RESEARCH ARTICLE

Enhancing students' reflective thinking skills through Problem-Oriented Project-Based Learning (POPBL) with PEKERTI worksheet

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Abstract: Reflective thinking skills are vital for 21st-century life skills. This study examines the effectiveness of the Problem-Oriented Project-Based Learning (POPBL) model combined with the PEKERTI Worksheet in improving the reflective thinking skills of eighth-grade students at Junior High School 2 Alla, Enrekang, South Sulawesi. POPBL emphasizes real-world problem-solving, while the PEKERTI Worksheet—focusing on questions (*PErtanyaan*), essential concepts (*Konsep Esensial*), action plans (*Rencana Tindakan*), and initiatives (*Inisatif*)—enhances the learning process. Using a quasi-experimental design with a non-equivalent control group, the study involved 75 students divided into three groups. Data were collected via observations, questionnaires, and tests, and analyzed using ANCOVA. Results showed significantly higher reflective thinking skills in the POPBL group using the PEKERTI Worksheet compared to the POPBL-only and conventional learning groups (p = 0.000). These findings suggest that integrating POPBL with the PEKERTI Worksheet effectively supports the education curriculum in Indonesia and develops essential life skills in junior high school students.

Keywords: PEKERTI worksheet; Problem-Oriented Project-Based Learning (POPBL); reflective thinking skills

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Introduction

Reflective thinking is a cornerstone of science education (Bassachs et al., 2020; García-Carmona, 2021; Vogelsang et al., 2022), enabling learners to engage in higher-order cognitive processes (Ayaz & Gök, 2023; Maksimović & Osmanović, 2019; Menon & Azam, 2021). It involves identifying problems, analyzing actions, and assessing outcomes to foster continuous improvement (Karaoglan-Yilmaz et al., 2023; Onrubia et al., 2022). Through reflective thinking, both teachers and students can embrace new ideas and adapt to evolving challenges, bridging theoretical concepts with real-world applications (Abdul Rabu & Badlishah, 2020; ElSayary, 2021; Slepcevic-Zach & Stock, 2018). Promoting reflective practices encourages students to consistently learn from their experiences, bridge the gap between theoretical concepts and real-life situations (Bunt & Gouws, 2020; Karaoglan-Yilmaz et al., 2023), and develop into lifelong learners (Ayaz & Gök, 2023; ElSayary, 2021; Kingkaew et al., 2023).

The concept of reflective thinking was pioneered by Dewey (1960), who described it as the deliberate and systematic examination of beliefs, knowledge, and practices informed by current understanding. He emphasized the importance of reflection as a crucial educational goal (Orakcı, 2021; Sabariego Puig et al., 2020). While some scholars view reflection as a challenging process that reconstructs prior knowledge and perceptions, others associate it with the investigation of dynamic and deliberate experiences (Allen & Blythe, 2018; Stylianides et al., 2013). Reflective thinking is a systematic problem-solving approach that involves using emotions, thoughts, and knowledge to achieve logical solutions (Bassachs et al., 2020; Ronen, 2020; Son & Lee, 2021). Reflective thinking is characterized by individuals gaining knowledge from their experiences, solving problems, and enhancing their professional growth (Daniëls et al., 2020; Parmigiani et al., 2019; Sebatana & Dudu, 2022).

Research conducted in Austria reveals that only 34.9% to 46.1% of individuals exhibit proficient reflective thinking skills (Slepcevic-Zach & Stock, 2018). The research in Malaysia by Yaacob et.al (2021) found that the level of reflective thinking skills among students remains low, particularly in analyzing and evaluating their own ideas. In Indonesia, Astutik et.al., (2022) investigation into reflective thinking skills among junior high school students in Lamongan found that their reflective thinking profiles, with an average score of 31.33, are classified as low. Preliminary study results from October in class VIII at SMP Negeri 2 Alla corroborate this finding, indicating a low score of 59.24 on the reflective thinking skills questionnaire. The dearth of reflective thinking skills among students can be attributed to insufficient learning opportunities that foster reflective activities, such as re-evaluating past learning experiences, not summarizing material, and being content with the teacher's delivery (Salido & Dasari, 2019). To address this issue, the education system requires adjustments. The focus should shift from solely preparing students for academic success to developing their overall abilities (Ibrohim et al., 2020). Prioritizing the development of reflective thinking skills in the curriculum is crucial as it not only enhances problem-solving and professional growth but also cultivates lifelong learning in a rapidly changing world. Therefore, creating effective learning environments that foster a culture of reflection should be a primary goal for teachers, particularly in science education. To support the development of students' reflective thinking skills, teachers must make scientific concepts more authentic and reflective of actual scientific practices.

