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Teacher Needs Analysis in Model Development TPACK-Based Problem Learning to Improve Critical Thinking Skills

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Abstract

This study aims to analyze the needs of elementary school teachers in developing a Problem Based Learning (PBL) model based on Technological Pedagogical Content Knowledge (TPACK) to improve students' critical thinking skills. The background of this study is based on the importance of mastering critical thinking skills as one of the 21st-century competencies, as well as the low integration of technology in problem-based learning in elementary schools. The study used a quantitative descriptive approach involving 100 elementary school teachers selected by purposive sampling. Data were collected through questionnaires and interviews, focusing on five main indicators: teachers' initial knowledge of TPACK-based PBL, availability of supporting facilities, teacher participation in related training, integration of TPACK in learning, and implementation of PBL. The results showed that only 36% of teachers were aware of TPACK-based PBL, 40% had adequate school facilities, 40% had attended training, 36% had integrated TPACK in learning, and 50% had implemented PBL. These findings indicate a gap between actual conditions and the ideal conditions required for optimal implementation of TPACK-based PBL. Therefore, the development of this learning model is urgent, with a focus on improving teacher understanding, providing ongoing training, and utilizing technology effectively to support innovative, contextual learning that is oriented towards developing students' critical thinking skills.

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Introduction

Education in the 21st century requires a transformation in the educational paradigm that shifts from a teacher-centered model to a student-centered model (Abaniel, 2021). This transformation arises from the statement that students need competencies related to global challenges, not limited to critical thinking, creativity, collaboration, and communication (Abdullah et al., 2020). In this context, critical thinking emerges as a fundamental component for cultivating an analytical mindset and facilitating informed decision-making(Alemán Saravia et al., 2023). Critical thinking skills are essential starting at the elementary level. During this developmental phase, children begin building the foundation of cognitive abilities that will serve them in addressing the challenges they face in later stages of education and in everyday contexts (Twiningsih et al., 2019). Students trained in critical thinking aim to analyze data, evaluate arguments, and solve problems through logical and systematic methodologies (Ahmad et al., 2023).

However, the reality on the ground shows that pedagogical practices in basic education often remain heavily influenced by traditional learning-based methods and direct memorization of content (Ahmed et al., 2021). This learning approach reduces students' opportunities to explore ideas, ask questions, and seek solutions to contextually relevant problems. These constraints negatively impact the development of students' critical thinking skills. One pedagogical strategy considered effective in fostering critical thinking skills is Problem-Based Learning (Dang & Vartiainen, 2022). This learning model promotes student learning through authentic problem solving, identification of relevant information, and construction of understanding through independent and collaborative inquiry (Dermentzi et al., 2022). Problem Based Learning also redefines the role of educators from knowledge transfer to facilitators who guide students' cognitive processes (Horvath et al., 2023).

In the implementation of Problem Based Learning in elementary education, many challenges arise, especially regarding the readiness of educators to design and manage learning experiences that combine content knowledge, pedagogical strategies, and technology integration (Kasuga et al., 2022). Not all educators have the skills necessary to develop problem scenarios that align with students' cognitive developmental stages while effectively utilizing technology as an educational resource (Li et al., 2022). In the contemporary digital age, technology has significant potential to enhance problem-based learning experiences. Technology integration can facilitate broader access to information, enable the visualization of abstract concepts, and enhance collaborative efforts (Voogt & McKenney, 2017). However, the successful integration of technology into the learning environment depends largely on the educator's skill in aligning technological, pedagogical, and content elements (Westbroek et al., 2019).

The TPACK (Technological Pedagogical Content Knowledge) conceptual framework provides relevant guidance in addressing these challenges. TPACK emphasizes the need for educators to understand three key domains: Content Knowledge, Pedagogical Knowledge, and Technological Knowledge, as well as the interactions among these domains (Rahayu, 2019). Educators equipped with TPACK competencies not only demonstrate mastery of subject matter and pedagogical approaches but are also adept at selecting and integrating technology wisely to enhance the educational experience.(Handini, 2025)This competency is very important in the context of Problem

Based Learning, where technology can function to facilitate information retrieval, simulate problems, and communicate ideas effectively (Irmita & Atun, 2018).

