

Integration of E-LKPD Liveworksheet-Assisted Problem-Based Learning Model into Critical Thinking Skills of Science Subjects

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ABSTRACT

This study analyzes the influence of the Problem-Based Learning (PBL) model assisted by e-LKPD Liveworksheet on the critical thinking skills of fifth-grade students in Natural and Social Sciences (IPAS) subjects at the elementary school level. Strengthening critical thinking is essential in supporting 21st-century learning, which requires students to analyze information, evaluate ideas, and solve problems independently. This research employed a quasi-experimental Pretest–Posttest Nonequivalent Control Group Design with 58 students, divided into an experimental and a control group. Critical thinking skills were measured using a validated and reliable ten-item multiple-choice test. Data were analyzed for normality and homogeneity, and an independent t-test and N-Gain calculations were performed using SPSS version 22. The findings indicate that the PBL model supported by e-LKPD Liveworksheet significantly improved students' critical thinking skills, evidenced by a significance value of 0.000 (< 0.05) and an average N-Gain score of 0.6179 in the medium-high category. These results demonstrate that integrating PBL with digital worksheets encourages active, contextual, and technology-enhanced learning. The study concludes that e-LKPD–assisted PBL is an effective and innovative strategy for enhancing elementary students' critical thinking skills.

Keywords:

Problem-Based Learning; E-LKPD Liveworksheet; Critical Thinking Skills; IPAS; Primary School.

ABSTRAK

Penelitian ini menganalisis pengaruh model Pembelajaran Berbasis Masalah (PBL) yang dibantu oleh e-LKPD Liveworksheet terhadap kemampuan berpikir kritis siswa kelas lima mata pelajaran Ilmu Pengetahuan Alam dan Sosial (IPAS) di tingkat sekolah dasar. Penguatan berpikir kritis sangat penting dalam mendukung pembelajaran abad ke-21, yang menuntut siswa untuk menganalisis informasi, mengevaluasi ide, dan memecahkan masalah secara mandiri. Penelitian ini menggunakan desain quasi-eksperimental Pretest–Posttest Nonequivalent Control Group Design dengan 58 siswa, yang dibagi menjadi kelompok eksperimen dan kelompok kontrol. Kemampuan berpikir kritis diukur menggunakan tes pilihan ganda sepuluh item yang telah divalidasi dan reliabel. Data dianalisis untuk normalitas dan homogenitas, dan uji t independen serta perhitungan N -Gain dilakukan menggunakan SPSS versi 22. Temuan menunjukkan bahwa model PBL yang didukung oleh e-LKPD Liveworksheet secara signifikan meningkatkan kemampuan berpikir kritis siswa, dibuktikan dengan nilai signifikansi $0,000 (< 0,05)$ dan skor N -Gain rata-rata $0,6179$ dalam kategori sedang-tinggi. Hasil ini menunjukkan bahwa integrasi PBL dengan lembar kerja digital mendorong pembelajaran aktif, kontekstual, dan berbasis teknologi. Studi ini menyimpulkan bahwa PBL yang dibantu e-LKPD merupakan strategi yang efektif dan inovatif untuk meningkatkan kemampuan berpikir kritis siswa sekolah dasar.

Kata kunci:

Problem-Based Learning; Lembar Kerja Langsung E-LKPD; Keterampilan Berpikir Kritis; IPAS; Sekolah Dasar.

1. Introduction

The development of science and technology in the 21st century requires a paradigm shift in education. Bella & Kristin (2024) emphasized that students are not only required to master factual knowledge but also to think critically about the complexity of life's problems. Critical thinking skills are one of the main competencies that need to be developed from the elementary education level. This competency plays an important role in forming the ability to analyze, evaluate, and make rational decisions. The application of learning that can grow these skills is a challenge for the world of education in the digital era.

Critical thinking skills involve analyzing, evaluating, and inferring information logically. Students who can think critically can solve problems independently, using evidence and reasons that can be accounted for. Critical thinking includes five main indicators, namely, providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and establishing thinking strategies (Putri & Yenny, 2025). These five indicators require an active and student-centered learning process. The passive learning process tends to hinder the growth of high-level thinking skills.

