

Preliminary Study on The Implementation of STEM-Integrated Problem-Based Learning in Elementary School Education

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Abstract

Twenty-first century learning requires instructional approaches that develop higher-order thinking skills and connect learning materials to students' real-life experiences. This study aimed to describe the implementation of STEM-integrated problem-based learning at SD Negeri 3 Kujon in IPAS learning. The study employed a qualitative descriptive approach, with data collected through classroom observations, teacher interviews, and analysis of instructional documents. The findings revealed that lesson planning was aligned with the Learning Outcomes and Learning Objectives of the Merdeka Curriculum and incorporated contextual problems relevant to students' experiences. The implementation of learning successfully increased students' active engagement through discussions, group collaboration, and problem-solving activities, while teachers acted as facilitators. Students also demonstrated positive responses characterized by high enthusiasm, interest, and participation during the learning process. The study concludes that STEM-integrated problem-based learning effectively supports active, contextual, and meaningful IPAS learning in accordance with the principles of the Merdeka Curriculum in elementary schools.

Keywords: *problem-based learning integrated with STEM, IPAS learning, Merdeka Curriculum, elementary school.*

Abstrak

Pembelajaran abad ke-21 menuntut pendekatan pembelajaran yang mampu mengembangkan keterampilan berpikir tingkat tinggi dan mengaitkan materi dengan kehidupan nyata peserta didik. Penelitian ini bertujuan mendeskripsikan implementasi problem-based learning terintegrasi STEM di SD Negeri 3 Kujon dalam pembelajaran IPAS. Penelitian menggunakan pendekatan deskriptif kualitatif dengan teknik pengumpulan data berupa observasi, wawancara guru, dan analisis dokumen pembelajaran. Hasil penelitian menunjukkan bahwa perencanaan pembelajaran telah disusun sesuai Capaian Pembelajaran dan Tujuan Pembelajaran Kurikulum Merdeka serta memuat masalah kontekstual yang relevan dengan pengalaman siswa. Pelaksanaan pembelajaran mampu meningkatkan keterlibatan aktif peserta didik melalui diskusi, kerja kelompok, dan aktivitas pemecahan masalah dengan guru sebagai fasilitator. Peserta didik juga menunjukkan respons positif berupa antusiasme, minat, dan partisipasi tinggi selama pembelajaran berlangsung. Penelitian ini menyimpulkan bahwa problem-based learning terintegrasi STEM efektif mendukung pembelajaran IPAS yang aktif, kontekstual, dan bermakna sesuai prinsip Kurikulum Merdeka di sekolah dasar.

Kata kunci: *problem-based learning terintegrasi STEM, pembelajaran IPAS, Kurikulum Merdeka, sekolah dasar.*

INTRODUCTION

The development of education in the 21st century requires a transformation of learning that not only emphasizes the mastery of factual knowledge but also the development of higher-order thinking skills (HOTS), such as critical, creative, collaborative, and communicative thinking. These skills are essential for students to deal with complex and dynamic problems in real life and to adapt to rapid developments in science and technology. The Organisation for Economic Co-operation and Development ((OECD), 2023) emphasizes that critical thinking and problem-solving skills remain key competencies that need to be strengthened among students in various countries, including Indonesia.

One instructional approach that is considered effective in developing HOTS is problem-based learning (PBL). PBL positions students as active learners who construct knowledge through engagement in authentic problem-solving activities that require analysis, evaluation, and creation. The implementation of PBL can significantly improve students' learning engagement and critical thinking skills at the elementary school level (Ariso & Susanta, 2023) . This is in line with the view that problem-based learning encourages students to actively construct their understanding through meaningful learning experiences.

The integration of PBL and STEM offers a promising approach to creating meaningful and contextual learning. The combination of PBL-STEM not only promotes the development of higher-order thinking skills but also facilitates interdisciplinary problem solving that is relevant to the context of Integrated Science and Social Studies (IPAS) learning in elementary schools. IPAS learning, which combines scientific and social perspectives, aligns well with the characteristics of STEM, as both emphasize the integration of knowledge and real-world problem solving.