The formulation of a TPACK-based Problem-Based Learning model at the elementary education level is anticipated to facilitate more significant and relevant learning experiences for students (Liang, To, & Lo, 2024). This model results in active student involvement in the educational process, fosters critical thinking skills, and promotes the effective use of technology (Melesse & Belay, 2022). However, prior to the development and implementation of this model, an extensive assessment of educators' needs is essential. Such a needs analysis will provide an overview of teachers' current competencies, the barriers they encounter, and the support needed for the implementation of Problem Based Learning integrated with TPACK. This needs analysis includes identifying the extent to which educators understand the concept of Problem Based Learning, their proficiency in TPACK components, and the readiness of the technological infrastructure within educational institutions. By ensuring these parameters, the model development can be tailored to align with the prevailing realities and field requirements.

In addition, the needs analysis also serves to describe the differences between the competencies that educators currently possess and those required to effectively implement the TPACK-based Problem-Based Learning model (Magableh & Abdullah, 2020). These identified gaps will further inform the formulation of training and professional development initiatives for educators. In the context of primary education, educators play a dual role: serving as instructors and facilitators of character development among students. Consequently, the designed learning model emphasizes not only academic performance but also the cultivation of critical thinking, curiosity, and collaborative skills. The implementation of TPACK-based Problem-Based Learning (PBL) aligns with national education policies that underscore the importance of 21st-century competencies (Akhyar & Suryani, 2019). For example, the Independent Curriculum provides educators with the opportunity to create learning experiences that are more contextual, innovative, and relevant to students' lives.

Previous investigations have proven that Problem Based Learning is capable of improving critical thinking skills (Akin & Ok, 2021). However, the impact of its implementation largely depends on the readiness of educators, both in terms of knowledge and skills regarding the integration of technology into educational practices. Therefore, the urgency of this research is pronounced, considering that educators are crucial to the success of the learning process. Without adequate teacher support and proficiency, the intended learning model will struggle to achieve the anticipated results. The findings of this needs analysis are anticipated to inform the development of a TPACK-based Problem-Based Learning model that truly suits the characteristics of elementary school students, educator competencies, and the conditions of educational institutions. Thus, the formulated model is intended to be not only theoretical but also practical in its application. This research also contributes to the advancement of knowledge in the educational domain, particularly in the integration of the Problem-Based Learning methodology with the TPACK framework. This aligns with the contemporary imperative for innovation in learning in the digital age. Beyond its academic contribution, this research has significant practical implications, particularly in offering policy recommendations for educational institutions and services in the development of teacher training programs focused on TPACK mastery and the application of Problem-Based Learning (Estaiteyeh & DeCoito, 2023).

TPACK-Based Problem Based Learning Concept

Problem-Based Learning (PBL) is a pedagogical framework that is fundamentally student-oriented, utilizing authentic real-world challenges as a catalyst for educational experiences (Amanda et al., 2024). This pedagogical approach aims to cultivate advanced cognitive skills among learners through solving relevant problems encountered in everyday life. Its strengths are primarily manifested in its capacity to inspire learners to engage in autonomous learning, enhance collaborative competencies, and refine critical analysis skills. Theoretically, PBL positions challenges at the beginning of the learning process, rather than merely serving as a mechanism for applying pre-existing knowledge (Boelt et al., 2023).

In elementary education, PBL facilitates the connection between academic learning and real-world experiences (Borah et al., 2024). Students are encouraged to understand that the material they assimilate goes beyond memorization; it serves as an instrument for understanding, analyzing, and resolving the dilemmas they face (Boye & Agyei, 2023). The basic principles of PBL include: (a) a focus on student-centered pedagogy, (b) identification of problems as a stimulus for learning, (c) collaborative learning in small groups, (d) the function of the educator as a facilitator, and (e) integrative learning that includes various disciplines.(Cássia Silva de Olivei et al., 2024). The stages of PBL typically consist of: (1) problem orientation, (2) student-led learning organization, (3) independent and collaborative inquiry, (4) solution formulation and presentation, and (5) reflective assessment of the learning experience (Chang et al., 2022). This fifth stage can be adapted and aligned with the unique characteristics of students. PBL offers many benefits, including: (a) increasing the level of motivation to learn, (b) cultivating critical and creative thinking skills, (c) developing collaborative skills, (d) integrating theoretical concepts with practical applications, and (e) fostering resilience in the learning process (Dang & Vartiainen, 2022).

