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Development of Technology-Integrated Problem-Based Learning Teaching Materials to Improve Critical Thinking Skills in Elementary School Students

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Abstract: This study aims to develop technology-integrated Problem Based Learning (PBL) teaching materials for Natural and Social Sciences (IPAS) to improve the critical thinking skills of elementary school students. The research model used is research and development (R&D) with reference to the 4-D model (Define, Design, Develop, and Disseminate). The research subjects were fourth-grade students at SDN 1 Bagik Payung and SDN 1 Terara. Data collection instruments included tests (pretest-posttest) and non-tests (expert validation questionnaires, student and teacher response questionnaires, and observations). The validation results showed that the teaching materials received a "Very Good" rating from technology experts, subject matter experts, and language experts. The small-scale pilot test demonstrated an average score increase from 59 to 88 at SDN 1 Bagik Payung and from 58 to 85 at SDN 1 Terara, with a moderate N-Gain category. The large-scale pilot test resulted in an average score increase from 57.33 to 89.33 at SDN 1 Bagik Payung and from 56.84 to 88.95 at SDN 1 Terara, with a high N-Gain category. Student and teacher responses to the product were also in the "Very Good" category. Thus, the PBL-based instructional materials integrated with technology developed have proven to be effective, feasible, and usable for enhancing elementary school students' critical thinking skills.

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Introduction

Basic education plays a crucial role in shaping the foundation of critical thinking skills in students. These skills are considered one of the essential abilities in the 21st century, where students are expected to be able to analyze, evaluate, and solve problems independently. However, research and field observations show that the critical thinking skills of elementary school students in Indonesia are still low. Many students tend to memorize rather than deeply understand concepts, making it difficult for them to develop a broader understanding to solve complex problems (Borge et al., 2024).

Critical thinking skills are one of the most important skills that students must possess in today's digital age. (Karunarathne & Calma, 2024) state that critical thinking is one of the

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key skills needed to face future challenges. According to the Programme for International Student Assessment (PISA) survey released by the OECD, the assessment results indicate that Indonesian students' literacy and critical thinking skills still lag behind those of other countries. One of the factors contributing to this low level of critical thinking skills is the teaching approach, which is still dominated by the lecture method. This method tends to discourage students from thinking deeply and critically, as students are more passive in receiving information than in seeking solutions to complex problems. Therefore, innovation in teaching methods that can facilitate the development of students' critical thinking skills from an early age is very important. Problem-Based Learning (PBL) is one approach that can help students develop critical thinking skills (Islamiati et al., 2024). Through PBL, students are encouraged to explore real-world problems and find solutions independently or in groups (Al-Thani & Ahmad, 2025; Ni'mah et al., 2024). As a result, PBL not only enhances students' conceptual understanding but also trains them in analyzing, evaluating, and solving problems(Purba et al., 2024; Rianti et al., 2024).

Previous studies have shown the effectiveness of the Problem-Based Learning approach in improving critical thinking and problem-solving skills in students. Research by (Astuti & Santosa, 2017) states that PBL can stimulate student activity in learning because they are directly involved in solving real problems. Students are encouraged to discuss, collaborate, and express their opinions in groups, which ultimately strengthens their understanding of concepts and critical thinking skills (Hajhosseini et al., 2016). However, these positive results have not been widely observed at the elementary education level in Indonesia, where the PBL approach is still rarely used in daily teaching and learning activities (Susilawati & Supriyatno, 2023).

In this digital age, integrating technology into PBL has great potential to maximize student learning outcomes (Thelma et al., 2024). Technology provides access to a wider range of interesting learning resources and can be integrated into the learning process to support exploration, discussion, and presentation activities (Abrami, 2001). However, the optimal use of technology in the classroom remains a challenge, especially in elementary schools, where access to technology and teachers' knowledge of its use are often limited (Abedi, 2024).

In addition, the use of technology in basic education is still not optimal. Although some schools are equipped with technological devices such as Chromebooks and tablets, their use is not yet maximized in the learning process. Technology is more often used as a separate additional medium from the main learning content, such as only for searching for information or displaying learning videos. In fact, the integration of technology in the PBL process can provide a more interactive and engaging learning experience for students. By using technology, students have the opportunity to access a wider range of information sources, interact with simulation applications, and use supporting software for data analysis. This enables students to delve deeper into the problems presented and develop their critical thinking skills in a relevant context.

