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Development of PjBL-STEM based student worksheets to improve mathematical literacy skills

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ABSTRACT
The research was motivated by the low level of mathematical literacy among fifth-grade students at SD Negeri 068003 Medan and the urgent need for contextual and engaging learning materials. This study aims to develop Project-Based Learning (PjBL) student worksheets (LKPD) using a STEM approach to enhance elementary students' mathematical literacy skills. The study employed a Research and Development (RnD) method using the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). The developed product was tested on 21 students through expert validation, limited trials, and effectiveness testing. The results showed that the LKPD met the criteria of being valid, practical, and effective in improving students' mathematical literacy. The average score increased after implementation. This research is original in its integration of PjBL and the STEM approach into the development of LKPD tailored to the characteristics of elementary students. The implications suggest that contextual and project-based learning tools can serve as strategic solutions to improve mathematical literacy while fostering 21st-century skills.

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ABSTRAK
Latar belakang penelitian ini didasarkan pada rendahnya kemampuan literasi matematis peserta didik kelas V SD Negeri 068003 Medan serta kebutuhan akan perangkat ajar yang kontekstual dan menantang. Penelitian ini bertujuan untuk mengembangkan Lembar Kerja Peserta Didik (LKPD) berbasis Project-Based Learning (PjBL) dengan pendekatan STEM guna meningkatkan kemampuan literasi matematis peserta didik sekolah dasar. Penelitian ini menggunakan metode Research and Development (RnD) dengan model pengembangan ADDIE (Analysis, Design, Development, Implementation, and Evaluation). Produk yang dikembangkan diuji pada 21 peserta didik kelas V melalui validasi ahli, uji coba terbatas, dan uji efektivitas. Hasil penelitian menunjukkan bahwa LKPD yang dikembangkan memenuhi kriteria valid, praktis, dan efektif dalam meningkatkan kemampuan literasi matematis peserta didik. Capaian skor rata-rata meningkat setelah penggunaan LKPD. Penelitian ini memiliki nilai orisinalitas dalam integrasi model PjBL dengan pendekatan STEM dalam pengembangan LKPD yang disesuaikan dengan karakteristik peserta didik sekolah dasar. Implikasi dari penelitian ini menunjukkan bahwa perangkat ajar yang kontekstual dan berbasis proyek dapat menjadi solusi strategis untuk meningkatkan literasi matematis, sekaligus menumbuhkan keterampilan abad ke-21.
Kata Kunci: *literasi matematis; LKPD; PjBL; STEM*

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INTRODUCTION

Mathematical literacy is an essential competence required for students to face the challenges of the 21st century, particularly in solving complex contextual problems. However, various studies indicate that Indonesian students' mathematical literacy remains at a concerning level (Kintoko et al., 2024). The results of PISA 2023 indicate that the average mathematics literacy score of Indonesian students was 366, well below the global average of 472, with 82% of students performing below Level 2. Factors contributing to low numeracy literacy include teachers' teaching experience, students' self-efficacy in mathematics, the availability of learning materials, students' behavioral issues, principal support, and inadequate school facilities (Nadila & Lestiana, 2024). This condition is further exacerbated by teaching practices that continue to emphasize mechanistic approaches and fail to connect mathematics to real-life contexts meaningfully, leading students to perceive mathematics as merely a school activity with little relevance to their daily lives (Maulina et al., 2024).

The challenge of improving mathematical literacy not only requires changes in instructional strategies but also highlights the importance of developing contextual, active, and integrated learning materials. The Project-Based Learning (PBL) model, integrated with the Science, Technology, Engineering, and Mathematics (STEM) approach, is effective in encouraging students to independently construct knowledge by completing projects based on real-world problems. This approach aligns with the demands of 21st-century learning by engaging students in activities that simultaneously develop critical thinking, collaboration, creativity, and communication skills (Himmi et al., 2025; Iskandar et al., 2024). The integration of STEM within PjBL not only strengthens the cognitive aspects of mathematics but also enhances the relevance of learning to everyday life, thereby better preparing students to address complex problems beyond the classroom (Ferdiani, 2024). Other studies have shown that learning models that combine STEM and PjBL can significantly improve student engagement and meaningful understanding of mathematical concepts (Supianti et al., 2025).