However, the implementation of Project-Based Learning (PBL) is accompanied by various challenges. Many educators face difficulties in formulating authentic problems, managing learning time allocation, and effectively facilitating group discussions. Furthermore, limitations related to resources and infrastructure, particularly in the area of technology, pose significant obstacles. To address these challenges, the incorporation of the TPACK (Technological Pedagogical Content Knowledge) framework into PBL is considered essential. TPACK is a comprehensive framework that describes the necessary knowledge that teachers must possess for the effective integration of technology with pedagogical strategies and educational content. The TPACK framework consists of three fundamental components: Content Knowledge (CK), demonstrating proficiency in the subject matter; Pedagogical Knowledge (PK), which encompasses an understanding of instructional strategies and methodologies; and Technological Knowledge (TK), which relates to the competencies necessary for the effective utilization of technology (Suprapto et al., 2021). The interaction between these three components culminates in a cohesive body of knowledge that enhances the meaningfulness of the learning experience.

In implementing TPACK-oriented PBL, educators are tasked not only with presenting contextual problems but also with utilizing technology to enrich students' educational experiences (Schmid et al., 2021). For example, students can use the internet for information retrieval, use simulation software to model various problems, or

engage with collaborative platforms for the exchange of ideas. The integration of TPACK in PBL encourages the development of digital literacy in addition to critical thinking skills in students (Guggemos & Seufert, 2021). They are not only engaged in the problem-solving process but also gain insight into the wise use of technology as a supporting tool in addressing these challenges. Empirical research shows that combining PBL with TPACK has the potential to increase student engagement, broaden cognitive horizons, and accelerate the understanding of complex concepts Handini, 2025). Technology serves as a conduit between the theoretical constructs provided by educators and their practical application in the external environment (Twiningsih, Gunarhadi, & Musadad, 2024).

In a TPACK-oriented PBL framework, the role of the educator shifts from being the primary source of information to being a facilitator in the design of learning experiences(Voogt & McKenney, 2017). Educators must be discerning in selecting appropriate technology, adapting pedagogical strategies, and ensuring that core content remains central to the learning process. An illustrative example of implementing TPACK-based PBL in elementary education is science instruction with a focus on environmental themes. Educators can begin the learning process by presenting a problem related to river pollution, encouraging students to investigate the causes and impacts through online research, processing the collected data into a digital infographic, and then presenting their proposed solutions using a presentation application. In this way, students not only gain knowledge of environmental concepts but also develop skills in information gathering, data analysis, critical thinking, and the effective use of technology to articulate their ideas. Challenges associated with implementing TPACK-based PBL in elementary education include limitations in educators' technological proficiency, device accessibility, and students' readiness for a more autonomous learning experience (Guggemos & Seufert, 2021). Consequently, improving teacher competency through TPACK-centered training emerges as a crucial step forward.

Mastery of TPACK among educators will significantly influence the success of the learning process (Westbroek et al., 2019). Educators who understand the complex relationships between content, pedagogy, and technology will demonstrate greater creativity in problem design, media selection, and facilitation of student discourse. With a foundation of TPACK, PBL can evolve into a pedagogical model that not only enhances critical thinking skills but also equips students to navigate the complexities and technological advancements characteristic of the 21st century (Akin & Ok, 2021). This analysis confirms the potential of the TPACK-based PBL framework as a viable approach to improving the quality of education in elementary schools. The review underscores the need to develop a pedagogical model that synergizes the strengths of PBL and TPACK to cultivate a critical, creative, and technologically proficient generation.

The Urgency of Teachers' Need for TPACK-Based Problem Based Learning

Basic education is the main foundation in forming character, thinking skills, and students' learning attitudes (Agustina & Naphiah, 2021). At this level, teachers are required not only to teach factual knowledge, but also to instill critical, creative, collaborative, and communicative thinking skills that characterize 21st-century skills (Zia-Ud-din et al., 2023). One relevant approach to developing these skills is Problem-Based Learning (PBL). PBL encourages students to learn through solving contextual problems relevant to their lives, thus encouraging active engagement, curiosity, and higher-order thinking skills (Sylva et al., 2020). In the context of modern developments

marked by technological advancements, PBL becomes more effective when integrated with the Technological Pedagogical Content Knowledge (TPACK) framework (Almulhem & Almulhem, 2022). TPACK helps teachers integrate content knowledge, pedagogy, and technology to create innovative and meaningful learning.