Initial observations at SD Negeri 1 Bagik Payung and several other public schools in cluster IV Bagik Payung, Suralaga District, show that students' critical thinking skills are still relatively low. This is reflected in the learning process, which tends to prioritize memorization, lacks exploratory discussions in the classroom, and minimizes the use of media and methods that encourage students to actively participate in the learning process. The teaching methods

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used by teachers are still dominated by conventional approaches, such as lectures and routine assignments, without being balanced by activities that challenge students to think critically. Students tend to be passive, merely receiving information without much exploration or questioning of the material presented. Additionally, the teaching materials used are still monotonous and fail to maximize the use of technology as a supportive medium. However, technology has great potential to help create a more interactive and innovative learning environment.

Problem-Based Learning (PBL) is considered one of the most effective approaches to enhancing students' critical thinking skills. PBL encourages students to learn through solving real-world problems that are not only relevant to their daily lives but also sharpen their analytical thinking and decision-making abilities. When integrated with technology, this approach can provide a more engaging, interactive, and relevant learning experience tailored to students' needs in the digital age. However, based on observations with several teachers at SD Negeri Gugus IV Bagik Payung in Suralaga District, there are challenges in implementing PBL-based instructional materials integrated with technology. Teachers feel they lack appropriate teaching materials that align with students' characteristics, as well as limitations in designing materials that can optimally integrate technology. Therefore, efforts are needed to develop PBL-based teaching materials integrated with technology to enhance students' critical thinking skills.

Therefore, this study aims to develop Problem Based Learning-based teaching materials integrated with technology to improve the critical thinking skills of elementary school students. It is hoped that through the development of these teaching materials, students will be more actively involved in the learning process and more motivated to think critically in solving problems. In addition, this study is expected to serve as a reference for teachers in implementing the PBL approach supported by the integration of technology in the classroom.

It is hoped that the development of these teaching materials will better prepare students to face the challenges of the digital age, which demands critical thinking and complex problem-solving skills. This research is also expected to make a real contribution to efforts to improve the quality of basic education in Indonesia, particularly in terms of the effective and innovative application of technology in learning.

Meanwhile, obstacles in implementing PBL in several public elementary schools in Cluster IV Bagik Payung that are integrated with technology pose their own challenges. Observations at the schools reveal that teachers often lack clear guidelines for implementing PBL, especially with the addition of technology integration. Additionally, many teachers feel less confident or inadequately trained in using technology as a teaching tool. This highlights the need for instructional materials that not only incorporate PBL but also effectively integrate technology, thereby simplifying the implementation process for teachers.

The needs analysis for this study shows that there are several key aspects that must be considered in developing technology-integrated Problem Based Learning teaching materials to improve the critical thinking skills of elementary school students. First, there is a 25% need for innovative learning methods, where students need a more engaging and relevant approach, such as PBL, to stimulate them to solve problems independently and critically. Additionally, there is a 20% need to integrate technology into learning. The use of technology in this digital age

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not only enhances students' interest in learning but also provides them with broader access to information.

Furthermore, 30% of these needs are for the development of teaching materials specifically designed to support students' critical thinking skills. The teaching materials used must take into account the important components of critical thinking, such as the ability to analyze, evaluate, and synthesize information. Teacher readiness is also an important factor, accounting for 15% of the needs. Teachers need to be equipped with the understanding and skills to implement PBL methods and technology to support effective learning processes. Finally, 10% is allocated for evaluating and monitoring the effectiveness of teaching materials. This is important to assess how well the developed teaching materials have succeeded in improving students' critical thinking skills and to make improvements or further developments if necessary.

Therefore, this study attempts to address this gap by developing PBL-based teaching materials integrated with specific technologies to improve the critical thinking skills of elementary school students. The development of these teaching materials is expected to meet practical needs in providing materials that are appropriate for the modern learning context, as well as to contribute academically to the development of technology-based teaching materials. Additionally, this study will also test the effectiveness of the developed teaching materials in improving students' critical thinking skills, which is still rarely done at the elementary education level. Thus, this study not only contributes to the development of knowledge but also offers practical solutions that are relevant and applicable in elementary schools.