The reality on the ground shows that the learning process in elementary schools is still dominated by lecture-based instruction and memorization exercises. Teachers place more emphasis on achieving low-level cognitive outcomes focused on remembering and understanding, and emphasize that this condition leads students to be less involved in the exploration and analysis of deeper concepts. Monotonous learning activities make it difficult for students to develop reflective thinking skills. This kind of learning needs to be reviewed to align with the demands of 21st-century competencies.

Natural and Social Sciences (IPAS) is one of the fields with great potential for training students' critical thinking skills. Social studies learning requires students to understand the relationship between natural phenomena and social life logically and systematically. Each IPAS material contains elements of problem exploration that can be used to form scientific reasoning. Students are expected to analyze the causes and effects of various phenomena and to find solutions to real problems in their surrounding environment. Strengthening critical thinking in IPAS can simultaneously develop students' scientific and social character (Nurhayat et al., 2022).

Critical thinking skills require learning conditions that position students as active constructors of knowledge. The Problem-Based Learning (PBL) model is one of the most appropriate approaches to achieve this because it situates learning within authentic, real-life problems that challenge students to investigate, reason, and make evidence-based judgments (Fidan & Tuncel, 2019; Jatiningsih & Dewi, 2022; Suryawan, Jana, Pujawan, Hartawan, & Putri, 2023). Yuliana and Kurnia (2024) highlight that PBL encourages learners to engage in inquiry cycles, identifying problems, collecting relevant information, formulating hypotheses, and evaluating solutions, thereby strengthening higher-order thinking. In addition, PBL shifts classroom interactions from teacher-centered instruction to collaborative meaning-making, fostering both independence and social reasoning (Zarvianti & Sahida, 2020; Putri & Wiarta, 2024; Adri, Ganefri, Sri Wahyuni, Zakir, & Jama, 2020). When supported by e-LKPD, the model becomes more effective, as digital worksheets clearly structure inquiry steps and provide interactive scaffolding. Consequently, integrating PBL and e-LKPD creates a learning environment that is not only cognitively demanding but also adaptable to the digital learning needs of elementary students.

Problem-Based Learning is grounded in constructivist principles that position students as active participants in developing their understanding (Wulandari, Wijayanti, & Budhi, 2018; Simbolon & Koeswanti, 2020; Istiana & Awaludin, 2018). However, its relevance becomes clearer when connected to the actual learning conditions found in Indonesian elementary schools. In many schools, including those in Probolinggo, learning still tends to rely on teacher explanations and the repetition of textbook material, limiting students' opportunities to investigate ideas or practice higher-order thinking. PBL provides an alternative learning model that directly addresses these challenges because each of its stages, from problem orientation to reflection, requires students to analyze information, evaluate possible solutions, and justify their reasoning (Ardiyanto et al., 2024). When applied in the context of IPAS learning in Probolinggo, PBL enables students to relate scientific and social concepts to real issues in their environment, making learning more meaningful and authentic (Bernika & Cahyono, 2021; Seruni, Munawaroh, Kurniadewi, & Nurjayadi, 2020; Gumartifa, Syahri, Siroj,

Nurrahmi, & Yusof, 2023). This approach aligns with national education goals while also helping teachers overcome the persistent gap between expected critical thinking skills and classroom realities.

Previous research has shown that PBL is effective in improving critical thinking skills at various levels of education. Aulia et al. (2023) prove that implementing PBL in elementary schools can increase students' active participation and analytical skills. Noviana et al. (2023) added that this model encourages students to think reflectively through discussions and group work. Similar findings were reported by Wahyuni et al. (2023), who stated that PBL improves logical and evaluative thinking skills in science learning. This empirical evidence corroborates the assumption that PBL is feasible for developing critical thinking skills in elementary school students (Aminatun et al., 2022; Tholib & Rugaiyah, 2022; Lewar, El Puang, & Lawotan, 2023; Hikmasari, Kartono, & Mariani, 2018).

The development of digital technology also provides teachers with opportunities to create more interactive learning experiences. The integration of technology into learning makes the learning process more engaging and meaningful. One form of digital innovation that is growing rapidly is the use of Electronic-LKPD (e-LKPD). e-LKPD is a digital worksheet that allows students to interact directly with learning materials. These media provide automated feedback and facilitate flexible self-paced learning. The use of e-LKPD supports the transformation of learning from conventional to interactive digital (Afifah & Junaedi, 2023).