Previous literature studies have revealed how reflective thinking has been examined in the literature in terms of appropriate approaches (Azevedo et al., 2022; Karaoglan-Yilmaz et al., 2023; Yilmaz & Keser, 2016). Currently, research is needed to demonstrate the interactions and opportunities for developing reflective thinking skills in education. To empower reflective thinking skills, a learning approach is needed that emphasizes student-centeredness, experiential learning, real-world problem-solving, collaboration, and tangible outcomes. Students apply their knowledge to solve authentic problems (Rizki & Suprapto, 2024). One effective strategy for fostering reflective and critical thinking skills is the Problem-Oriented Project-Based Learning (POPBL) model. POPBL integrates problem-based learning (PBL) and project-based learning (PjBL), providing a student-centered framework in which learners engage in authentic projects that tackle problems relevant to their surroundings (Rizki & Suprapto, 2024). Problem-Based Learning (PBL), Project-Based Learning (PjBL), and Problem-Oriented Project-Based Learning (POPBL) each adopt distinct approaches. PBL begins with the introduction of a problem that students must solve through collaboration and critical thinking, utilizing relevant content knowledge. In contrast, PjBL focuses on completing predetermined projects with an emphasis on final outcomes. Meanwhile, POPBL requires students to formulate their own problems before designing projects to address those issues, highlighting the learning process and fostering the development of analytical skills and collaboration among students (Yasin & Rahman, 2011).The problems used in POPBL are authentic, constructive, integrated, and appropriately complex, stimulating critical and reflective thinking. Rongbutsri (2017) POPBL model consists of eight stages: group formation, problem formulation, planning, data collection, analysis, problem-solving, reporting, and exam preparation. However, implementing these stages can be challenging due to time constraints. Ibrohim and his research team from Biology Department of State University of Malang addressed this by simplifying POPBL into four stages: orientation and problem formulation, organizing student learning, designing and executing the project, and presenting results and evaluation. Previous studies have demonstrated the effectiveness of POPBL in enhancing critical thinking skills, creativity, and collaboration (Filmi et al., 2024; Francisco et al., 2024; Komalasari et al., 2024; Suwistika et al., 2024).

While POPBL provides students with considerable freedom for exploration and problem-solving, it can sometimes lead to challenges, particularly for those unfamiliar with this approach. Students often struggle with time management and the structured planning required to complete projects effectively. To mitigate these challenges, a structured framework is essential to guide students in organizing and managing their project work (Barell, 2016). The PEKERTI worksheet addresses this need. PEKERTI, an acronym in Indonesian for *PErtanyaan* (questions), *Konsep Esensial* (essential concepts), *Rencana dan Tindakan* (plans and actions), and *Inisiatif* (initiatives), is designed to be both memorable and practical. Adapted from the KWLHAQ framework, it systematically guides students through project execution and problem-solving. The worksheet prompts students to reflect on what they know, what they aim to learn, how to plan and execute tasks, and how to apply the knowledge gained. This structured approach aids in understanding scientific concepts and bridging them with real-world applications, enhancing school practices and student engagement (Mihardi, 2013; Taslidere & Eryilmaz, 2012; Zouhor et al., 2016). By supporting middle school students in implementing the POPBL model, the PEKERTI worksheet fosters deeper reflection on both project execution and the application of learning. Despite its potential, no prior research has examined the combined effectiveness of POPBL and the PEKERTI worksheet. This study seeks to fill this gap by evaluating their impact on improving reflective thinking skills among middle school students.