Research Method

This research model includes research and development (R&D), which is a series of systematic steps to produce new products or improve existing products so that they are suitable for use (Fahrurrozi, 2020). This research refers to the 4-D model (Thiagarajan, 1974), which consists of the definition stage, design stage, development stage, and dissemination stage.(Nugraheni et al., 2024) In the definition stage, needs analysis, learning objective formulation, student characteristic analysis, and material analysis are conducted to ensure the product's alignment with the curriculum. Next, the design stage produced an integrated technology-based IPAS print module equipped with a barcode to access Google Sites containing materials, videos, questions, worksheets, simulations, and attendance records, as well as the development of research instruments. The development stage included expert validation and limited testing on a small group to improve the initial product design.

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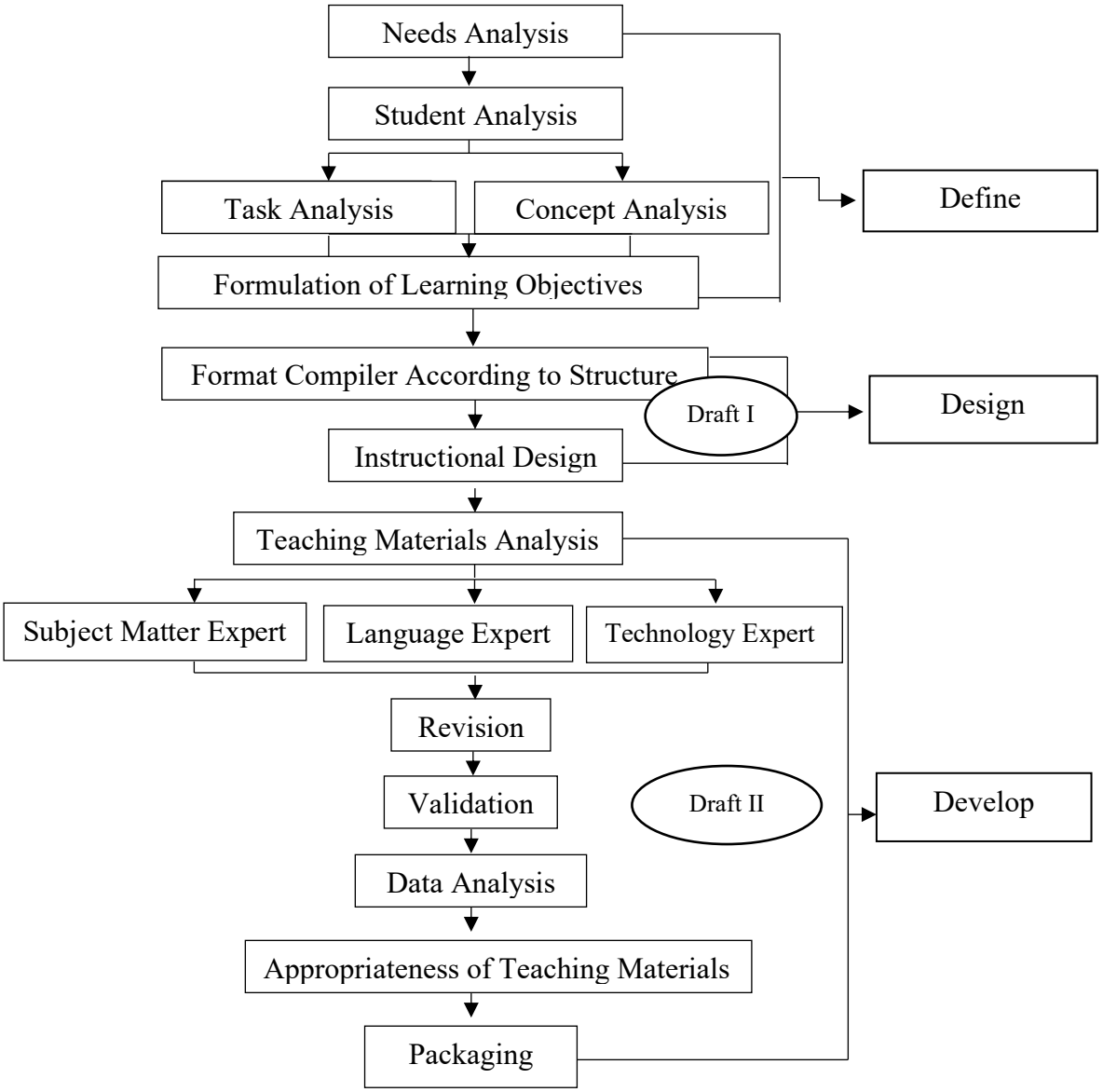

Figure 1. Development Procedure

Product Testing

The testing design in this study involved validation instruments by technology experts, material experts, and language experts, as well as response questionnaires for teachers and students as product users, plus observation instruments used by teachers as observers during the testing process. The purpose of this testing was to obtain assessments, input, and suggestions from validators so that the level of validity and feasibility of the product could be determined. The feedback obtained is then used to make revisions so that the product is more in line with the needs. The test subjects are fourth-grade students at SDN 1 Bagik Payung in Suralaga District and SDN 1 Terara in Terara District.

