. Similarly, the percentage of students achieving the Minimum Mastery Criterion (MMC) increased from 75% to 87.50%, exceeding the predetermined indicator of success. These findings indicate that the systematic implementation of Problem-Based Learning effectively enhanced students' understanding of science concepts and contributed to improved academic achievement.

Table 5. Results of Cycle III

Indicator	**Cycle II**	**Cycle III**
Teacher activity	80%	90%
Student activity	75%	85%
Mean learning outcome	72.50	82.26
Students achieving mastery	75.00%	87.50%

The findings of Cycle III demonstrate that the implementation of Problem-Based Learning successfully achieved the expected learning objectives. The consistent improvements in teacher performance, student participation, and science learning outcomes indicate that the instructional modifications introduced throughout the research cycles effectively enhanced the quality of classroom learning. As the predetermined success criteria had been achieved, no further action cycle was considered necessary.

3.5 Overall Improvement of Students' Science Learning Outcomes

The implementation of the Problem-Based Learning (PBL) model across the three Classroom Action Research cycles demonstrated a consistent improvement in both the learning process and students' science learning outcomes. Progressive improvements were observed in teacher performance, student participation, average achievement scores, and the percentage of students achieving the Minimum Mastery Criterion (MMC). These findings indicate that continuous instructional refinement through Problem-Based Learning effectively enhanced the quality of science instruction and students' academic achievement.

The implementation of Problem-Based Learning also resulted in increasingly active classroom participation. Teacher activity improved from 70% in Cycle I to 80% in Cycle II and reached 90% in Cycle III. Similarly, student learning activity increased from 65% in Cycle I to 75% in Cycle II and further improved to 85% in Cycle III. The gradual increase in classroom participation demonstrates that students became progressively more engaged in identifying problems, discussing ideas collaboratively, conducting investigations, and presenting scientific explanations throughout the intervention.

A similar trend was observed in students' science learning outcomes. The mean achievement score increased from 70.25 in Cycle I to 72.50 in Cycle II and reached 82.26 in Cycle III. Likewise, the percentage of students achieving the Minimum Mastery Criterion improved from 70.83% in Cycle I to 75.00% in Cycle II and finally 87.50% in Cycle III. These results indicate that the instructional improvements implemented throughout the research cycles successfully strengthened students' conceptual understanding and learning achievement in science.

Table 6. Overall Improvement of Students' Science Learning Outcomes

Indicator	**Cycle I**	**Cycle II**	**Cycle III**
Teacher activity	70%	80%	90%
Student activity	65%	75%	85%
Mean learning outcome	70.25	72.50	82.26
Students achieving mastery	70.83%	75.00%	87.50%

The overall findings demonstrate that the systematic implementation of Problem-Based Learning contributed to continuous improvements in both the learning process and students' science achievement. The highest performance was achieved in Cycle III, where the predetermined success indicators were exceeded. These results provide empirical evidence that Problem-Based Learning is an effective instructional approach for improving science learning outcomes in elementary education by fostering active participation, collaborative learning, and meaningful problem-solving experiences.

3.6 Discussion

The findings of this study demonstrate that the implementation of the Problem-Based Learning (PBL) model effectively improved students' science learning outcomes in primary education. The continuous improvement observed throughout the three action research cycles indicates that PBL created a more engaging and student-centered learning environment, enabling students to actively construct scientific knowledge through authentic problem-solving experiences. Rather than functioning solely as recipients of information, students became active participants who investigated scientific problems, discussed alternative solutions, and collaboratively developed conceptual understanding. These findings support the constructivist perspective, which emphasizes that meaningful learning occurs when learners actively construct knowledge through interaction with authentic learning experiences [18], [19].