Method

This study utilized a quasi-experimental design with a pretest-posttest non-equivalent control group. The population consisted of all eighth-grade students at SMPN 2 Alla, Enrekang Regency, South Sulawesi, Indonesia. Three classes were randomly selected after an equivalency test: the experimental group received instruction through the POPBL model integrated with the PEKERTI worksheet, the positive control group used POPBL, and the negative control group followed conventional teaching methods. A total of 75 students participated in the study, with the curriculum focusing on the respiratory and excretory systems in Phase D of the biology syllabus. Table 1 outlines the learning stages for the three instructional methods.

Table 1. Stages of the learning model in experimental and control group

Learning model	Sintax
Conventional Learning Model	1. Teacher-led explanation of learning material. 2. Question-and-answer activities. 3. Assignment completion.
POPBL Model	1. Orientation and problem formulation. 2. Organizing students for collaborative study. 3. Designing and implementing a project. 4. Presenting and evaluating the project outcomes.
POPBL with PEKERTI Worksheet	1. Orientation and problem formulation through contextual and complex questions. 2. Organizing students to learn by articulating their understanding of essential concepts based on prior knowledge. 3. Designing and implementing a project through structured planning and real-world actions. 4. Taking the initiative to present solutions as a product or project outcome based on what has been learned.

Research instruments included observation sheets, a reflective thinking questionnaire, and reflective thinking skills tests. The questionnaire, adapted from Mezirow (1997), assessed four reflective thinking indicators: 1) habitual action, 2) understanding, 3) reflection, and 4) critical reflection. It comprised 16 closed-ended statements on a five-point Likert scale (strongly disagree to strongly agree). The reflective thinking skills test consisted of five essay questions aligned with Mezirow's indicators. Both instruments underwent validity and reliability checks. Pearson's product-moment correlation confirmed item validity ($r = 0.531–0.852$; r-table = 0.195), while Cronbach's alpha showed high reliability (0.936 for the questionnaire and 0.913 for the essay test). Data from pretest and posttest assessments were analyzed using inferential statistics. A one-way ANCOVA at a 5% significance level tested the hypothesis. Prerequisite tests for normality (one-sample Kolmogorov-Smirnov) and homogeneity (Levene's test) were conducted to ensure assumptions were met. Post-hoc analysis using the Least Significant Difference (LSD) test determined significant differences between the treatment groups.

Results and Discussion

The analysis of students' reflective thinking skills was conducted after confirming that the data met the necessary prerequisites for hypothesis testing, including normality and homogeneity. As shown in Table 2, the p-values from the normality and homogeneity tests were all greater than 0.05, indicating that the data were normally distributed and had equal variances. These results justified proceeding with a one-way ANCOVA to evaluate the effectiveness of the three instructional models: the POPBL model with the PEKERTI worksheet, the POPBL model, and the conventional learning model.

Table 2. Result of normality and homogeneity tests or reflective thinking skills

Variable	Test		N	P	α	Conclusion
Reflective thinking skills	Normality	*Pre-test*	75	0.200	0.05	Normal
	Normality	*Post-test*	75	0.080	0.05	Normal
	Homogeneity	*Post-test*	75	0.342	0.05	Homogenous

The one-way ANCOVA analysis, performed using SPSS version 26, utilized pre-test and post-test scores to measure the impact of each learning model on students' reflective thinking skills. Table 3 presents the descriptive analysis of these scores, showing significant improvements across all groups. Among the three models, the POPBL integrated with the PEKERTI worksheet demonstrated the most substantial improvement, with an average difference of 44.47 in reflective thinking skills.

Table 3. The mean scores of pre-test, post-test, differences, and improvement in reflective thinking skills for each learning model

No.	Variable	Pretest	Posttest	Difference	Improvements (%)
1.	POPBL-PEKERTI worksheet	42.88	83.35	44.47	103
2.	POPBL	42.29	79.46	37.17	87.89
3.	Conventional	42.75	69.55	26.80	63.69

This finding highlights the effectiveness of combining the POPBL model with the structured guidance provided by the PEKERTI worksheet in fostering reflective thinking. The worksheet's systematic approach—emphasizing questions, essential concepts, planning and actions, and initiatives—appears to bridge the gap between theoretical understanding and practical application, enabling students to engage deeply with the learning material. For a visual representation of the improvements in reflective thinking skills across the three models, refer to Figure 1.