The Liveworksheet platform is one of the most popular media for developing e-LKPD in elementary schools. This media allows teachers to design digital worksheets with interactive features such as drag-and-drop, auto-fill, and audio-visual elements. Students can work on the questions online and receive the assessment results immediately after completing the activity. Sidiq et al. (2024) emphasized that these features make learning more engaging, efficient, and aligned with the characteristics of the digital generation. Liveworksheets also allow teachers to monitor student learning outcomes in real time without using paper.

The results of a study by Astitiani & Sutyarningsih (2024) show that the use of Liveworksheet-based e-LKPD can improve learning outcomes and student active participation. Pratiwi & Oktaviarini (2023) added that this media is effective in developing high-level thinking skills through exploratory activities. In line with this, Aulia et al. (2023) found that the e-LKPD Liveworksheet is highly valid, practical, and effective for learning science in elementary schools. The findings prove that the use of digital media in learning can encourage higher cognitive engagement. This innovation is a strategic step toward implementing 21st-century learning.

The integration between the Problem-Based Learning model and the e-LKPD Liveworksheet media is an innovative learning strategy with great potential. The combination of the two creates a collaborative, interactive, and contextual learning environment. Students are trained to think critically through problem-solving, supported by digital media that facilitate information exploration. This model fosters learning motivation while strengthening conceptual analysis skills (Kote et al., 2024). The application of this model is expected to address learning challenges that remain teacher-centered.

Initial observations at one of the elementary schools in Probolinggo Regency show that social studies learning still uses the lecture method with a printed LKPD. Students' learning activities have not led to the formation of high-level thinking skills. Teachers rarely use digital media that allows interaction and reflection during learning. As a result, students are less motivated to think critically

and often rely on memorization in understanding concepts. This phenomenon shows the need for more challenging and relevant learning model innovation.

The integration of PBL with e-LKPD Liveworksheet offers a solution to low levels of critical thinking in elementary schools. Through the stages of problem presentation, information collection, data analysis, and reflection, students are directed to think logically and systematically. The digital media used helps them understand concepts more concretely through interactive activities. Susilawati et al. (2024) emphasized that this kind of learning can shift passive learning patterns to active, exploratory ones. This strategy also supports the school's efforts in implementing a competency-oriented curriculum.

Critical thinking skills are closely related to students' scientific and social literacy skills. Problem-based IPAS learning teaches students to understand the relationship between scientific concepts and people's lives. Every problem presented in class becomes a means to hone critical reasoning and social empathy. This kind of learning process aligns with the goal of Social Studies Education, which integrates knowledge, attitudes, and skills. This approach also supports the creation of a generation that thinks logically and reflectively and is responsible for its social environment (Mirawati et al., 2022).

The implementation of PBL assisted by e-LKPD Liveworksheet not only supports the development of critical thinking but also strengthens learning independence. Students are allowed to manage their learning time and access information resources independently. The teacher serves as a facilitator, guiding and providing feedback throughout the learning process. Such an interaction pattern fosters a sense of responsibility and confidence in students (Setiawan et al., 2024). Problem-based digital learning also helps students get used to using technology productively.

The use of e-LKPD Liveworksheet aligns with the principle of Freedom of Learning, which emphasizes independence and freedom of exploration. Students can learn at their own pace and in their own style with teacher guidance. This model opens up space for learning innovations that are not limited by time and place. Rizmayannudin & Nuroh (2024) found that integrating technology into social studies learning creates a more dynamic learning experience and is adaptable to students' needs. Basic education is an important arena for building critical thinking skills from an early age.

The application of the Problem-Based Learning model, supported by the e-LKPD Liveworksheet, makes a real contribution to improving learning quality in elementary schools. The integration of models and media not only strengthens cognitive skills but also fosters students' motivation and curiosity (Wulandari & Astuti, 2023). Challenging and interactive learning can create a fun and meaningful learning environment. This model aligns with the vision of national education for forming students who think critically, creatively, and adaptively. Consistent implementation is expected to improve the quality of basic education sustainably.