The Merdeka Curriculum emphasizes the importance of student-centered and contextual learning that supports the development of the Pancasila Student Profile. The Ministry of Education, Culture,(Kementerian Pendidikan, Kebudayaan, Riset, 2023)(Kementerian Pendidikan, Kebudayaan, Riset, 2022) states that learning should encourage students to think critically, solve problems, and relate knowledge to everyday life. In this context, student responses become important indicators of meaningful learning. Student responses, such as interest, participation, and engagement, reflect both cognitive and affective involvement during the learning process and indicate the effectiveness of the instructional approach used.

However, these ideal conditions are not yet fully reflected in learning practices in elementary schools. Various studies indicate that teaching is still dominated by lecture methods and routine exercises, resulting in passive learning and limited opportunities for students to develop critical thinking skills (Afandi, M.; Fatma, N. K.; Yustiana, 2024). A preliminary study conducted at SD Negeri 3 Kujon shows that IPAS learning still focuses on content delivery and closed-ended questions. Based on initial observations in the even semester of the 2024/2025 academic year, approximately 65% of students experienced difficulties when dealing with contextual problem-based questions, and only a small number of students were able to explain their reasoning or solution strategies verbally.

This condition has implications for the low level of higher-order thinking skills among students, particularly in understanding contextual problems and linking concepts across disciplines. If this issue is not addressed, it will hinder the achievement of 21st-century learning objectives and the development of the Pancasila Student Profile. Therefore, it is necessary to implement an instructional approach that can effectively address these challenges.

Although numerous studies have examined the implementation of PBL and STEM in primary education, most of them focus on measuring learning outcomes or improving specific skills through quantitative approaches. Research that explicitly examines the relationship between PBL, STEM integration, the development of HOTS, and student responses within a systematic conceptual framework—particularly in the context of IPAS learning—is still limited. Furthermore, studies that describe the actual implementation process, including planning, implementation, and student responses in real classroom settings, remain scarce.

Based on the above background, the research problem of this study is how STEM-integrated problem-based learning is implemented in elementary schools, particularly in terms of lesson planning, instructional implementation, and student responses in IPAS learning. Accordingly, the objective of this study is to describe the implementation of STEM-integrated problem-based learning at SD Negeri 3 Kujon comprehensively. The findings of this study are expected to provide an empirical description and serve as a practical reference for teachers and educational institutions in developing more contextual, meaningful, and 21st-century-oriented IPAS learning.

RESEARCH METHODS

This study employed a descriptive qualitative approach to examine the implementation of STEM-integrated problem-based learning in elementary schools, allowing contextual and holistic exploration of classroom phenomena (Creswell, J. W. Poth, 2018) (Sugiyono, 2022). A preliminary study design was used to identify initial conditions, potentials, and challenges (Setyosari, 2020), following procedures adapted from (Miles, M. B. Huberman, A. M. Saldaña, 2020).

The subjects consisted of one teacher and 28 fifth-grade students at SD Negeri 3 Kujon, selected purposively. The study was conducted over two months (August–September 2025). Data were collected through four classroom observations (2 × 35 minutes each), semi-structured interviews, and documentation.

The instruments were developed based on PBL theory (Arends, 2012) and the STEM framework (Bybee, 2013), focusing on student engagement, problem-solving processes, and STEM integration. Data validity was ensured through triangulation.

Data analysis employed an interactive model, including data reduction, display, and conclusion drawing, using open coding and categorization into themes such as planning, implementation, student engagement, and STEM integration.

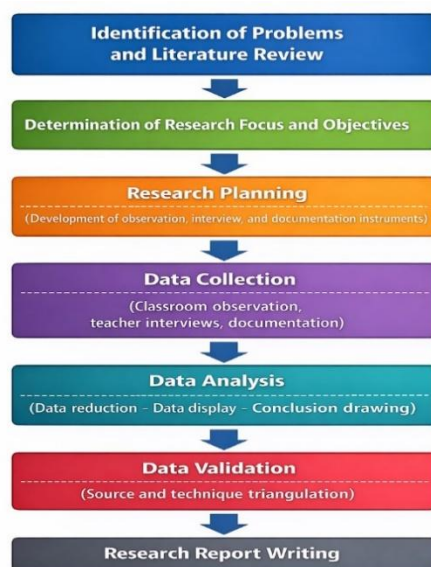


Figure 1. Research Procedure Flow Model Miles, Huberman & Saldana (2020)

The research subjects were teachers and students at SD Negeri 3 Kujon who were directly involved in the implementation of integrated STEM problem-based learning. The subjects were selected purposively, considering that the school had implemented an innovative learning approach relevant to the research objectives. The research object focused on the learning process, including planning, implementation, and learning interactions that reflected the characteristics of PBM-STEM. This research was conducted in the first semester of the 2025/2026 academic year at SD Negeri 3 Kujon, which was chosen because it had begun to implement integrated STEM problem-based learning.