The gradual improvement in students' learning outcomes can be attributed to the essential characteristics of Problem-Based Learning. The model encourages students to identify real-world problems, gather relevant information, analyze evidence, collaborate with peers, and formulate appropriate solutions. Such learning activities facilitate deeper conceptual understanding because students are required to connect prior knowledge with newly acquired information while simultaneously developing reasoning and inquiry skills. Hmelo-Silver explained that Problem-Based Learning promotes meaningful learning by integrating knowledge acquisition with collaborative problem-solving and self-directed learning processes [6]. Likewise, Savery emphasized that authentic problem-solving provides meaningful contexts that strengthen students' conceptual understanding and encourage lifelong learning habits [5].

The findings are also consistent with previous empirical studies reporting the effectiveness of Problem-Based Learning in improving academic achievement and classroom engagement. Research has shown that PBL enhances students' motivation, learning participation, and conceptual understanding by encouraging active exploration and collaborative learning [3], [4]. In science education, inquiry-oriented learning activities enable students to relate abstract scientific concepts to real-life situations, making learning more meaningful and improving knowledge retention [7]. Therefore, the positive improvement observed in this study reinforces existing evidence that student-centered instructional approaches contribute significantly to elementary students' science learning outcomes.

An important finding of this research is the progressive improvement achieved through the cyclical implementation of Classroom Action Research. Each cycle involved systematic planning, implementation, observation, and reflection, allowing instructional strategies to be continuously refined based on classroom needs. This iterative process enabled the teacher to identify weaknesses during the learning process and implement more effective instructional improvements in subsequent cycles. Such findings are consistent with the principles of Classroom Action Research proposed by Kemmis, McTaggart, and Nixon, who argue that reflective practice enables teachers to improve both instructional quality and student learning outcomes through continuous professional inquiry [14].

The increase in classroom participation throughout the intervention further demonstrates the effectiveness of Problem-Based Learning in promoting active learning. Initially, many students were reluctant to express ideas and depended heavily on teacher explanations. As the implementation progressed, students became increasingly confident in asking questions, participating in discussions, presenting group findings, and solving scientific problems collaboratively. This finding is supported by Hattie, who concluded that learning environments characterized by active engagement, collaboration, and meaningful classroom interaction produce stronger learning outcomes than passive instructional approaches [8]. Active participation not only enhances students' understanding of scientific concepts but also develops communication, collaboration, and independent learning skills.

From a practical perspective, the findings suggest that Problem-Based Learning provides an effective instructional framework for improving science learning in primary education. The model shifts classroom instruction from teacher-centered practices toward student-centered learning by encouraging inquiry, collaboration, and evidence-based reasoning. Such instructional practices are closely aligned with current educational priorities that emphasize scientific literacy, problem-solving, and higher-order thinking skills as essential competencies for twenty-first-century learners [1], [2]. Consequently, elementary school teachers may consider integrating authentic problem-solving activities into science instruction to improve both learning engagement and academic achievement.

This study also contributes to the existing literature by providing empirical evidence regarding the implementation of Problem-Based Learning in an Islamic primary school (Madrasah Ibtidaiyah), a context that remains relatively underrepresented in international educational research. While previous studies have predominantly examined Problem-Based Learning through experimental or quasi-experimental designs, this research demonstrates how iterative instructional improvement through Classroom Action Research can progressively enhance students' science learning outcomes in authentic classroom settings. Therefore, the study extends the application of constructivist learning theory within primary science education while offering practical guidance for teachers seeking to improve classroom instruction through reflective pedagogical practice.