The main purpose of this study is to determine the influence of the e-LKPD Liveworksheet-assisted Problem-Based Learning model on the critical thinking skills of grade V students in science subjects. This research is expected to contribute to learning innovations that integrate pedagogical approaches and digital technology. The research results are expected to serve as a reference for teachers in designing learning experiences that foster critical and reflective thinking. This research can also enrich the literature on the effectiveness of problem-based learning in basic education. The

integration of the two is believed to be a learning strategy relevant to the needs of 21st-century education.

2. Methods

2.1. Research Design

This study uses a quantitative, quasi-experimental approach because it involves two naturally formed groups. The main purpose of the study was to determine the effect of the Problem-Based Learning model assisted by e-LKPD Liveworksheet on the critical thinking skills of class V students. The experimental group received problem-based learning with the e-LKPD Liveworksheet, while the control group received learning with the Discovery Learning method. The research design is shown in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	O ₁	X (PBL + e-LKPD Liveworksheet)	O ₂
Control	O ₁	– (Discovery Learning)	O ₂

Description: O₁ = Pretest O₂ = Posttest X = Treatment with e-LKPD-assisted PBL model Liveworksheet

2.2 Population and Sample

The population of this study comprises all class V students at one of the State Elementary Schools in Probolinggo Regency, totaling 58 students. Samples were taken using saturated sampling, in which the entire population was used as the sample because the population was small. The VA class, comprising 28 students, served as the experimental group, while the VB class, comprising 30 students, served as the control group. The research was carried out during the even semester of the 2024/2025 academic year in the subject of social studies. The research implementation comprises three stages: preparation, implementation, and evaluation of learning outcomes.

2.3 Research Instruments

The research instrument consists of two types, namely treatment instruments and measurement instruments. The treatment instruments are in the form of teaching modules and e-LKPD Liveworksheet, which are designed based on the syntax of the Problem-Based Learning model. The measurement instrument is a critical thinking skills test comprising 10 multiple-choice questions, arranged according to Ennis's critical thinking indicators, including: providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and thinking strategies and tactics. Details of the research instruments are presented in Table 2.

Table 2. Research Instruments

Instrument Type	Shape	Number of Items	Measured Aspects	Validity & Reliability
e-LKPD Liveworksheet	Interactive digital sheet	5 activities	PBL syntax (problem identification, data collection, analysis, solution, reflection)	Validated by media experts and subject matter experts

Critical Thinking Skills Test	Multiple choice	10 grains	Analysis (C4) and Evaluation (C5)	$r_{count} > r_{table}$; Cronbach's Alpha = 0.872
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2.4 Data Collection Procedure

Data collection techniques included a pretest and posttest to measure critical thinking skills before and after treatment. The data was analyzed using SPSS software version 22 to ensure the accuracy of the test results. Statistical analysis includes normality tests, homogeneity tests, t-tests, and N-Gain calculations. The normality test used the Shapiro-Wilk method, the homogeneity test used Levene's Test, and the t-test was used to assess significant differences between groups. N-Gain analysis was carried out to assess the effectiveness of improving student learning outcomes.

2.5 Data Analysis Techniques

A summary of data analysis techniques is presented in Table 3.

Table 3. Data Analysis Techniques

Test Type	Purpose of Analysis	Significance Criteria	Interpretation
Normality (Shapiro-Wilk) Test	Define data distribution	Sig. > 0.05	Normally distributed data
Homogeneity (Levene Test) Test	Determining the similarity of variance	Sig. > 0.05	Homogeneous data
Independent T-Test	Testing differences between groups	Sig. < 0.05	There is a significant difference
N-Gain	Measuring improvement in learning outcomes	<0.3 low; 0.3–0.7 moderate; >0.7 high	Effectiveness of treatment

This research method was chosen because it revealed the cause-and-effect relationship between the application of the learning model and improvements in critical thinking skills. The research procedure is carried out systematically to maintain the validity and reliability of the results. The learning conditions in both groups are made equal so that any difference in results is due solely to the treatment. The data obtained are objectively analyzed and presented quantitatively to support scientific interpretation. The results of the analysis are expected to provide empirical evidence on the effectiveness of the e-LKPD Liveworksheet-assisted Problem-Based Learning model in improving students' critical thinking skills.