The data collection techniques in this study included observation, interviews, and documentation. Observations were made to directly observe learning activities and student engagement. Semi-structured interviews were used to explore teachers' understanding and experiences related to the implementation of STEM-based problem-based learning. Documentation was used as supporting data in the form of learning tools, student work, and learning activity records. Data validity was maintained through source triangulation and techniques as recommended by (Miles, M. B. Huberman, A. M. Saldaña, 2020) Miles et al. (2020) (Sugiyono, 2022).

Data analysis was conducted qualitatively using an interactive analysis model that included data reduction, data presentation, and conclusion drawing. The analysis process was carried out continuously from the data collection stage until a comprehensive understanding of the implementation of integrated STEM problem-based learning was obtained. This approach allowed researchers to interpret the data in depth and systematically in accordance with the research objectives (Miles, M. B. Huberman, A. M. Saldaña, 2020), (Creswell, J. W. Poth, 2018).

RESEARCH RESULTS AND DISCUSSION

This study aims to describe the implementation of STEM-integrated problem-based learning at SD Negeri 3 Kujon, focusing on planning, implementation, and student responses. Data were obtained through classroom observations, semi-structured

interviews, and document analysis. The results of document analysis show that teachers have developed lesson plans aligned with the Learning Outcomes (CP) and Learning Objectives (TP) of the Merdeka Curriculum. The plans include contextual problems and activities integrating science and mathematics, although technology and engineering components are still limited. In the implementation phase, learning begins with contextual problems relevant to students' daily lives. For example, students were asked to design a simple water filter using plastic bottles, sand, and gravel (engineering), test water clarity (science), measure results (mathematics), and discuss the process (technology integration). Students worked collaboratively in groups to identify problems and propose solutions. Observation data show that students actively participated in discussions, asked questions, and collaborated in completing tasks. Based on observation indicators, student activeness was categorized as "high" because more than 75% of students were involved in group discussions and task completion. Participation in discussions was categorized as "moderate to high," while the ability to relate STEM concepts was "moderate," as students were still limited in connecting technology and engineering aspects. Interview results support these findings. One teacher stated, "Students are more active when learning starts with real problems, but they still need guidance to connect the activities with technology and engineering concepts." Students also expressed positive responses, such as, "Learning is more interesting because we can work in groups and solve real problems." Documentation analysis, including lesson plans and student worksheets, shows that learning activities were structured according to PBL stages, such as problem orientation, investigation, and presentation. However, the integration of STEM elements was not yet fully balanced. Overall, the findings indicate that STEM-integrated problem-based learning can foster active engagement and collaborative learning. However, the integration of technology and engineering components still needs improvement.

Table 1. Results of the Analysis of STEM Integrated Problem-Based Learning Planning

| Aspect Analyzed | Findings | Description |
|---|--|---|
| Formulation of Learning Objectives | Aligned with CP and TP of the Merdeka Curriculum | Learning objectives are directed toward the development of higher-order thinking skills |
| Use of Contextual Problems | Present | Problems are derived from students' daily life experiences |
| Integration of STEM Elements | Moderately evident | Science and mathematics are dominant; technology and engineering components are still limited |
| Suitability to Students' Characteristics | Appropriate | Learning activities are adjusted to students' developmental levels |

These findings indicate that teachers have a good initial understanding of designing STEM-integrated problem-based learning. However, the analysis also shows that the integration of STEM elements in planning is not fully balanced. Science and mathematics elements appear more dominant, while technology and engineering aspects are still limited and have not been explicitly designed. This condition is in line with the findings of (Smith et al., 2022) who stated that in planning problem-based learning in the STEM context, teachers tend to more easily integrate conceptual aspects such as science and mathematics, while technology and engineering elements are often less optimally developed because they

require more complex design, modeling, and engineering application experience. This finding is also supported by the results of the study by (Martaningsih et al., 2022), which showed that in STEM learning in elementary schools, engineering and technology elements are often not optimally implemented due to limited examples of applicable learning tools.