Numerous prior studies have examined the effectiveness of the PjBL model and the STEM approach, separately, in improving mathematics learning outcomes. However, relatively few studies have specifically focused on developing instructional materials in the form of PjBL–STEM integrated Student Worksheets (*Lembar Kerja Peserta Didik*/LKPD) that are tailored to the characteristics of elementary school students and aimed at enhancing mathematical literacy (Nurfadhilah et al., 2024; Sholihah & Masfiyah, 2023). Most existing studies remain limited to the implementation of instructional models without accompanying systematic, validated learning products, particularly in geometry topics such as the volume of cubes and rectangular prisms, which are abstract for students (Kumalasari et al., 2023). This study addresses this gap by developing PjBL–STEM-based LKPD through the systematic stages of the ADDIE development model, explicitly integrating mathematical literacy into each learning activity. Students' engagement in authentic projects that require mathematical modeling and contextual problem solving is expected to facilitate more effective transfer of knowledge from the classroom to real-life situations.

This study aims to develop PjBL-based Student Worksheets (*Lembar Kerja Peserta Didik*/LKPD) integrated with the STEM approach, systematically designed using the ADDIE development model. The development focuses on enhancing elementary school students' mathematical literacy skills through learning activities that are contextual, collaborative, and oriented toward real-world problem solving. The resulting product is expected to be not only valid and practical for classroom use but also effective in improving students' ability to formulate, apply, and interpret mathematical concepts meaningfully. The theoretical contribution of this study lies in integrating the STEM approach at each stage of project-based learning, as reflected in the LKPD design. In contrast, its practical contribution is the provision of relevant, applicable, and ready-to-use instructional materials for teachers to support mathematics literacy-based learning at the elementary school level. Indonesian students' mathematical literacy achievement in

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international assessments such as PISA remains relatively low. This condition underscores the urgency of strengthening mathematical literacy at the elementary school level. Therefore, efforts should be directed toward developing contextual learning that encourages students' active engagement in constructing models, applying concepts, and interpreting results meaningfully.

The problem of low mathematical literacy, particularly in geometry topics such as the volume of cubes and rectangular prisms, calls for innovation in the development of instructional materials that bridge conceptual understanding with practical applications in everyday life. The selection of the PjBL model, integrated with the STEM approach, represents a promising solution, as it enables students to explore mathematical concepts through authentic projects that integrate science, technology, and engineering. This study is significant because it not only offers a contextual pedagogical approach but also produces a tangible learning product: Student Worksheets (Lembar Kerja Peserta Didik/LKPD), designed for elementary school students and validated and empirically implemented. The findings of this study are expected to make a strategic contribution to improving the quality of mathematics instruction in elementary schools and to serve as a reference for the future development of similar instructional materials.

LITERATURE REVIEW

Mathematical Literacy Skills

Mathematical literacy is an important indicator of the extent to which students can apply mathematical concepts, facts, procedures, and reasoning to solve problems encountered in real-life situations. Mathematical literacy is not limited to computational skills; rather, it encompasses the ability to understand contextual problems, construct mathematical models, and interpret and evaluate the resulting solutions reflectively (Jannah & Hayati, 2024; Purnama, 2024). The PISA 2022 framework defines mathematical literacy as an individual's capacity to think mathematically and to formulate, use, and interpret mathematics in a variety of real-world contexts (Syah et al., 2024). This approach encompasses understanding concepts, facts, and procedures, as well as the use of mathematical tools and representations to explain and predict phenomena (Harmika et al., 2024). The focus of mathematical literacy is not solely on outcomes but also on the thinking processes that involve reasoning skills, decision-making, and awareness of the limitations of the mathematical models employed (Haryadi & Mudzakkir, 2024).