3. Results and Discussion

3.1 Results

The results of this study were obtained from the analysis of pretest and posttest data on the critical thinking skills of class V students in the science subject. The research involved two classes: the VA class, an experimental group receiving the Problem-Based Learning model assisted by e-LKPD Liveworksheet, and the VB class, a control group using Discovery Learning. Data collection is conducted using validated, reliable multiple-choice tests. The test result data were processed in

SPSS version 22 for Windows using a series of statistical tests, including normality and homogeneity tests, t-tests, and N-Gain calculations. This analysis aims to determine the effect of applying the learning model on students' critical thinking skills.

The normality and homogeneity tests were carried out as prerequisites for parametric statistical analysis. The results of the Shapiro-Wilk normality test showed that the data in both groups were normally distributed, with p -values > 0.05 . The homogeneity test using Levene's Test showed that the variances between groups were homogeneous ($p > 0.05$). Both of these results indicate that the data are suitable for further analysis using independent t-tests. A summary of the results of the prerequisite test is presented in Table 4.

Table 4. Normality and Homogeneity Test Results

Test Type	Group	Sig.	Information
Normality (Shapiro-Wilk)	Pretest Experiment	0.089	Usual
	Posttest Experiment	0.074	Usual
	Control Pretest	0.109	Usual
	Posttest Control	0.094	Usual
Homogeneity (Live Test)	Pretest	0.623	Homogeneous
	Posttest	0.486	Homogeneous

The results presented in Table 4 show that all pretest and posttest scores from both the experimental and control groups met the assumptions required for parametric testing. The Shapiro-Wilk normality test yielded p -values ranging from 0.074 to 0.109, all of which were greater than 0.05, indicating that the data were normally distributed. Likewise, the homogeneity test using Levene's Test yielded p -values of 0.623 for the pretest and 0.486 for the posttest, indicating that the variances between the two groups were homogeneous. These findings confirm that the datasets meet the assumptions of normality and homogeneity, thereby validating the use of the independent t-test to examine further differences in students' critical thinking skills between the experimental and control groups.

After confirming that the data met the prerequisites, an independent t-test was performed to assess differences in learning outcomes between the experimental and control groups. The analysis showed that the experimental group had an average pretest score of 47.14, while the control group had an average pretest score of 33.00, with a p -value of 0.000 (< 0.05). This result shows a difference in initial ability, but the difference does not affect the final result because the increase is calculated based on N-Gain. In the posttest, the experimental group's average score increased to 77.86, while the control group's average score remained 55.67, with a significance value of 0.000 < 0.05 . This suggests a significant difference between the two groups after treatment. A summary of the t-test results is presented in Table 5.

Table 5. Pretest and Posttest t-test results

Test Type	Group	N	Average	Sig. (2-tailed)	Information
Pretest	Experiment	28	47,14	0,000	Significant differences

	Control	30	33,00		
Posttest	Experiment	28	77,86	0,000	Significant differences
	Control	30	55,67		

The analysis of improvements in learning outcomes used the Normalized Gain (N-Gain) metric to assess the learning model's effectiveness in developing critical thinking skills. The average N-Gain value of the experimental group was 0.6179 (moderate–high category), while the control group was 0.3513 (medium category). The t-test on N-Gain showed a p-value of 0.000 (< 0.05), indicating a significant difference in improvement between the two groups. The data show that learning with the Problem-Based Learning model, supported by e-LKPD Liveworksheet, is more effective at improving critical thinking skills than conventional learning. The results of the N-Gain test are presented in Table 6.

Table 6. N-Gain Test Results

Group	N	Average N-Gain	Category	Sig. (2-tailed)	Information
Experiment	28	0.6179	Medium–High	0.000	Effective
Control	30	0.3513	Keep		

Overall, the study's results show that the Problem-Based Learning model, supported by the e-LKPD Liveworksheet, has a significant impact on students' critical thinking skills. Learners in the experimental group demonstrated greater ability to analyze, evaluate, and infer information than those in the control group. This improvement reflects students' active involvement in the learning process and the support of interactive digital media. Empirical data prove that problem-based learning combined with digital technology can be a strategic alternative in improving the quality of social studies learning in elementary schools.