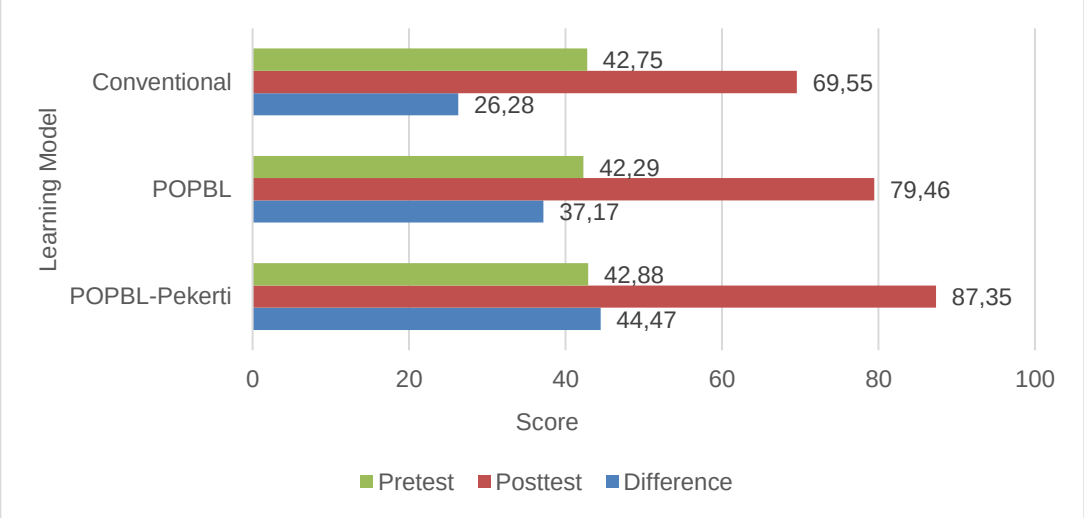

Figure 1. Average pretest-posttest scores of reflective thinking skills for each learning model

The ANCOVA analysis of the reflective thinking skills variable yielded a highly significant result ($p < 0.001$), confirming the research hypothesis that the POPBL model, when combined with PEKERTI worksheets, effectively enhances students' reflective thinking skills. A detailed summary of the ANCOVA results is presented in Table 4. The findings highlight the substantial impact of the learning model on students' reflective thinking, with the POPBL integrated with PEKERTI worksheets demonstrating superior effectiveness.

Table 4. Result of one-way ANCOVA on students' reflective thinking skills

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4113.294[a]	3	1371.098	171.845	.000	.879
Intercept	3405.843	1	3405.843	426.868	.000	.857
Reflective thinking skills	65.482	1	65.482	8.207	.005	.104
Learning model	4037.211	2	2018.606	253.000	.000	.877
Error	566.486	71	7.979			
Total	471452.188	75				
Corrected Total	4679.780	74				

To further analyze these differences, an LSD test was conducted at a 0.05 significance level. As shown in Table 5, the adjusted mean score for reflective thinking skills in the POPBL with PEKERTI group was significantly higher than both the POPBL-only group and the conventional learning group. This underscores the added value of the PEKERTI worksheet in structuring and guiding students' reflective learning processes within the POPBL framework.

The POPBL model is a student-centered pedagogical approach that begins with problem identification and progresses through problem-solving via projects. By engaging with real-world issues, students apply relevant concepts and principles, fostering the development of reflective thinking skills. These skills are vital for effective problem-solving, enabling students to critically evaluate each stage of the

learning process and refine their approaches. Reflective thinking is an essential component of intellectual development, equipping students with the ability to organize, transfer, and evaluate knowledge in meaningful ways (Chen, 2020; Karaoglan-Yilmaz et.al., 2023). Unlike rote memorization, reflective thinking empowers students to understand concepts deeply, leading to enhanced academic performance (Draissi et.al., 2021; Karaoglan-Yilmaz et.al., 2023; Swanson, 2010). Moreover, reflective thinking helps students identify their strengths and weaknesses, allowing them to address challenges with well-considered solutions (Alt et al., 2022; Ho et al., 2021; Mamlok-Naaman & Eilks, 2012).