PISA classifies mathematical literacy into three main processes: (1) formulating, which refers to the ability to translate real-world situations into mathematical models; (2) employing, which involves the ability to apply mathematical concepts and procedures to solve the formulated models; and (3) interpreting, which is the ability to reflect mathematical results into the original context in order to draw meaningful conclusions (Putri et al., 2024). These three processes reflect the demands of 21st-century skills oriented toward problem solving, critical thinking, and mathematical communication. Furthermore, mathematical literacy encompasses mastery of four core content areas: quantity, change and relationships, space and shape, and uncertainty and data. This understanding is essential for enabling students to connect mathematics to real-world phenomena, such as data-driven decision-making or the modeling of everyday events (Alfiany et al., 2023).

The PISA scale categorizes mathematical literacy into eight levels, ranging from Level 1a to Level 6, with indicators that assess cognitive demands from basic procedural thinking to higher-order reflective and strategic thinking (Habibi & Prahmana, 2022). In the context of elementary education, strong mathematical literacy indicates students' readiness to understand mathematics not merely as abstract knowledge but as a logical tool for evaluation, argument construction, and effective problem-solving in real-life situations. This ability has become increasingly crucial in a world saturated with numerical information and quantitative data, thereby encouraging teachers to design learning activities that explicitly integrate mathematical literacy into instructional practices (Rodliyah et al., 2023; Suciawati et al., 2023).

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STEM Approach in Mathematics Learning

The Science, Technology, Engineering, and Mathematics (STEM) approach is a cross-disciplinary integration that develops critical, creative, and collaborative thinking skills, as well as problem-solving abilities, through project-based and exploratory activities. This approach facilitates students' connection of theoretical knowledge to real-life applications, thereby making learning more meaningful (Putra et al., 2023). STEM-based learning is developed through three main models, namely the silo (separate), embedded, and integrated models. Among these, the integrated model is considered the most effective, as it enables students to understand the interconnections among science, technology, engineering, and mathematics concepts within a unified and contextual learning experience (Lutfiyana et al., 2025).

The STEM approach is commonly implemented through a five-stage process, namely reflection, research, discovery, application, and communication. Each stage is designed to promote active student engagement, ranging from problem identification to the systematic presentation of solutions (Sabila et al., 2023). The integration of the STEM approach into elementary mathematics instruction is highly relevant, particularly for geometry topics such as three-dimensional shapes. Students are trained to apply volume concepts through activities involving designing, calculating, and representing real objects, such as cube and rectangular prism nets. These activities not only strengthen mathematical understanding but also simultaneously develop 21st-century skills (Anggriani et al., 2024).

Integration of PjBL and STEM Approach

The integration of Project-Based Learning (PjBL) and the STEM approach in this study is intended to create a collaborative, contextual, and real-world problem-solving learning experience (Nurcahyo & Afryaningsih, 2024; Syawalia et al., 2023). The PjBL model is employed as an instructional framework that positions students as the central actors in the processes of inquiry and project completion. Each project activity is designed to represent the interconnections among the four STEM components: science, technology, engineering, and mathematics. Each stage of the PjBL syntax, ranging from the formulation of driving questions and project planning to implementation, monitoring, evaluation, and reflection, is structured to enable students to develop STEM skills in an integrated manner. For example, during the planning and implementation stages, students are required not only to calculate the volumes of three-dimensional shapes but also to design problem-based 3D structures, select appropriate materials, and collaboratively develop solution strategies within contextual scenarios (Rahmadani et al., 2022). This integration provides a strong pedagogical foundation for developing LKPD as a learning medium that emphasizes not only mathematical cognitive aspects but also incorporates scientific, technological, and engineering dimensions in real-world contexts. The strength of this approach lies in its ability to bridge mathematical content with everyday life, while simultaneously fostering mathematical literacy and 21st-century skills (Athaya et al., 2024; Mawaddah & Mahmudi, 2021).