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Data Collection Techniques and Instruments

The data collection techniques in this study consisted of tests and non-tests. The test technique was carried out by giving multiple-choice questions (pre-test and post-test) to measure the improvement in students' critical thinking skills before and after using IPAS teaching materials based on Problem-Based Learning integrated with technology. Meanwhile, non-test techniques include observation and questionnaires. Observations were conducted in the preliminary study to determine the initial conditions of students, teachers, and the learning environment. Questionnaires were used to assess the suitability of the teaching materials and to measure teacher and student responses. The questionnaire instruments consisted of expert validation questionnaires and response questionnaires, both of which used a Likert scale with five answer options.

The data collection instruments used in accordance with this technique include test sheets and questionnaires. Test sheets are given to students before and after learning to determine their level of critical thinking skills. Meanwhile, questionnaires are used to obtain expert validation data on the suitability of teaching materials, as well as data on teacher and student responses to the use of PBL-based IPAS teaching materials integrated with technology.

Result and Discussion

1. Product Design Development Results

The product of this research and development activity is teaching material based on Problem-Based Learning (PBL) integrated with technology in the IPAS subject for the odd semester. During the research and development process, various stages of activities were carried out with various twists and turns in the dynamics that occurred in the field. This was part of a long process that ultimately produced a quality and tested product that presented a more innovative learning process to improve the critical thinking skills of students.

Product Design Validation Results

An assessment of teaching materials based on technology-integrated Problem Based Learning was conducted to determine the feasibility of the product from the perspectives of technology experts, subject matter experts, and language experts. Therefore, prior to field testing, the product must be validated by technology experts, subject matter experts, and language experts. The validated assessment results from the experts are calculated to obtain scores for each aspect. These scores are then converted to assess the feasibility of the technology-integrated Problem-Based Learning teaching materials from the perspectives of technology, content, and language.

Results of Learning Technology Expert Validation

The validation of the feasibility of teaching materials based on Problem-Based Learning integrated with technology from a technological perspective was conducted by technology experts from Hamzanwadi University. This validation was carried out on July 22, 2025. The results of this technology expert assessment were conducted to obtain written and verbal feedback or suggestions for improvement. The technology feasibility assessment covered several aspects, including: the design of the developed instructional materials, the learning process, and the use of the instructional materials. The results of the total feasibility score conversion by the technology experts can be seen in the following table:

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Table 1. Conversion of Expert Technology Validation Scores

No	Score	Value	Category
1.	X > 63	A	Very Good
2.	51 < X ≤ 63	B	Good
3.	39 < X ≤ 51	C	Enough
4.	27 < X ≤ 39	D	Less
5.	X ≤ 27	E	Very Poor

Table 1 can be used as a reference to determine the level of suitability of teaching materials based on Problem-Based Learning (PBL) integrated with technology. The validation is considered suitable if all aspects receive a minimum score of 51 with a category B rating and are classified as good. If the validation results according to technology experts are below this score, the product is deemed unsuitable for use and testing.

Based on the validation results from technology experts, out of 3 evaluation aspects comprising 8 indicators with 15 statements, 7 statements received a score of 4 (agree) and 8 statements received a score of 5 (strongly agree). Therefore, when this score is converted, it yields a value of 68, which falls within the score range X > 63, meaning it exceeds the minimum score set.

Thus, the validation results from the educational technology expert for the developed instructional materials fall into the "Very Good" category. For further details, please refer to the diagram below.