The development of a TPACK-based PBL model in elementary schools is urgent because the majority of teachers still face challenges in optimally integrating technology into learning (Aires et al., 2023). In fact, the use of appropriate technology can enrich the problem-solving process, expand access to information, and enhance student creativity. Without a structured model, the implementation of PBL in elementary schools is often suboptimal. Some teachers simply position problems as sparks for brief discussions without in-depth investigation or the use of technology to support solution-finding. The TPACK-based PBL model can provide clear guidance for teachers on how to select relevant technology, design authentic problems, and manage problem-based learning processes that are appropriate to the cognitive developmental level of elementary school students (Amanda et al., 2022).

The urgency of developing this model is also driven by national education policies, particularly the Independent Curriculum, which emphasizes contextual, integrative, and project-based learning. TPACK-based PBL aligns with these principles because it connects subject matter to real-life situations and utilizes technology for exploration (Amanda et al., 2024). At elementary school age, students are in the concrete operational development stage according to Piaget's theory (Anunpattana et al., 2021). They learn better when they are exposed to real-world situations that can be observed, analyzed, and solved. TPACK-based PBL provides students with the opportunity to experience this type of learning firsthand (Kappler Hewitt & Weckstein, 2012). Critical thinking skills resulting from TPACK-based PBL will help students in decision-making, logical reasoning, and problem-solving in various fields (Palieraki & Koutrouba, 2021). This is not only beneficial in the school environment but also in everyday life. Developing this model is also crucial for addressing teacher competency gaps. Not all elementary school teachers have experience designing lessons that integrate technology and PBL. With a clear model, teachers will find it easier to adapt and implement it.

TPACK-based PBL can also help students build digital literacy from an early age (Whitley et al., 2019). They learn to use technology not only for entertainment, but also as a tool to find information, solve problems, and collaborate with friends (Valiandes et al., 2018). In the era of globalization, students must become accustomed to accessing various sources of information and evaluating them critically. TPACK-based PBL facilitates this by creatively combining digital information retrieval, data analysis, and solution presentation (Strogilos et al., 2020). Another urgent need is to provide more equitable learning opportunities. With technology, students in areas lacking physical learning resources can still access relevant materials and information to support their problem-solving process. Without the right learning model, technology in schools is often used only for teacher presentations or passive video viewing. TPACK-based PBL encourages the use of technology that is interactive and oriented toward developing student skills (Sanahuj et al., 2020). This model also facilitates cross-subject learning. For example, in solving environmental problems, students can integrate science, mathematics, language arts, and social studies concepts, while using technology to search for data, create simulations, and present their findings.

The development of TPACK-based PBL will encourage the role of teachers as facilitators and guides, not just as information providers (Strogilos et al., 2020). Teachers become designers of challenging yet relevant learning experiences for students (Roy et al., 2013). This urgency is further strengthened by the fact that the future world of work requires individuals capable of solving complex problems with the help of technology. TPACK-based PBL equips students with these skills from an early age. Furthermore, the development of this model can serve as a foundation for ongoing teacher training. Teachers can learn from proven models and then adapt them to local needs and student characteristics. The development of TPACK-based PBL in elementary schools not only improves the quality of the learning process but also impacts learning outcomes. Students become more active, creative, and independent in finding solutions.

Method

This study uses a quantitative descriptive approach with the aim of analyzing the needs of elementary school teachers in developing a Problem Based Learning (PBL) model based on Technological Pedagogical Content Knowledge (TPACK) to improve students' critical thinking skills. The research subjects were 100 elementary school teachers selected through a purposive sampling technique, taking into account their involvement in the learning process and the availability of access to learning technology. Data were collected through a questionnaire instrument compiled based on five main indicators, namely teachers' initial knowledge of TPACK-based PBL, the availability of school facilities, teacher participation in related training, the level of TPACK integration in learning, and PBL implementation in the classroom. Each indicator was measured using a percentage scale to determine the level of teacher readiness. The data collection process was supplemented with short interviews to deepen information regarding obstacles and teachers' needs in implementing TPACK-based PBL. The collected data were analyzed descriptively to present the percentage distribution of each indicator, then interpreted to identify gaps between existing conditions and the ideal conditions required in developing the learning model. The results of this analysis were used as a basis for formulating the urgency and direction of developing a TPACK-based PBL model that is appropriate to the context of elementary education.