Table 5. LSD Model Test Results on Reflective Thinking Skills

Model	Corrected Average	LSD notation
Conventional	69.528	a
POPBL	79.539	b
POPBL-PEKERTI worksheet	87.294	c

Reflective thinking, as defined by Mezirow (1997), is composed of four key indicators: 1) habitual action, 2) understanding, 3) reflection, and 4) critical reflection. These indicators served as the foundation for constructing the reflective thinking skill items, as outlined in Table 6. Figure 3 illustrates the average scores for each reflective thinking indicator across the learning methods employed in this study.

Table 6. Reflective thinking skill indicators

Indicator	Description
Habitual Action	Students can solve familiar problems, producing spontaneous solutions related to the issue.
Understanding	Students can use their knowledge to determine actions.
Reflection	Students explore their experiences and knowledge by asking questions, testing assumptions in problem-solving, and gaining new understanding and appreciation
Critical Reflection	Students are aware of their thoughts, feelings, and actions to make wise decisions

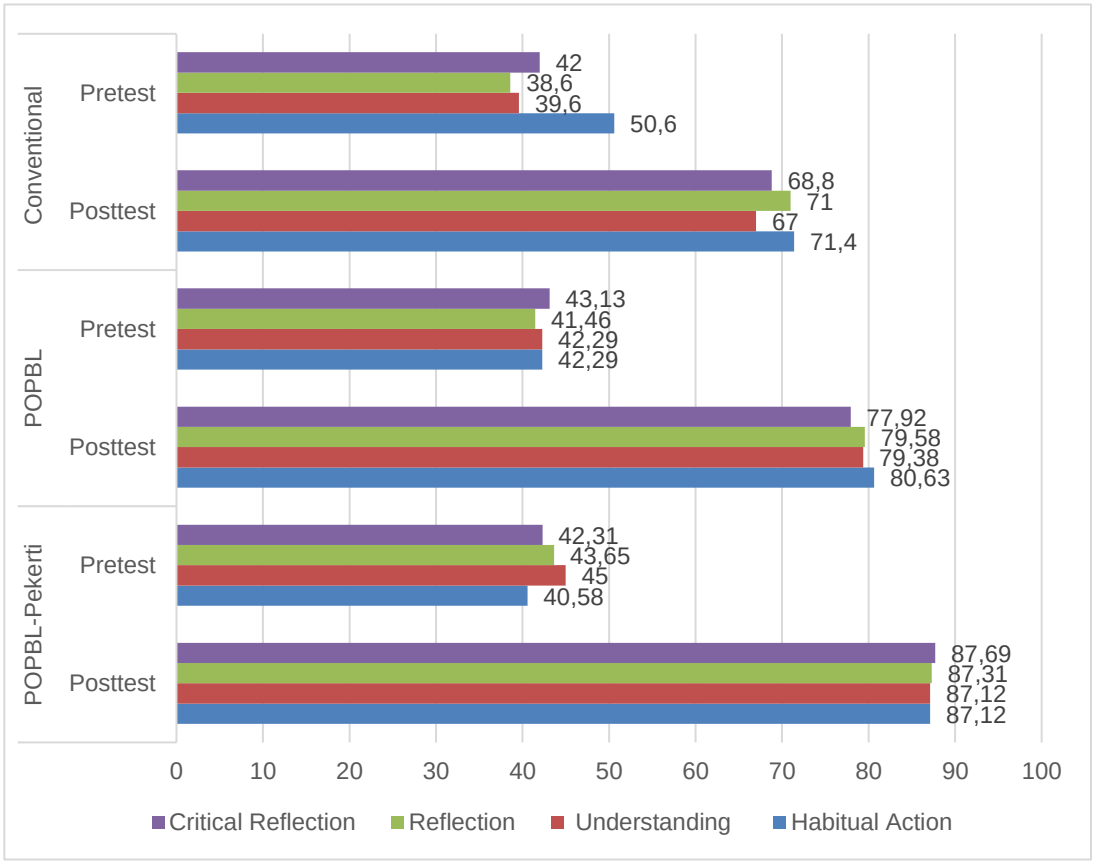

Figure 3. The differences average for each indicator

The findings demonstrate that integrating the Problem-Oriented Project-Based Learning (POPBL) model with the PEKERTI worksheet significantly enhances students' reflective thinking skills. This enhancement can be attributed to the structured stages of the POPBL model, which actively engages students in reflective practices throughout the learning process. In the initial stage of POPBL, paired with the PEKERTI worksheet, students are introduced to complex, real-world problems through articles and educational videos. This phase emphasizes orientation and problem formulation, guided by structured prompts in the PEKERTI worksheet. Students are encouraged to formulate both fundamental and complex questions, which serve as the basis for the project. By identifying and refining these questions, students engage in habitual action, a key indicator of reflective thinking. This process not only helps them independently identify relevant issues but also fosters a deeper understanding of the problem at hand.

The PEKERTI worksheet plays a critical role in scaffolding students' reflective thinking. During this stage, students generate multiple questions, select one as their problem statement, and use it to guide their project work. This practice cultivates critical reflection, as students must evaluate the significance and relevance of their questions. Those who pose challenging, exploratory questions demonstrate an advanced level of critical reflection and understanding, essential for tackling real-world problems. Throughout this process, students engage in routine actions, leveraging their prior knowledge and curiosity to systematically address the problem. This approach empowers them to become active participants in their learning journey, promoting autonomy while maintaining instructor support (Ali, 2019). The structured reflection enabled by the PEKERTI worksheet encourages students to become more aware of their learning experiences, linking theoretical knowledge to practical application. The integration of reflective thinking skills, particularly habitual action, and critical reflection, prepares students to handle complex problems effectively. These findings are consistent with previous studies, which suggest that structured, problem-based approaches significantly enhance reflective thinking by enabling students to manage problem situations competently (Aslam et al., 2021; Hiscox et al., 2022; Zafeer et al., 2023).