Despite these contributions, several limitations should be acknowledged. This study involved only one fifth-grade classroom in a single Islamic primary school, thereby limiting the generalizability of the findings. In addition, the Classroom Action Research design primarily focused on improving instructional practice rather than establishing causal relationships between Problem-Based Learning and students' academic achievement. Future studies are therefore encouraged to employ quasi-experimental or experimental designs involving larger and more diverse samples across different educational contexts. Further research may also investigate the long-term effects of Problem-Based Learning on scientific literacy, critical thinking, problem-solving ability, and collaborative learning skills among elementary school students

4 CONCLUSION

The findings of this Classroom Action Research demonstrate that the implementation of the Problem-Based Learning (PBL) model effectively improved fifth-grade students' science learning outcomes at MI Nurul Huda Bandung. The systematic application of PBL through three iterative cycles enhanced both the learning process and students' academic achievement. Students became more actively involved in identifying problems, collaborating with peers, discussing scientific concepts, and applying their knowledge to authentic situations. The consistent improvements observed in teacher performance, student participation, mean achievement scores, and learning mastery indicate that Problem-Based Learning provides an effective student-centered instructional approach for improving science learning in primary education.

This study contributes to both educational theory and classroom practice. Theoretically, the findings provide additional empirical evidence supporting constructivist learning theory by demonstrating that authentic problem-solving and collaborative inquiry facilitate meaningful knowledge construction and improve students' science learning outcomes. Moreover, this study extends the current literature by presenting evidence from an Islamic primary school (Madrasah Ibtidaiyah), a context that has received relatively limited attention in international educational research. Practically, the study offers an evidence-based instructional framework that can assist elementary school teachers in designing science learning activities that promote inquiry, collaboration, active participation, and problem-solving skills while supporting the implementation of student-centered learning aligned with twenty-first-century educational objectives.

Despite these contributions, several limitations should be acknowledged. The study involved only one fifth-grade classroom in a single Islamic primary school, which may limit the generalizability of the findings to broader educational contexts. Furthermore, the Classroom Action Research design focused on improving instructional practice within one classroom rather than establishing causal relationships between Problem-Based Learning and students' learning outcomes. Therefore, future studies are recommended to employ quasi-experimental or experimental designs involving larger and more diverse samples across different schools and regions. Further research may also investigate the long-term effects of Problem-Based Learning on scientific literacy, critical thinking, problem-solving ability, and collaborative learning skills to provide a more comprehensive understanding of its effectiveness in primary science education.

5 ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Principal, teachers, and fifth-grade students of MI Nurul Huda Bandung, Indonesia, for their valuable cooperation, participation, and support throughout the implementation of this study. The authors also extend their appreciation to colleagues and all individuals who provided constructive feedback, technical assistance, and encouragement during the research process and the preparation of this manuscript.

6 DECLARATIONS

AI USAGE STATEMENT

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to improve the language quality, grammar, readability, and academic writing style of the manuscript. The tool was also used to assist in organizing the manuscript structure and refining academic expressions. All AI-generated outputs were critically reviewed, verified, revised, and edited by the authors. The authors take full responsibility for the originality, accuracy, integrity, and scientific content of this publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization, Investigation, Methodology, Data Collection, Data Curation, Formal Analysis, Visualization, Writing – Original Draft.

Author 2: Methodology, Validation, Supervision, Formal Analysis, Writing – Review & Editing.

Author 3: Methodology Consultation, International Collaboration, Validation, Critical Revision, Writing – Review & Editing.

All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

FUNDING STATEMENT

This research received no external funding and did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

COMPETING INTEREST

The authors declare that they have no competing interests, including financial, professional, or personal relationships that could have influenced the work reported in this manuscript.

ETHICAL APPROVAL

This study was conducted in accordance with the ethical principles of educational research involving human participants. Permission to conduct the research was obtained from the Principal of MI Nurul Huda Bandung, Indonesia, prior to data collection. Participation was voluntary, and informed consent was obtained from the school authorities and participants' parents or legal guardians where appropriate. All participant information was anonymized, and the confidentiality and privacy of the participants were maintained throughout the research process.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

CONSENT TO PARTICIPATE

All participants voluntarily participated in this study. Informed consent was obtained from the school administration and the participants' parents or legal guardians prior to the implementation of the research.

CONSENT FOR PUBLICATION
The authors consent to the publication of this manuscript and confirm that all authors have reviewed and approved the final version of the manuscript for publication.

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