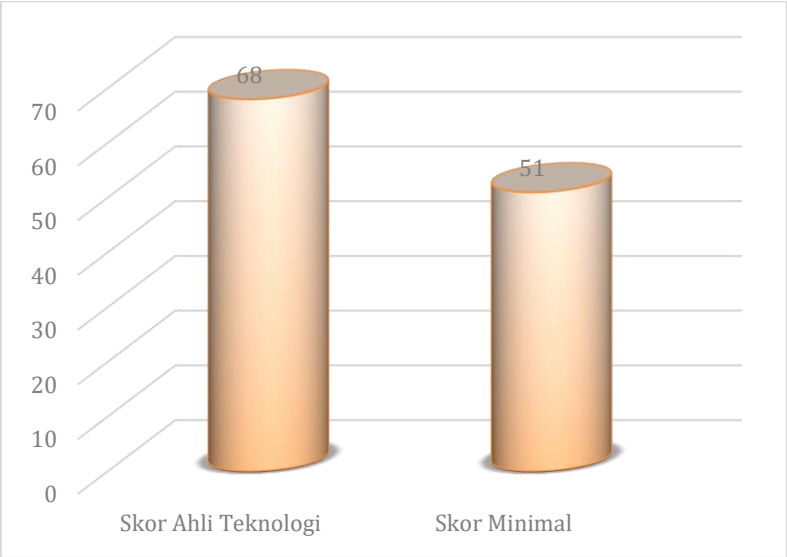

Figure 1. Expert Validation Score Diagram Technology

a. Results of Expert Validation

The validation of the suitability of teaching materials based on Problem-Based Learning integrated with technology from the content perspective was conducted by subject matter experts from the IPAS department at Hamzanwadi University on July 24, 2025. The results of this subject matter expert validation were conducted to obtain written and verbal feedback or

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suggestions for improvement. The assessment of material suitability covered several aspects, including: accuracy of the material, language and writing, and the use of Problem-Based Learning (PBL) integrated with technology in teaching. The results of the total suitability score conversion by the subject matter expert can be seen in the table below:

Table 2. Conversion of Expert Validation Scores

No	Score	Value	Category
1	X > 63	A	Very Good
2	51 < X ≤ 63	B	Good
3	39 < X ≤ 51	C	Enough
4	27 < X ≤ 39	D	Less
5	X ≤ 27	E	Very Poor

Table 2 can be used as a reference to determine the feasibility of technology-integrated Problem Based Learning teaching materials according to subject matter experts. The teaching materials are considered feasible if all aspects receive a minimum score of 51 with a B grade and are classified as good. If the validation results according to subject matter experts are below this score, the product is deemed unfit for use and testing.

Based on the data from the subject matter expert validation, the 3 assessment aspects containing 15 statements received scores as follows: 7 statements received a score of 4 (agree) and 8 statements received a score of 5 (strongly agree). Therefore, when this score is converted, it yields a value of 68, which falls within the score range X > 63, meaning it exceeds the minimum score that has been set.

Therefore, the validation results from subject matter experts on the teaching materials that have been developed are in the "Very Good" category. More details can be seen in the diagram below.

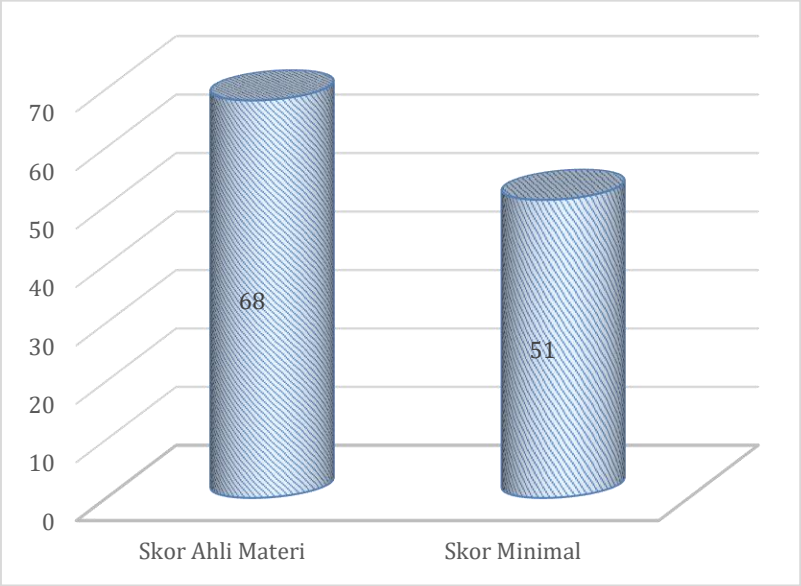

Figure 2. Diagram of Expert Material Validation Scores

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b. Results of Language Expert Validation