The second stage of the POPBL model involves organizing students to explore essential concepts related to the problem at hand. At this stage, students use the PEKERTI worksheet to read into relevant literature from diverse sources. They identify concepts they already understand and pinpoint areas for further exploration. This reflective process aligns with the development of understanding, a key indicator of reflective thinking. Through reading and summarizing activities, students critically engage with the material, which fosters their ability to connect prior knowledge with new information (Chittooran, 2015). Students participate in both individual and group reflective activities, enhancing their comprehension and creating a foundation for deeper knowledge acquisition (Kholid et.al., 2020). This phase supports students in consolidating their learning experiences, mapping essential concepts, and integrating intellectual competencies (Ríos et.al., 2010; Shekar, 2014). Guided exploration encourages students to think abstractly, apply learned strategies to new tasks, and reflect on their cognitive processes to devise effective solutions (Erickson et.al., 2021; Gette & Kryjevskaia, 2019).

The third stage involves planning and executing the project, which plays a pivotal role in developing project management skills. These skills are essential for real-world problem-solving and future professional endeavors. At this stage, students apply learned concepts in practical contexts, boosting their motivation and engagement (Tseng et al., 2022). With the guidance of the PEKERTI worksheet, students systematically outline their project plan and execution steps, promoting self-directed learning (Hockings et al., 2018). The instructional approach is grounded in Vygotsky's Zone of Proximal Development, where students are challenged within their capabilities while receiving the necessary support (Vygotsky, 1980). At this stage, the critical thinking skill being developed is 'reflection,' where students apply the understanding they have gained in planning and executing the project through systematic actions. Reflective activities encourage students to engage actively in their learning and enhance their metacognitive skills (Greenwood, 2019). Developing a project implementation plan for problem-solving can improve students' reflective skills in applying problem-solving steps, identifying solutions, and evaluating outcomes. The process of constructing solutions to problems through projects involves curiosity, technical skills, and the ability to connect knowledge (Bosman, 2019). Students who have refined their reflective abilities can identify and prioritize solutions in various situations, enabling them to make informed decisions and effectively manage more complex tasks (Akpur, 2020; Gette & Kryjevskaia, 2019; Karaoglan-Yilmaz et.al., 2023).