The Nature of Student Worksheets (LKPD)

Student Worksheets (*Lembar Kerja Peserta Didik*/LKPD) are instructional media designed to guide students in actively, systematically, and purposefully constructing knowledge. These materials serve as structured guides for completing learning tasks and activities aligned with specific learning objectives. The quality of LKPD plays a crucial role in determining the effectiveness of the learning process, as well-designed worksheets can facilitate exploratory and collaborative activities and promote students' critical thinking skills. The criteria for high-quality LKPD encompass didactic, constructional, and technical

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aspects. From a didactic perspective, LKPD should align with students' characteristics and learning principles that support conceptual understanding. In terms of construction, the content of LKPD needs to be organized systematically, logically, and contextually. At the same time, the technical aspect includes clear instructions, an attractive visual design, and practical usability in classroom settings. These principles serve as the primary guidelines for developing the PjBL–STEM-based LKPD in this study. Within the PjBL–STEM context, the LKPD design is structured to guide students through the stages of a project in an organized manner, beginning with problem exploration, solution planning, and project implementation, and culminating in outcome evaluation. Each activity in the LKPD is designed to stimulate mathematical literacy by applying mathematical concepts to real-life situations involving science, technology, and engineering (Pamungkas et al., 2023). Such a design is expected to enhance students' engagement and understanding, and to increase the relevance of learning for elementary school students.

METHODS

This study employed a research and development (R&D) design using the ADDIE model as a systematic framework for the design, development, and evaluation of instructional products. The study was conducted at SD Negeri 068003 Medan during the even semester of the 2024/2025 academic year. The subjects of this study were 21 students from class VA. In contrast, the study focused on a Project-Based Learning (PBL)-based Student Worksheet (Lembar Kerja Peserta Didik/LKPD) integrated with the STEM approach, developed to enhance elementary school students' mathematical literacy. Data collection techniques included observation, interviews, validation questionnaires, and mathematical literacy tests.

The development process for the PjBL–STEM-based Student Worksheets (LKPD) in this study followed the ADDIE model, which comprises five main stages. The analysis stage involved examining the curriculum, student characteristics, and learning needs, revealing that mathematics instruction remained largely teacher-centered and insufficiently contextual. The design stage included developing mathematical literacy instruments and the initial design of the LKPD structure, integrated with the PjBL syntax and STEM elements. The development stage involved product validation by subject matter, media, language, and learning practitioners, each with relevant academic qualifications and professional experience in their respective fields. This validation process generated feedback that informed revisions to the product until it met the established feasibility criteria. The implementation stage involved Grade VA students at SD Negeri 068003 Medan through instrument trials, observations of the learning process, and data collection to assess the practicality and effectiveness of the product. The evaluation stage involved analyzing validation data and student responses, followed by further revisions when deficiencies were identified, to ensure that the developed LKPD was fully feasible and optimally supported the enhancement of students' mathematical literacy.

The development process for the PjBL–STEM-based Student Worksheets (LKPD) in this study followed the ADDIE model, which comprises five main stages. The analysis stage involved a review of the curriculum, student characteristics, and learning needs, revealing that mathematics instruction was still predominantly teacher-centered and lacked contextual relevance. The design stage included the development of mathematical literacy instruments and the initial structuring of the LKPD, integrated with the PjBL syntax and STEM elements. The development stage was conducted through product validation by subject-matter experts, media experts, language experts, and learning practitioners, each with relevant academic qualifications and professional experience in their respective fields. This validation process generated feedback that informed revisions to the product until it met the established feasibility criteria. The implementation stage involved Grade VA students at SD Negeri 068003 Medan, using instrument trials, classroom observations, and data collection to assess the product's practicality and effectiveness.

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The evaluation stage involved analyzing validation data and student responses, followed by further revisions when deficiencies were identified, to ensure that the developed LKPD was feasible and optimally supported the enhancement of students' mathematical literacy.