In the implementation phase, learning begins with the presentation of contextual problems relevant to students' daily experiences. Students are guided to identify problems, ask questions, and seek solutions through group discussions. Observations show that students actively participate in discussions, express their opinions, and collaborate in groups to solve the given problems. The teacher acts as a facilitator, guiding the learning process, providing prompting questions, and helping students connect science and mathematics concepts to the problems they face.

Hasil observasi menunjukkan bahwa peserta didik terlibat aktif dalam diskusi. Observations showed that students were actively involved in group discussions, exchanging ideas, and collaborating to complete assigned tasks. However, their ability to connect technology and engineering concepts was still limited, resulting in STEM learning not being fully integrated. A summary of the observation results of the learning implementation is presented in Table 2.

Table 2. Observation Results of STEM Integrated Problem-Based Learning

| Aspect Analyzed | Findings | Category |
|------------------------------------|------------------|-----------------|
| Student Activeness | High | Good |
| Participation in Group Discussions | Moderate to High | Good |
| Ability to Relate STEM Concepts | Moderate | Fair |
| Teacher's Role as a Facilitator | Optimal | Good |
| Learning Time Management | Adequate | Fair |

These findings indicate that STEM-integrated problem-based learning (PBL) can encourage active student engagement and create a collaborative learning environment. Students engage in group discussions, exchange ideas, and collaborate to solve assigned problems. This is in line with the research findings of (Putri et al., 2023), which stated that the implementation of a STEM-integrated problem-based learning model significantly increases student engagement and critical thinking skills through authentic problem-solving. Furthermore, these findings are reinforced by the study by (Smith et al., 2022), which confirms that PBL in the STEM context is effective in encouraging active student participation and the development of higher-order thinking skills.

However, students' ability to relate technology and engineering concepts is still at a moderate level. This indicates that the integration of technology and engineering aspects in the learning process is not yet fully optimal and still requires more structured guidance from teachers. This finding is in line with the results of a meta-analysis by (Ilwandri et al., 2023), which concluded that although PBL-STEM learning is effective in improving 21st-century skills, the implementation of engineering and technology elements in elementary schools remains a major challenge that requires more systematic planning and scaffolding support from teachers.

In addition to observing the learning process, this study also examined students' responses to the application of integrated STEM problem-based learning. Based on the results of interviews and observations, most students showed high enthusiasm for learning.

Students stated that they were more interested in participating in learning because the material was related to real-world problems and was solved through group work. In addition, students' activity in asking questions and expressing opinions also increased. A summary of student responses to STEM-based problem-based learning is shown in Table 3.

Table 3. Student Responses to STEM-Integrated Problem-Based Learning

| Response Indicator | Findings |
|--|------------------|
| Interest in Learning Activities | High |
| Understanding of the Material | Moderate to High |
| Group Collaboration | Good |
| Activeness in Asking Questions and Expressing Opinions | Improved |

Students' positive responses to STEM-integrated problem-based learning demonstrate that this approach can create meaningful and participatory learning experiences. The high level of student interest and engagement indicates that learning that connects material to real-life problems can significantly increase learning motivation. Furthermore, student involvement in group discussions and the courage to express opinions reflect the development of self-confidence and social skills during the learning process. These findings align with the research findings of (Smith et al., 2022) which showed that problem-based learning in a STEM context positively contributes to increased learning motivation, active participation, and the development of higher-order thinking skills in students through direct involvement in authentic problem-solving. Similar results were also reported by (M. Kholifah, 2023) ,who confirmed that STEM learning in elementary schools can increase student engagement and interest in learning when linked to real-life contexts.