The fourth stage involves presenting solution initiatives in the form of products or project outcomes, as well as evaluating the processes and learning results. At this stage, students present their solution initiatives by providing evaluations of what they have learned and gained during the learning and project implementation through presentations. During these presentation activities, students assess each other's accuracy and the usefulness of the project outcomes in solving problems (Foster et.al., 2018).This activity trains students to give feedback and manage their apprehensions in expressing opinions (Mohamed & Asmawi, 2018). At this stage, the indicators of reflective thinking skills being

developed are reflection and critical reflection. The aspect of critical reflection is fostered as students evaluate the effectiveness of the solutions provided, identifying their strengths and weaknesses, as well as suggesting improvements for future project implementations. Meanwhile, the aspect of reflection is developed when students share insights into what they have learned, the concepts they have not yet understood, and the benefits they have gained during the learning and project implementation. All evaluations and reflections regarding the planning and execution of the project are recorded by the students in the PEKERTI worksheet, which contains clear guidelines. The evaluation aims to enhance students' sensitivity in analyzing similar problems encountered in daily life, enabling them to consider various strategies deemed effective in addressing similar challenges in the future (Mahanal et.al., 2019). Systematic evaluation is crucial for documenting project progress and addressing potential misunderstandings. This stage also provides support for groups facing difficulties or obstacles. Self-evaluation theory (Moreno, 2010) emphasizes the importance of students assessing the processes and outcomes of collaborative projects as a foundation for subsequent actions. Furthermore, participation in presentations helps students develop a sense of responsibility for their work and offers an opportunity to demonstrate their understanding of the material while practicing their communication skills. This aligns with cognitive distribution theory, as conveying ideas to others can enhance one's own understanding. Critical reflection is honed as students identify weaknesses in their approaches, rethink strategies, and refine decision-making processes (Gencel, & Saracaloğlu, 2018). Enhanced reflective thinking skills have been linked to higher academic performance and greater cognitive abilities (Ghanizadeh, 2017; Hsieh & Chen, 2012; Yang et.al., 2022).

The integration of the POPBL model with the PEKERTI worksheet significantly strengthens reflective thinking skills across all stages of the learning process. Each phase—exploring concepts, planning, execution, and evaluation—aligns with specific indicators of reflective thinking, providing a structured framework for learning. The PEKERTI worksheet enhances guidance and support, making problem-solving more effective and reflective learning more structured. By activating prior knowledge, enhancing metacognition, and fostering self-directed learning, the PEKERTI worksheet transforms the POPBL model into a comprehensive tool for developing reflective thinking skills, surpassing the effectiveness of POPBL alone or conventional teaching methods (Greenwood, 2019; Kumari & Jinto, 2014). This approach not only improves academic outcomes but also prepares students for lifelong learning and problem-solving challenges. The findings suggest that this model can serve as an effective strategy for fostering 21st-century skills in students.

Conclusion

Based on the analysis and discussion of the research findings, it can be concluded that the integration of the Problem-Oriented Project-Based Learning (POPBL) model with the PEKERTI worksheet is highly effective in enhancing students' reflective thinking skills at SMP Negeri 2 Alla, Enrekang Regency, South Sulawesi. This combined approach provides a structured framework that systematically guides students through the process of identifying, analyzing, and addressing complex problems using structured projects. The integration of the PEKERTI worksheet within the POPBL model plays a pivotal role in fostering reflective thinking skills by encouraging students to engage deeply with the problem-solving process. This involves not only cognitive processes such as analysis, evaluation, and synthesis but also the integration of emotions, prior knowledge, and critical reflection to achieve logical and well-reasoned solutions. This comprehensive approach equips students with the skills necessary for effective problem-solving and supports the development of higher-order thinking abilities.

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Conflicts of Interest

The authors declare that there are no conflicts of interest related to the publication of this paper.

Author Contributions

N. S. Sinusi: Conducted the research, collected data, wrote the original article, and revised the manuscript. **I. Ibrohim:** Developed the methodology and supervised the research. **S. E. Rahayu:** Supervised the research.

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