Results

Based on the results of field observations of 100 elementary school teachers, the following are the results of interviews with elementary school teachers. The graph presented in Figure 1 demonstrates the current state of elementary school teachers' readiness to implement TPACK-based Problem Based Learning (PBL). Five key indicators are measured, ranging from teachers' initial knowledge to the implementation of PBL in the classroom. This data serves as an important mirror to identify the gap between the current situation and the ideal implementation of TPACK-based learning in elementary schools. The first indicator shows that only about 36% of teachers were previously familiar with the TPACK-based PBL model. This figure is relatively low and indicates that most teachers do not yet have a comprehensive understanding of the concept and mechanisms of implementing TPACK-based PBL. This is a major urgency because basic knowledge is the foundation for implementing innovative learning models.

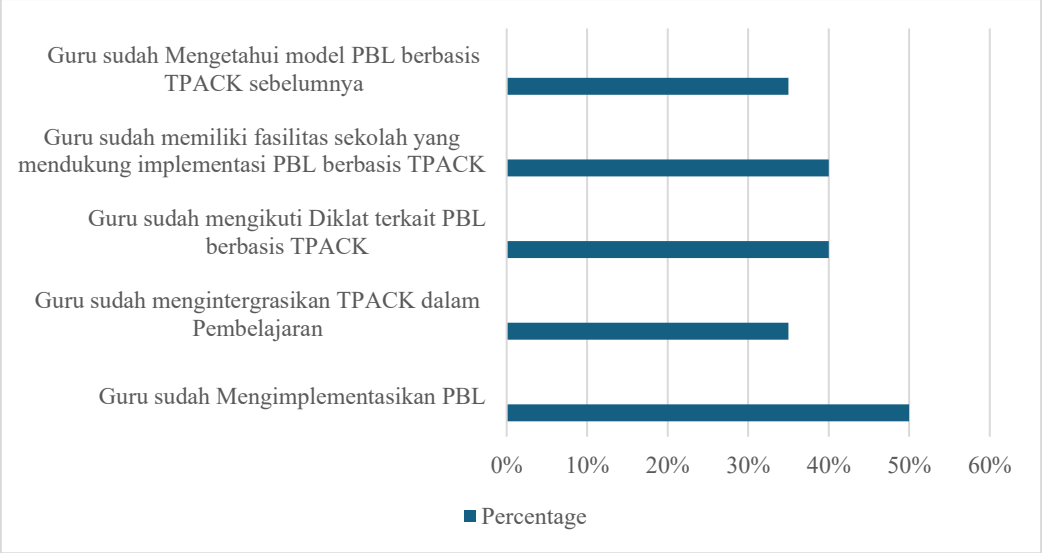

Figure 1. Results of the Analysis of Teacher Needs for the Development of a TPACK-based PBL Model

This low level of initial knowledge indicates the need for extensive outreach efforts through seminars, workshops, and learning modules tailored to the elementary school context. Without this initial understanding, teachers will struggle to implement this model appropriately and optimally. The second indicator, school ownership of facilities that support the implementation of TPACK-based PBL, is at 40%. This means that although some schools have technological resources such as projectors, computers, or internet access, many elementary schools still face infrastructure limitations. Adequate infrastructure is one of the pillars of TPACK, as without the support of facilities, the integration of technology into the learning process will be hampered. Therefore, the urgency of developing this model must also include strategies for maximizing the use of available facilities and adapting to school conditions with limited resources. The third indicator shows that only 40% of teachers have participated in training related to TPACK-based PBL. This means that most teachers have not received formal training or intensive mentoring in mastering this concept. This situation emphasizes the need for ongoing training to be part of the development of TPACK-based PBL models. Providing tools and modules is not enough; teachers also need practical guidance that can be applied directly in the classroom.

The fourth indicator shows that 36% of teachers have integrated TPACK into their lessons. This figure is consistent with teachers' low prior knowledge and suggests that integrating technology, pedagogy, and content is not yet common practice in elementary schools. This low level of integration is crucial for creating a structured learning model, providing teachers with step-by-step guidance for effectively integrating TPACK into PBL. This way, technology becomes more than just a presentation tool, but a strategic tool for problem-solving that actively engages students.