Validation of the suitability of teaching materials based on Problem-Based Learning integrated with technology from a linguistic perspective by lecturers at Hamzanwadi University, East Lombok, on July 25, 2025. The product validation components consist of two evaluation aspects. The results of this language expert evaluation are conducted to obtain written or verbal feedback or improvement suggestions. The language suitability evaluation covers several aspects, namely: language suitability and compliance with language rules. The results of the total language suitability score conversion can be seen in the following table:

Table 3. Conversion of Language Expert Validation Scores

No	Score	Value	Category
1	$X > 63$	A	Very Good
2	$51 < X \leq 63$	B	Good
3	$39 < X \leq 51$	C	Enough
4	$27 < X \leq 39$	D	Less
5	$X \leq 27$	E	Very Poor

Table 3 can be used as a reference to determine the level of suitability of technology-integrated Problem-Based Learning (PBL) teaching materials according to language experts. The assessment is considered suitable if all aspects receive a minimum score of 51 with a B grade and are included in the good category. If the assessment results according to language experts are less than this score, the product is declared unsuitable for use and testing.

The product validation components consist of 15 statement items to be evaluated. Two statements received a score of 4 (agree) and 13 statements received a score of 5 (strongly agree). When converted, this yields a score of 73 on the $X > 63$ scale, which can be categorized as "Very Good." For further clarification, please refer to the diagram below.

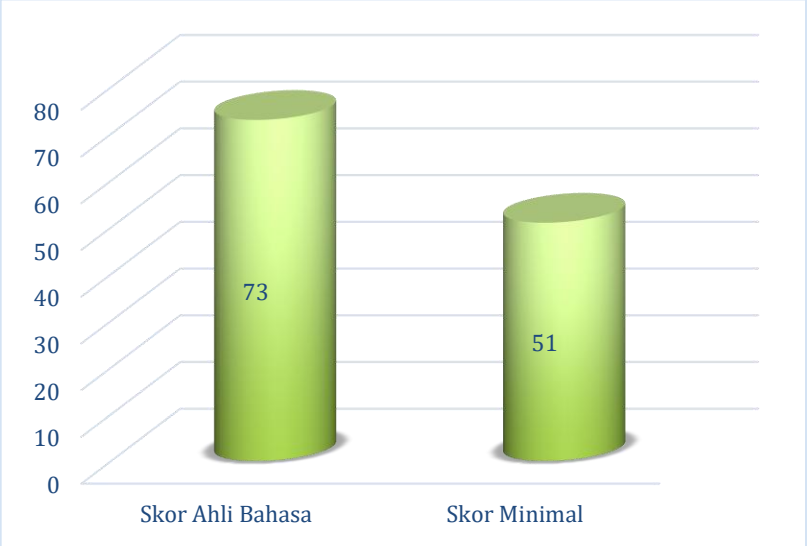

Figure 3. Diagram of Language Expert Validation Results

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Thus, the final product design can be used immediately or tested on a small or large scale. The teaching materials that have been developed, validated, and evaluated by the three experts are recommended as development results that are suitable for application in learning activities.

2. Final Revision of Product Design

a. Revision by Technology Experts

The advice given by technology experts regarding the product development draft was that researchers should modify the introductory learning video on the Google Sites application so that it does not distract students' concentration when watching the learning video.

b. Revision by Subject Matter Experts

The responses and recommendations provided by subject matter experts are covered in the chapter on technology-integrated Problem Based Learning teaching materials adapted to the surrounding environment.

c. Revision by Language Experts

The advice given by language experts is for researchers to maintain the use of sentences with a subject, predicate, and object pattern and to avoid using slang or non-standard language.

3. Product Test Results

a. Product Trial Results in Small Groups

The first trial of the development of teaching materials based on Problem-Based Learning integrated with technology was conducted on July 28, 2025, at SDN 1 Bagik Payung. The activity involved administering a pretest to 10 fourth-grade students. The results obtained by the students during the pretest were as follows: 2 students scored above the minimum passing grade (KKM), while 8 students scored below the KKM, with an average score of 59. To assess the effectiveness of the Problem-Based Learning-based instructional materials developed, an analysis was conducted using the N-Gain Score. Following the implementation of the developed product during the learning process on July 29, 2025, an improvement in students' critical thinking skills was observed through the post-test activity. Students who took the post-test achieved an average score of 88, and all 10 students who participated in the post-test activity scored above the minimum competency standard (KKM).