Data analysis employed both quantitative and qualitative descriptive techniques, with validity, practicality, and effectiveness serving as the criteria for evaluating the success of the product. Validity was determined based on expert judgment scores, practicality was measured through teacher and student responses, and effectiveness was assessed by comparing students' mathematical literacy scores before and after the use of the LKPD. The field trial was conducted using pretests and posttests to compare Grade V students' understanding of the taught material. Test results were analyzed to determine the percentage of learning mastery, with success defined as at least 75% of students achieving a score of ≥70. If this criterion was not met, a review and subsequent re-trial were conducted. The difference between pretest and posttest scores was analyzed using the gain score technique as an indicator of treatment effectiveness. Furthermore, the effectiveness of the PjBL–STEM-based LKPD was measured using the N-Gain index based on Hake's formula to examine the overall improvement in learning outcomes before and after the implementation of the product.

RESULTS AND DISCUSSION

Analysis Stage (Analyze)

The analysis stage was conducted to identify learning needs, student characteristics, and the alignment of instructional content with a contextual learning approach. Based on classroom observations and interviews with Grade V teachers at SD Negeri 068003 Medan, it was found that students had difficulty understanding the concepts of the volume of cubes and rectangular prisms. Learning activities tended to be procedural in nature and had not yet directed students toward higher-order mathematical thinking skills. The needs analysis indicated that the instructional materials remained limited to textbooks, with no support for worksheets that could facilitate contextual problem-solving. Meanwhile, data from the Computer-Based National Assessment (Asesmen Nasional Berbasis Komputer/ANBK) and the school's internal diagnostic assessments showed that students' numeracy literacy achievement was below the adequate level, with a predominance of unanswered items.

These findings reinforce the urgency of developing Student Worksheets (*Lembar Kerja Peserta Didik*/LKPD) that are contextual, active, and supportive of the structured development of mathematical literacy. The assessment of students' mathematical literacy skills was based on the three PISA cognitive processes, namely formulating, employing, and interpreting. The findings indicate that although most students can understand and process basic mathematical information, they still experience difficulties at higher-order stages of thinking, such as selecting appropriate strategies and interpreting solutions. This condition underscores the need for innovative instructional materials, such as PjBL–STEM-based LKPD, that can foster all three levels of mathematical literacy through contextual, structured, and reflective learning experiences. The results of this analysis are presented in Table 1 below.

Table 1. Results of the Analysis of Students' Abilities on Number Material

Cognitive level of mathematical literacy	Question format	Cognitive level achievement indicators	Results of the analysis of student answers
Formulate	Filling No. 1	• Able to take or obtain problems from available information.	Based on the students' responses, 76% of students were unable to use mathematics to solve the problems. Furthermore, 71% of students made errors in algebraic

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Cognitive level of mathematical literacy	Question format	Cognitive level achievement indicators	Results of the analysis of student answers
		• Able to formulate number operations from real situations. • Able to create effective algebraic procedures.	procedures, indicating a lack of mastery of calculation techniques.
Employ	Filling No. 2	• Understand the information in the problem presented. • Select the appropriate strategy for a real-world problem using a method appropriate to the problem type. • Apply strategies and operations to solve problems related to mathematical concepts and procedures requiring systematic steps. • State the final answer based on problem-solving operations.	From the students' answers, it can be concluded that 80% of them were still not careful in determining their strategy. These students identified only the purchase price of oil, whereas the request was for the selling price. This error indicates that the students erred in determining their strategy.
Interprete	Filling No. 3	• Analyzing information as the initial step in problem-solving. • Able to think, select alternative strategies and solutions, and draw valid conclusions based on the results and facts obtained.	Based on the students' responses, 76% of students were not thorough enough in their analysis of the information. In the problem about the selling price of oil in a small bottle, students only completed the purchase price. However, they were able to interpret the solution based on the facts.