The fifth indicator, PBL implementation, showed the highest rate at 50%. This indicates that some teachers are accustomed to using a problem-based approach in teaching, although it has not been optimally integrated with TPACK. This fact opens up significant opportunities for improving the quality of learning. Teachers who have implemented PBL can be directed to systematically integrate technology and content aspects according to the TPACK framework, so that learning becomes more relevant to the challenges of the 21st century. Overall, this

data shows that some teachers have experience and initial capital, but there are significant gaps in understanding, facilities, training, and technology integration. This gap underlies the urgency of developing a TPACK-based PBL model at the elementary school level.

This model is needed to provide practical guidance that is not only theoretical but also applicable to field conditions. This is crucial because elementary school teachers often face limitations in time, resources, and technical support. Another pressing issue is the demands of the Independent Curriculum, which encourages project-based learning and problem-solving. Without TPACK integration, teachers may implement PBL traditionally without leveraging the potential of technology to enrich students' learning experiences.With the TPACK-based PBL model, students are not only trained to think critically in solving problems, but also accustomed to using technology creatively, understanding material concepts in depth, and relating them to real life. For teachers, this model will serve as a guideline for designing more effective learning scenarios, selecting appropriate media, and implementing evaluation strategies that align with learning objectives. Furthermore, the development of this model also has the potential to increase teacher motivation in teaching. With clear guidance, teachers will be more confident and encouraged to try new strategies that challenge students. Equally important, the integration of TPACK into PBL can bridge the digital literacy gap among elementary school students. This is highly relevant considering the world of education is currently moving towards an increasingly rapid digital transformation.The data in the graph can also serve as evaluation material for policymakers in schools and education offices to design more targeted teacher competency improvement programs. In conclusion, this data demonstrates the real urgency of developing and implementing a TPACK-based PBL model at the elementary school level. This model is expected to address the challenges of low teacher understanding, limited facilities, inadequate training, and minimal technology integration, thereby making learning more meaningful, innovative, and relevant to the needs of the times.

Discussion

The study results indicate a significant gap between teachers' knowledge and skills in implementing TPACK-based Problem-Based Learning (PBL) and the desired ideal conditions. This finding aligns with Arends' (2012) view, which emphasizes that PBL requires teachers to be prepared to systematically manage problem-based learning, from planning to evaluation. The percentage of teachers who understand the concept of TPACK-based PBL is only 36%, reinforcing the findings of Yanti and Wulandari's (2020) study, which found that elementary school teachers' understanding of TPACK is still low, particularly in the aspect of integrating technology into problem-based learning. The finding that only 40% of teachers have facilities to support TPACK-based PBL corroborates the findings of a study by Wijaya et al. (2021), which identified limited technological infrastructure as one of the main obstacles to implementing innovative learning in elementary schools.

The low teacher participation in TPACK-based PBL training (40%) is consistent with research by Fatimah and Ramdhani (2019) which states that teacher training in Indonesia is still not focused on technology integration in contextual learning. The level of TPACK integration in learning, which only reached 36%, indicates that mastery of technology, pedagogical, and content competencies is still fragmented. This is in line with the findings of

Koehler & Mishra (2009) who emphasized the importance of understanding the relationship between TPACK components, not just mastering each aspect separately. The fact that PBL implementation reached 50% indicates a fairly good initial capital. Research by Sastrawijaya (2018) showed that teachers who have implemented PBL more easily adapt this approach to the TPACK framework than teachers who have never used PBL at all.

The low rate of TPACK integration in PBL is also influenced by the lack of applicable learning model examples. This is consistent with the study by Rahmawati et al. (2021), which suggests the development of a PBL-TPACK-based learning model that can be directly adopted by teachers. The results of this study also strengthen the argument that teacher training should not only focus on mastery of technology but also on skills in integrating that technology into problem-based learning contexts. This relationship was revealed by Sahin's (2011) research, which highlighted the importance of contextualized training in implementing TPACK. In the context of the Independent Curriculum, this study's results are relevant to the findings of Putri and Utami (2022) that the PBL model integrated with TPACK can improve higher-order thinking skills (HOTS) in elementary school students, provided teachers have adequate understanding.