This study aims to describe the implementation of STEM-integrated problem-based learning at SD Negeri 3 Kujon, focusing on planning, implementation, and student responses. Data were obtained through classroom observations, semi-structured interviews, and document analysis, and are presented in an integrated manner. The findings show that in terms of planning, teachers have developed lesson plans aligned with the Merdeka Curriculum, incorporating contextual problems and integrating science and mathematics, although technology and engineering elements remain limited and not systematically structured. During implementation, learning begins with real-life problems, such as designing a simple water filter, which integrates science, mathematics, and basic engineering activities. Observation data indicate that students were actively engaged in discussions and collaborative problem solving. Student activeness was categorized as high, while their ability to connect STEM concepts, especially technology and engineering, remained moderate. Interview results support these findings. Teachers reported increased student participation, although students still require guidance in linking activities to technology and engineering concepts. Students also expressed positive responses, indicating that learning was more engaging and meaningful. Documentation analysis shows that learning followed PBL stages, but STEM integration was still dominated by science and mathematics. Overall, student responses reflected high enthusiasm and active participation. Despite alignment with previous studies, several challenges were identified. The integration of engineering remains difficult due to its design-based nature, teacher readiness in STEM pedagogy is still limited, and inadequate facilities hinder optimal implementation. Therefore, successful STEM-integrated PBL requires balanced design, improved teacher competence, and sufficient learning resources.

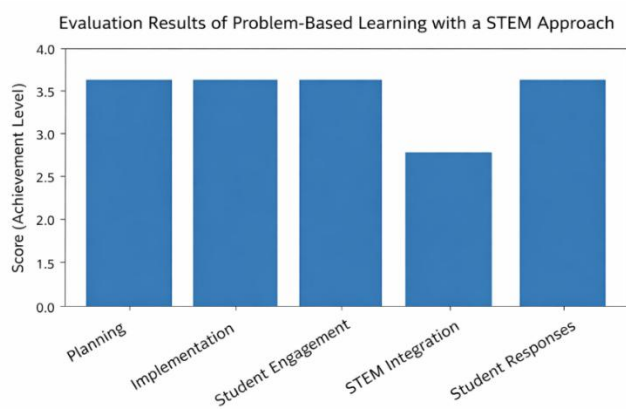


Figure 2. Bar chart of STEM integrated problem-based learning implementation

Figure 2 presents a bar chart showing the results of the implementation of STEM-integrated problem-based learning. The chart shows that the aspects of planning, implementation, and student response were in the good category, while the aspect of STEM integration was in the fair category. These findings indicate that although the learning was carried out effectively, the integration of technology and engineering elements still needs to be improved so that the implementation of STEM-integrated problem-based learning can run more optimally.

CONCLUSION

Based on the results of the study, it can be concluded that STEM-integrated problem-based learning at SD Negeri 3 Kujon has been implemented quite well, both in the planning and implementation stages, as well as in terms of student response to learning. The learning plan was developed with reference to the Learning Outcomes and Learning Objectives of the Merdeka Curriculum and was designed using contextual problems that were close to the students' daily experiences. At the implementation stage, learning took place actively and participatively, marked by student involvement in discussions, group work, and problem-solving processes. However, the results of the study show that the integration of technology and engineering elements in learning still needs to be improved in order to achieve more optimal STEM integration. Overall, STEM-integrated problem-based learning contributes positively to encouraging student engagement in learning and supporting the development of higher-order thinking skills.

The findings of this study imply that the implementation of integrated STEM problem-based learning has strong potential to create meaningful, contextual, and context-based learning that is in line with the direction of the Merdeka Curriculum policy. This approach not only encourages students to be actively and collaboratively involved in the learning process, but also helps teachers in designing learning that is oriented towards strengthening 21st-century competencies, such as critical thinking, creativity, and problem-solving skills. Thus, the results of this study can serve as a practical reference for teachers and schools in developing more innovative learning through the integrated integration of science, technology, engineering, and mathematics.

Based on these findings, it is recommended that teachers optimize the integration of technology and engineering elements in integrated STEM problem-based learning, particularly through more systematic lesson planning and the use of learning media and activities that support student exploration and design processes. Schools are also expected to provide support through training programs and facilitation of professional development for teachers related to

STEM-based learning. For future researchers, it is recommended to examine the implementation of integrated STEM problem-based learning with a broader scope, both in terms of education levels, duration of implementation, and by adding quantitative measurements of the impact of learning on improving students' higher-order thinking skills.

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