3.2 Discussion

The results of this study indicate that implementing the Problem-Based Learning model, supported by e-LKPD Liveworksheet, significantly improved students' critical thinking skills, as reflected in the substantial increase in posttest scores in the experimental group. These findings suggest that PBL, when supported by interactive digital worksheets, creates learning conditions that require students to analyze information, justify decisions, and connect concepts to real-life situations. This aligns with some previous studies; however, the present findings extend existing evidence by showing that digital scaffolding through e-LKPD can accelerate students' ability to reason systematically within the context of IPAS learning in Probolinggo. Interestingly, not all earlier studies fully support this pattern.

For instance, several studies reported that PBL was effective only when students had strong initial learning independence or when digital literacy was an adequate condition, both of which were not consistently present in the current research setting. These discrepancies highlight that PBL success varies depending on contextual factors such as teacher facilitation, classroom culture, and students' familiarity with digital tools. Therefore, the present study contributes to the literature by

demonstrating that even in schools with limited digital exposure, structured e-LKPD integration can still strengthen the connection between theoretical understanding and practical problem-solving.

The role of e-LKPD Liveworksheet in this study is an important factor in optimizing problem-based learning. This digital media provides a more interactive and interesting learning experience for students (Wahyuni et al., 2023). The automated feature on Liveworksheet allows students to work on exercises with live feedback, thus increasing learning motivation. The use of digital media also helps teachers monitor student work results in real time. The integration of technology into this learning model has been shown to increase the effectiveness of the social studies learning process in elementary schools (Rizmayannudin & Nuroh, 2024).

The improvement in critical thinking skills in the experimental group reflected the teachers' success in facilitating the problem-based learning process. The teacher serves as a facilitator, guiding students in identifying problems, gathering information, and drawing conclusions. Nurhayati et al. (2022) stated that shifting teachers' roles from the main source of information to learning companions encourages students' active participation. This activity fosters two-way interaction between students and teachers during learning. Learning experiences like this create a more participatory and reflective classroom atmosphere (Aulia et al., 2023).

Critical thinking skills are among the 21st-century skills that are important to develop from the elementary school level. This ability not only requires students to understand concepts but also to apply them in analyzing and evaluating daily-life problems (Wulandari & Astuti, 2023). Problem-based learning assisted by e-LKPD Liveworksheet provides students with an opportunity to apply science concepts practically. This learning process trains students to think openly about various alternative solutions. The situation helps students build a critical and creative scientific attitude towards the social phenomena around them.

The results showed that conventional learning strategies were less effective at training higher-level thinking skills. Learning that is still teacher-centered tends to make students passive and dependent on instruction (Afifah & Junaedi, 2023). The use of lecture methods and practice questions without real context limits students' analytical skills. This condition differs from the experimental group, which is encouraged to find the answer to the problem on its own. Active learning like this helps students understand the IPAS concept through reflective thinking.

The e-LKPD-assisted Problem-Based Learning Model has proven effective because it aligns with constructivist principles. The principle emphasizes that students build knowledge through active learning experiences. When students face real problems, they are encouraged to search for, analyze, and evaluate information (Sidiq et al., 2024). These cognitive processes strengthen critical thinking skills, which are the main goal of this study. Problem-solving activities also provide authentic experiences that are relevant to the real world.

The role of e-LKPD Liveworksheet in enriching the learning experience demonstrates that digital innovation significantly impacts student engagement. This interactive media helps visualize abstract IPAS concepts in more concrete terms. Engaging displays and automatic responses make students more focused and motivated to complete tasks. Digital integration also provides flexibility in learning as it can be accessed through a variety of devices. This facility provides teachers with efficient opportunities to evaluate learning (Astitioni & Sutyaningsih, 2024).

The results of this study support those of Yuliana & Kurnia (2024), who found that the Problem-Based Learning model improves critical thinking skills through analysis and reflection. Similar findings were also revealed by Mirawati et al. (2022). The application of digital media can strengthen student learning interactions. This study extends these results by demonstrating that integrating PBL and e-LKPD models produces significant synergistic effects. The combination of the two creates an active, collaborative, and discovery-based learning environment. This fact reinforces the relevance of the technology-based PBL model in the digital era of basic education.