Meanwhile, the second trial of the Problem-Based Learning-based teaching material development product was conducted on July 30, 2025, at SDN 1 Terara. In this activity, fourth-grade students were given a pretest consisting of 10 questions. The pretest results showed that 2 students scored above the minimum passing grade (KKM) and 8 students scored below the KKM, with an average score of 58. Following the implementation of the Problem-Based Learning (PBL) instructional materials, 10 students participated in a post-test. The post-test results showed that 1 student scored below the minimum competency standard (KKM), while 9 students scored above the KKM, with an average score of 85.

Based on the results of the pretest and posttest conducted on small groups in two different schools, it can be concluded that the calculation of the N-Gain effectiveness interpretation category obtained a score of 74.17% at SDN 1 Bagik Payung and 71.33% at SDN 1 Terara. Therefore, the percentage of N -Gain interpretation percentage at both schools can be categorized as sufficiently effective, while the effectiveness test calculation using the N-Gain score division yielded a value of 0.74 at SDN 1 Bagik Payung and 0.71 at SDN 1 Terara, meeting the moderate criteria. Therefore, it can be concluded that the use of Problem-Based

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Learning-based instructional materials integrated with technology is effective for use as instructional materials in the learning process to enhance students' critical thinking skills.

b. Product Trial Results in Large Groups

Product testing aims to determine the effectiveness of the developed product. In this case, testing is conducted through the implementation of teaching materials based on Problem-Based Learning integrated with technology, thereby enhancing students' critical thinking skills. The process of testing the effectiveness of the developed teaching materials was carried out by administering pre-tests and post-tests to students during large-scale group testing activities. This activity was conducted on August 4, 2025, at SDN 1 Bagik Payung with 15 students participating, and at SDN 1 Terara on August 5, 2025, with 19 students participating. The large-scale group test was conducted by administering pretest questions to students at each school. The results obtained by students at SDN 1 Bagik Payung during the pretest were as follows: 3 students scored above the minimum passing grade (KKM), 12 students scored below the KKM, with an average score of 57.33, while the results obtained by the students at SDN 1 Terara were as follows: 4 students scored above the KKM and 15 students scored below the KKM, with an average score of 56.84.

Next, the implementation of Problem-Based Learning (PBL)-based teaching materials integrated with technology was carried out in each school. The learning process was conducted in accordance with the teaching modules that had been created and the Problem-Based Learning (PBL)-based learning syntax. The implementation of these teaching materials was concluded with a post-test. Students at SDN 1 Bagik Payung who participated in the post-test achieved an average score of 89.33, with 1 student scoring below the minimum passing grade (KKM) and 14 students scoring above the KKM. Meanwhile, at SDN 1 Terara, the results obtained by the students were 1 student scoring below the passing grade and 18 students scoring above the passing grade, with an average score of 88.95. Data from the pretest and posttest of the large group.

A significant improvement was observed in the posttest results compared to the pretest results. Based on the pretest and posttest results in two different schools, it can be concluded that the calculation of the N-Gain effectiveness interpretation category obtained a value of 79.11% at SDN 1 Bagik Payung and 78.31% at SDN 1 Terara. Therefore, the N -Gain interpretation percentage at both schools can be categorized as effective, while the effectiveness test calculation using the N-Gain score division obtained a value of 0.79 at SDN 1 Bagik Payung and 0.78 at SDN 1 Terara with high criteria.

Based on the pretest and posttest results, it can be concluded that the effectiveness test of the Problem-Based Learning-based teaching material integrated with technology is effective for use as teaching material in the learning process to improve students' critical thinking skills.