Source: Research 2025

Based on the data presented in Table 1, it is evident that, at the formulation level, 76% of students understood the problem and applied basic arithmetic operations in the given context. However, 71% of them still made errors in algebraic procedures, indicating limited mastery of computational techniques. At the employ level, approximately 80% of students were able to comprehend the information presented in the problem but continued to make mistakes in selecting appropriate solution strategies, such as incorrectly comparing unit prices when solving purchasing-related problems. Meanwhile, at the interpretive level, 76% of students were deemed sufficiently careful in their analysis of information, yet they were unable to draw reflective, comprehensive conclusions.

Design Stage (Design)

The design stage aimed to develop the structure and content of the PjBL–STEM-based Student Worksheets (LKPD) to align with the characteristics of elementary school students and the learning objectives. The design process involved organizing the learning flow according to the PjBL syntax, beginning with the presentation of contextual problems, project planning, activity implementation, and culminating in the presentation of results and reflection. Each step was aligned with STEM elements to ensure that the activities in the LKPD naturally promote the integration of cross-disciplinary knowledge. The LKPD was designed to facilitate students' active engagement in completing projects related to the concepts of the volume of cubes and rectangular prisms. The activities in the LKPD were structured to

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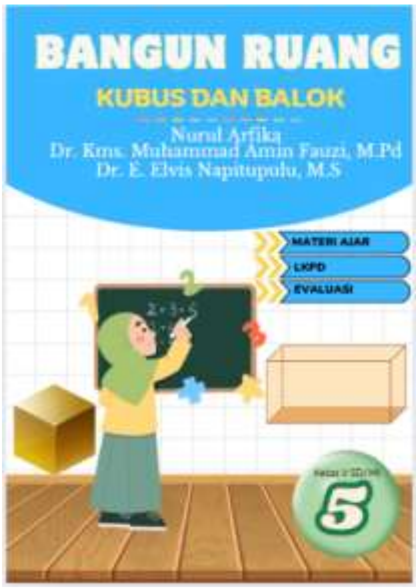
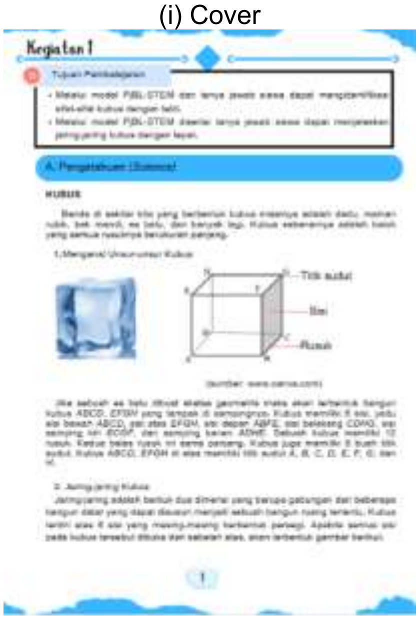
involve students in observation, measurement, calculation, design, and conclusion, with an emphasis on mathematical literacy, encompassing the abilities to formulate, apply, and interpret mathematical concepts.



(i) Cover

(ii) The beginning



(iii) Content section

(iv) Closing section

Figure 1. Initial Appearance of the PjBL-STEM-Based Student Worksheet Design
Source: 2025 Research

The design process incorporated the principles of high-quality LKPD criteria across the didactic, constructional, and technical aspects. The initial draft of the LKPD was prepared in print and subsequently validated by subject-matter and media experts. The preliminary design of the LKPD was developed using the PjBL syntax and the STEM integration principles identified during the analysis stage. Each activity component was structured to facilitate a project-based learning process that is both systematic and

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contextual. This design process is illustrated in Figure 1, which presents the logical flow of LKPD development, from the formulation of learning objectives to the design of activities that reflect STEM elements and mathematical literacy components.