The technological infrastructure issues identified in this study are also reflected in global studies such as those conducted by the OECD (2020), which show that disparities in facilities between schools impact the success of technology integration in learning. In terms of teacher motivation, these findings align with research by Hermawan (2021), which states that teachers are more motivated to adopt new approaches if clear models, examples of good practice, and principal support are available. The fact that 50% of teachers have implemented PBL presents a significant opportunity for the development of a TPACK-based PBL model. This finding is consistent with a study by Simanjuntak et al. (2020), which found that teachers familiar with PBL adapt more quickly to technology-based innovations. These results also reaffirm that TPACK integration requires a blended approach, combining face-to-face learning and the use of technology. This finding is reinforced by research by Graham (2011), which demonstrated the effectiveness of blended learning in a PBL context. The development of a TPACK-based PBL model proposed in this study will address the challenge of low technology integration, as identified in a study by Supriyadi (2019), which emphasized the need for digital learning innovation in elementary schools.

Previous research by Ertmer & Ottenbreit-Leftwich (2010) emphasized that changing teaching practices requires teachers' belief in the benefits of technology, in addition to technical skills. The results of this study indicate that this belief has not been fully developed due to a lack of practical experience. The finding regarding the low level of teacher training is relevant to the UNESCO report (2021), which states that teachers' capacity to utilize technology remains a major challenge in developing countries, including Indonesia. The low level of student digital literacy caused by the lack of TPACK integration is also in line with research by Rachmawati et al. (2021), who found that problem-based learning integrated with technology can significantly improve students' digital literacy skills. Comparing the results of this study with previous research, it is clear that the biggest gap is not in the implementation of PBL itself, but rather in the utilization of technology as an integral part of the problem-based learning process. Therefore, the development of a TPACK-based PBL model that is contextualized to the conditions of elementary schools in Indonesia is an urgent need. This model must be accompanied by implementation guidelines, practical training, and strategies for utilizing technology appropriate to school

conditions. The overall discussion leads to the conclusion that the findings of this study strengthen evidence from various previous studies, while also providing new contributions in the form of empirical data on the level of preparedness of elementary school teachers. This data can be used as a basis for designing an effective TPACK-based PBL model to improve students' critical thinking skills.

Conclusion

Based on the findings obtained from the needs analysis, it can be concluded that the readiness of elementary school educators in implementing Problem-Based Learning (PBL) based on Technological Pedagogical Content Knowledge (TPACK) is still lacking in several critical dimensions. Only a small percentage of educators have understood the principles of TPACK-based PBL, have sufficient support resources, participated in relevant training sessions, and consistently incorporated TPACK into their pedagogical practices. Although approximately fifty percent of the participating educators have implemented PBL, the implementation has not fully utilized the synergistic potential of the integration of technology, pedagogy, and content. This disparity indicates the necessity for the formulation of a TPACK-based PBL framework that is systematically organized, practically applicable, and contextually relevant to elementary education. This model is anticipated to serve as a pragmatic resource for educators in the design of problem-based learning that effectively utilizes technology, enhances students' critical thinking skills, and facilitates the achievement of 21st-century educational goals. Initiatives aimed at model development should be complemented by ongoing professional development, the provision of supportive resources, and policies that encourage innovative learning practices in elementary education.

Recommendations

A structured and applicable TPACK-based Problem Based Learning model is designed, adapted to the characteristics of elementary school students and real-world conditions. This model must include step-by-step guidance that is easy for teachers to adapt. Regular training and mentoring programs for teachers are implemented, focusing on mastery of PBL concepts, TPACK integration skills, and the use of relevant educational technology to support the learning process. Local governments and schools are expected to prioritize the provision of technology-based learning support facilities, such as adequate internet access, ICT devices, and digital learning media that can support TPACK-based PBL. TPACK-based PBL needs to be integrated into school policies and programs, including the Learning Implementation Plan (RPP) and the Education Unit Operational Curriculum (KOSP), so that its implementation is more consistent. Accessible digital problem-based learning resources are provided for teachers and students, including interactive modules, learning videos, simulations, and contextual question banks that support critical thinking skills. Encourage the formation of learning communities or Professional Learning Communities (PLCs) among teachers to share good practices, provide feedback, and collaborate in designing PBL-TPACK-based learning. Periodic evaluations of the implementation of TPACK-based PBL are conducted, including the level of implementation, the impact on students' critical thinking skills, and the challenges faced, so that continuous improvements can be made. Further research on the effectiveness of the developed TPACK-based PBL model is recommended, both through limited trials and experimental research, to obtain stronger empirical evidence.

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