Student involvement in each stage of learning contributes to increased conceptual understanding. Each stage in the PBL model, from problem orientation to reflection, requires students to think logically and systematically. Ardiyanto et al. (2024) emphasized that the process fosters the ability to assess information accuracy and develop rational arguments. Through e-LKPD, students also learn to organize data more efficiently. Such learning activities strengthen students' analytical and evaluative abilities.

Critical thinking skills are not measured solely by test results but also by active involvement in the learning process. Students who actively express opinions show the ability to connect knowledge with real situations. Group discussion activities in the PBL model provide students with space to exchange ideas and deepen understanding (Susilawati et al., 2024). This situation creates a collaborative learning climate that supports cognitive and social development. This kind of learning process also fosters a sense of responsibility for the results of group work.

Increased critical thinking skills also reflect a strengthening of students' metacognitive aspects. Thinking about one's own way of thinking helps students control and evaluate the strategies they use. When students recognize errors in their thinking, they learn to improve their approach and find more appropriate solutions (Bella & Kristin, 2024). This metacognitive experience enriches the ability to think critically on an ongoing basis. Problem-based learning naturally provides space for the development of these aspects.

This learning model positively impacts students' motivation to learn. When students feel involved in the solution process, their curiosity increases. This situation fosters the spirit of independent learning and encourages students to continue exploring concepts. Setiawan et al. (2024) emphasized that intrinsic motivation, which grows during learning, strengthens cognitive learning outcomes. The relationship between motivation and critical thinking in this study is an indicator of active learning success (Koten et al., 2024).

The increase in N-Gain values in the experimental group demonstrated the effectiveness of the e-LKPD-assisted PBL model. The gain value is classified as medium-high, indicating a significant increase in understanding of concepts. These results confirm that problem-based learning can improve learning outcomes more than conventional methods (Pratiwi & Oktaviarini, 2023). This effectiveness is evident not only in the final grade but also in the thought process that develops during learning. This success can be used as a basis for developing more innovative IPAS learning strategies.

The limitations of this study lie in the time required for implementation and students' digital skills. Some students still need guidance in operating e-LKPD independently. This condition requires teachers to provide more intensive assistance in the early stages of learning. However, these limitations do not reduce the effectiveness of the PBL model in improving critical thinking skills.

Technological adaptation is gradually becoming a solution to overcome this obstacle in the next learning (Noviana et al., 2023).

The findings of this study provide important implications for teachers and curriculum developers in elementary schools. The application of the PBL model assisted by e-LKPD can be used as a strategy to develop students' high-level thinking skills. Teachers can use this model to improve the quality of social studies learning, making it more contextual and relevant to real life. The integration of technology in learning is a strategic step in realizing a creative and critically reasoned Pancasila student profile. Meaningful learning experiences will help students develop lifelong, sustainable thinking skills.

4. Conclusion

The results of this study demonstrate that integrating the Problem-Based Learning model, supported by e-LKPD Liveworksheet, has a significant impact on improving elementary students' critical thinking skills in science subjects. The effectiveness of this model lies in its ability to create active, contextual, and inquiry-oriented learning experiences. At the same time, the use of digital worksheets increases student engagement and supports structured problem-solving processes. Beyond its practical benefits, the findings also contribute to theoretical discussions on technology-enhanced constructivist learning by showing that digital scaffolding can strengthen students' ability to connect conceptual understanding with real-world problems, even in schools with limited technological exposure.

However, this study has several limitations, including its relatively short implementation period and the varying levels of students' digital literacy, which may have influenced learning outcomes. The research was also limited to a single school in Probolinggo, reducing the generalizability of the findings. Future studies should involve a larger, more diverse sample, examine the long-term impact of e-LKPD-assisted PBL, and explore how different levels of teacher facilitation and technological readiness affect students' development of higher-order thinking skills. Despite these limitations, the study provides meaningful insights for improving instructional practices. Teachers are encouraged to integrate PBL with digital media, while schools should support continuous professional development to ensure sustainable implementation of innovative learning models.

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