Student Response Questionnaire Results

The main product test was conducted by filling out a student response questionnaire completed by fourth-grade students at SDN 1 Terara on August 2, 2025, with a total of 19 respondents. The analysis of the student response questionnaire yielded a total score of 1,302 with an overall average of 68.5, falling within the score range of $X > 63$. Based on the overall score, it can be categorized as “very good.” The following are the five categories that can be used as a reference:

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Table 4. Results of Student Response Questionnaire Validation Calculations

No	Score	Value	Category
1	X > 63	A	Very Good
2	51 < X ≤ 63	B	Good
3	39 < X ≤ 51	C	Enough
4	27 < X ≤ 39	D	Less
5	X ≤ 27	E	Very Poor

Table 5. Student Response Scores

Total Score	Average	Category
1302	68,5	Very Good
	4,6	

c. Teacher Response Questionnaire Results

The observation activity was conducted by a fourth-grade teacher at SDN 1 Terara, who was tasked with assessing the learning process by implementing technology-integrated Problem-Based Learning (PBL) teaching materials directly. The assessment obtained by the observer can be used as a reference to determine the suitability of the teaching materials developed. Based on the data from the teacher's observation form filled out by the observer, it shows that out of 15 items to be assessed, Two statements received a score of 4 (agree) and 13 statements received a score of 5 (strongly agree). When converted, this yields a score of 73 on the X > 63 scale, indicating that the teacher's implementation of technology-integrated Problem-Based Learning instructional materials can be categorized as “very good.” The following five categories can be used as a reference:

Table 6. Results of Teacher Response Questionnaire Validation Calculations

No	Score	Value	Category
1	X > 63	A	Very Good
2	51 < X ≤ 63	B	Good
3	39 < X ≤ 51	C	Enough
4	27 < X ≤ 39	D	Less
5	X ≤ 27	E	Very Poor

Discussion

The implementation of technology-integrated Problem Based Learning teaching materials can be carried out in small and large groups in fourth grade elementary schools. Data collection related to the effectiveness of teaching materials was conducted during the implementation process. The process of implementing technology-integrated Problem-Based Learning teaching materials requires students to be more active and independent in teaching and learning activities, where by using these teaching materials, students construct their knowledge with problems in everyday life so that students are able to improve their critical thinking skills to solve problems by utilizing technology and collaborating. The teaching materials developed by researchers provide students with the opportunity to learn and understand the material independently with the help of technology. The teaching materials can

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be accessed anytime and anywhere through the students' own devices or gadgets. Furthermore, the effectiveness of implementing the developed instructional materials has shown optimal results, as evidenced by the survey responses from students, who appear highly motivated to use technology-integrated Problem-Based Learning, and the learning process is highly effective. Meanwhile, data from classroom teacher observations indicate that the developed instructional materials have made students very enthusiastic about the learning process. The evaluation stage was conducted to obtain pretest and posttest data. Significant differences between the pretest and posttest results indicate the effectiveness of Problem Based Learning-based teaching materials. integrated technology that can improve students' critical thinking skills.

Based on the results of the pretest, posttest, student response questionnaires, and teacher observation sheets filled out by observers, it was found that the technology-integrated Problem-Based Learning (PBL) teaching materials were highly effective and worthy of use. This aligns with the findings of research by (Nikmati, 2024), which showed that the use of interactive digital learning media can enhance students' critical thinking skills(Arni et al., 2024; Song & Cai, 2024). In addition to providing an engaging learning experience, this method is expected to generally enhance students' critical thinking skills (Blyznyuk & Kachak, 2024). Therefore, this technology-integrated Problem-Based Learning (PBL) instructional material is highly effective and suitable for use at the elementary school level.

Conclusion

This study produced technology-integrated Problem Based Learning teaching materials for IPAS subjects that have undergone validation, revision, and testing. Validation results by technology experts, subject matter experts, and language experts showed that the product was in the “Very Good” category, making it suitable for use in learning. Small and large group trials showed a significant increase in students' critical thinking skills, with N-Gain scores in the moderate to high category. Additionally, the results of student and teacher feedback surveys confirm that the developed instructional materials received a “Very Good” rating and are effective in enhancing students' motivation and active engagement in learning. Thus, the technology-integrated PBL-based instructional materials developed are effective, suitable, and can be implemented as an educational innovation to enhance elementary school students' critical thinking skills.

Recommendation

Based on the research results, several recommendations can be made as follows. First, teachers are advised to utilize technology-integrated Problem Based Learning teaching materials as an alternative learning medium to improve students' critical thinking skills. Second, schools can support the implementation of this innovative learning by providing supporting facilities, such as digital devices and adequate internet access. Third, further research is needed at other grade levels and subject areas to expand the scope of the effectiveness of technology-integrated PBL-based teaching materials. Additionally, long-term evaluation of the impact of using these teaching materials is also important to determine the consistency of improvements in students' critical thinking skills.

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