Development Stage (Develop)

The development stage produced the initial product, PjBL–STEM-based Student Worksheets (LKPD), designed based on the results of the analysis stage and the learning syntax. The initial product was then validated by three experts, namely a subject-matter expert, a media expert, and a language expert. This validation aimed to ensure that the LKPD was suitable for use in instructional settings with respect to content, visual design, and language. The subject-matter expert evaluated the alignment of the LKPD content with basic competencies, the accuracy of mathematical concepts, and the relevance of the activities to mathematical literacy objectives. The validation results indicated that the LKPD was classified as highly valid, with recommendations to refine several problem contexts better to reflect real-world issues relevant to students' daily lives. Revisions were also made to strengthen the alignment between the project stages and the PISA indicators, particularly with respect to mathematical modeling and data interpretation. The media expert assessed aspects of layout, readability, aesthetics, and ease of navigation of the LKPD for elementary school students. The visual design was considered attractive and consistent; however, adjustments were still required to the color contrast and text alignment to make the worksheets more child-friendly.

The media expert recommended simplifying icons and adjusting the layout to enable students to complete the LKPD independently without encountering navigation difficulties. The language expert focused on linguistic aspects, including sentence structure, word choice, clarity of instructions, and alignment with the language literacy abilities of elementary school students. Overall, the language was deemed appropriate for students' cognitive development levels; however, several technical terms were suggested for simplification to avoid multiple interpretations. Instructional sentences were revised to be more communicative, direct, and supportive of active student participation. After all feedback was received, improvements to the LKPD product were made across content, visual, and technical aspects, as well as language use. These revisions were implemented to enhance informational clarity, visual appeal, and the accuracy of terminology. Based on the recapitulation results, all validators concluded that the LKPD fell into the "very valid" category and was appropriate for classroom implementation.

Before revision | After revision | Before revision | After revision

Figure 2. Display According to Expert Suggestions
Source: 2025 Research

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Based on the validation results from the three experts, further development of the LKPD was undertaken to enhance the content quality, visual appearance, and language use. Several revisions were made, including adjusting the problem contexts to better align with students' real-life experiences, simplifying instructional sentences, and optimizing the page layout to improve navigational clarity. Visual components such as icons, guiding lines, and step numbering were also refined to support students' independence in completing the projects. This revision process resulted in a version of the LKPD that is fully integrated with the PjBL syntax and STEM elements across all learning activities. The series of development stages is illustrated in Figure 2, which presents the refinement process of the LKPD from the validation results to the final product ready for classroom implementation.

Implementation Stage (Implementation)

The implementation stage was conducted to examine the applicability and practicality of the developed and validated PjBL–STEM-based LKPD. A limited trial was conducted in Grade V at SD Negeri 068003 Medan, involving 21 students as research participants. The learning process was implemented in accordance with the PjBL syntax, integrated into each activity step in the LKPD, including the presentation of contextual problems, project planning, activity implementation, and evaluation and reflection.

During implementation, students were actively engaged in completing project tasks that required applying mathematical concepts to real-world situations. Learning activities were facilitated through the LKPD, which guided students from understanding the problem and collecting data to performing volume calculations and compiling project reports. The teacher served as a facilitator, guiding students through discussions and observations and continuously monitoring the learning process.

The practicality of the LKPD was assessed through direct responses from students and teachers during the limited implementation process in Grade V at SD Negeri 068003 Medan. Data were collected through structured observations and interviews to elicit users' perceptions of ease of use, clarity of instructions, visual appeal, and the LKPD's effectiveness in guiding project activities. Given the relatively small number of participants and the naturalistic learning context, observation and interview techniques were deemed more suitable for capturing learning experiences holistically. Student responses indicated that the LKPD was easy to understand, visually appealing, and encouraged active engagement. Teachers reported that the LKPD facilitated the presentation of learning activities in a more structured and enjoyable manner while promoting student collaboration. These findings provided the basis for evaluating the product's effectiveness.

Evaluation Stage(*Evaluation*)

The evaluation stage aimed to assess the effectiveness of the PjBL–STEM-based LKPD in improving students' mathematical literacy following implementation. The evaluation was conducted by comparing pretest and posttest results using instruments developed from mathematical literacy indicators aligned with the PISA framework, covering the aspects of formulating, employing, and interpreting. Based on the analysis results, the average score increased from 54.30 on the pretest to 80.95 on the posttest, indicating a significant improvement in students' understanding and contextual application of mathematical concepts. Effectiveness was calculated using the normalized gain (N-Gain) formula. The N-Gain results fell into the great improvement category, indicating that the developed LKPD was effective in encouraging students to think critically, apply problem-solving strategies, and reflect on results within real-life contexts. Overall, the developed product met three main criteria: validity, practicality, and effectiveness. This success supports the assumption that integrating Project-Based Learning (PBL) and the STEM approach into LKPD can

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enhance the quality of mathematics instruction and systematically and measurably foster elementary school students' mathematical literacy.

Discussion

The study's results indicate that the use of PjBL-based LKPD, integrated with the STEM approach, is effective in improving elementary school students' mathematical literacy. This is reflected in the increase in students' average scores from the pretest to the posttest, as well as the N-Gain value, which falls into the high category. These findings are consistent with the definition of mathematical literacy as an individual's ability to formulate, apply, and interpret mathematics in various real-life contexts (Syah et al., 2024).

The integration of the Project-Based Learning (PBL) model with the STEM approach within the LKPD enables students to engage in learning processes that actively emphasize real-world problem solving. This approach not only enhances students' understanding of mathematical concepts but also develops their critical and creative thinking skills (Mawaddah & Mahmudi, 2021).

Previous studies have shown that implementing the Project-Based Learning (PjBL) model is effective in improving students' mathematical literacy, particularly in learning topics such as systems of linear equations in two variables (Nurfadilah et al., 2024). The STEM approach in mathematics learning provides opportunities for students to integrate knowledge from various disciplines, enabling them to understand the connections between mathematical concepts and their real-life applications. This supports the notion that mathematical literacy is not merely a matter of content mastery but also of the ability to apply mathematical concepts in relevant contexts. The development and implementation of PjBL–STEM-based LKPD in elementary school mathematics learning can therefore serve as an effective strategy to enhance students' mathematical literacy, in line with curriculum demands and the needs of 21st-century education. In addition to improving mathematical literacy, implementing PjBL–STEM-based LKPD also contributes to the development of 21st-century skills, such as critical thinking, problem-solving, and collaboration.

Other studies have found that the PjBL–STEM approach not only significantly improves students' mathematical literacy but also fosters students' character development, including teamwork, communication, and responsibility, which are essential for achieving holistic educational outcomes (Sholihah & Masfiyah, 2023). Furthermore, integrating PjBL and STEM into mathematics education provides students with more meaningful, contextual learning experiences. The PjBL model is highly suitable for implementation in STEM education, as its syntax, comprising planning, creation, processing, and evaluation, aligns closely with the stages of STEM-based learning (Ferdiani, 2024). Finally, the PjBL–STEM approach has been shown to enhance students' learning motivation. Other research indicates that project-based learning in STEM contexts can increase students' motivation to learn, scientific literacy, and overall learning outcomes (Himmi et al., 2025).

CONCLUSION

This study produced a PjBL–STEM-based student worksheet (LKPD) designed to enhance the mathematical literacy of fifth-grade students at SD Negeri 068003 Medan. The product was declared valid based on evaluations conducted by subject-matter, media, and language experts. It was also considered practical due to its ease of use and appeal to both students and teachers. The effectiveness of the LKPD was evidenced by students' active engagement in contextual, meaningful project-based learning activities.

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The development results indicate that the LKPD is a suitable alternative instructional tool for elementary school mathematics. Future research is recommended to test this product on a larger scale and to employ more in-depth analytical approaches in order to strengthen the generalizability of the findings.

AUTHOR'S NOTE

The author declares that there is no conflict of interest regarding the publication of this article. The author confirms that the data and content of the article are free from plagiarism.

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