Integration of Problem-Based Learning (PBL) and Technology in Online Learning: A Literature Study

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ABSTRACT

Problem-Based Learning (PBL) is an effective pedagogical approach for enhancing critical thinking and problem-solving skills. With the rise of online learning, technology plays a crucial role in supporting PBL implementation. This study explored the integration of PBL and technology in online learning through a literature review, analyzing scientific journals and books to evaluate its effectiveness, benefits, and challenges. The findings revealed that technology-enabled PBL enhances student participation, strengthens critical thinking, and fosters interactive learning experiences. Key technologies such as Learning Management Systems (LMS), online collaboration tools, and simulations significantly support the PBL process. However, challenges include limited infrastructure, insufficient teacher training, and difficulties in designing online PBL activities. The study concludes that integrating PBL with technology holds great potential for improving online learning quality. Successful implementation requires targeted teacher training, appropriate technology selection, and supportive education policies. Further empirical research is recommended to assess the impact of this integration on student learning outcomes.

Keywords: *Problem-Based Learning, learning models, technology, online learning, literature studies*

1. INTRODUCTION

Problem-Based Learning (PBL) has become one of the most widely used pedagogical approaches to encourage the development of critical thinking, problem-solving, and student collaboration skills (Hastawan et al., 2023; Hmelo-Silver, 2004; Prasetyo, n.d.). PBL puts students at the center of the learning process by involving them in solving real problems that are relevant to daily life (Hmelo-Silver, 2004). Through PBL, students learn not only to understand certain concepts but also to develop analytical thinking skills and work together in a team (Hmelo-Silver, 2004). In the context of modern education, the need to implement PBL has become increasingly urgent, especially with the increasing demands on 21st century skills (Iskandar et al., 2023; Maulidia et al., 2023).

On the other hand, technology has brought major changes in the world of education, especially through online learning (Iskandar et al., 2023). Various digital tools such as Learning Management Systems (LMS), online discussion forums, and computer-based simulations provide new opportunities to optimize student learning experiences (Bradley, 2021; Huong & Hung, 2021; Sim & Ismail, 2023). However, although technology has great potential, its application is often not utilized to the fullest to support learning models such as PBL (Bradley, 2021).

The integration of PBL and technology in online learning faces various gaps. Several studies show that the implementation of online PBL still faces challenges such as lack of student involvement, lack of teacher training in designing digital problem-based learning, and technical obstacles such as uneven internet access (Meng et al., 2023). Based on this background, this study aims to explore the integration of PBL and technology in online learning through literature study methods. This research is expected to provide insight into the potential, benefits, and challenges of this approach, as well as offer recommendations to optimize its application in modern education.

2. METHODS

This study employed a literature review design to systematically analyze existing research on the integration of Problem-Based Learning (PBL) and technology in online learning. The methodology was structured

to ensure comprehensiveness, validity, and reproducibility. The research adopted a qualitative synthesis approach, focusing on identifying, evaluating, and synthesizing relevant scholarly works. The process included Peer-reviewed articles. Academic literature is taken from databases (Google Scholar, ERIC, Scopus, ScienceDirect) and selected papers based on relevance to PBL-technology integration.

3.   RESULTS & DISCUSSION

3.1   Theory of Problem-Based Learning (PBL)

PBL as a student-centered learning approach that encourages real problem-solving (Almulla, 2020). A pedagogical approach that focuses on students as a learning center, in which students are actively involved in the learning process through relevant and complex problem-solving (Aytaç & Kula, 2020; Kerimbayev et al., 2023). PBL introduced by Barrow is defined as a learning strategy that aims to encourage students to learn by identifying, analyzing, and solving real problems (Almulla, 2020). This approach not only provides factual knowledge but also develops critical thinking, problem-solving, and decision-making skills (Orhan, 2024).

In PBL, students did not passively receive information, but rather act as investigators who collect information and create solutions based on in-depth analysis (Ali, 2019; Hue, 2021). This makes learning more meaningful because students learn to connect theory with practice (Brand-Gruwel, 2012; Miraj et al., 2021). Research shows that problem-based learning was able to increase students' motivation to learn because they feel more involved and have control over the learning process (Almulla, 2020; Orhan, 2024; Hmelo-Silver, 2004). PBL is based on three main principles that support its effectiveness, namely collaboration, independent learning, and experiential learning (Ali, 2019; Hue, 2021).

3.2   Collaboration

PBL encourages students to work in teams to solve complex problems (Glazewski & Ertmer, 2020). This collaboration not only to hone communication skills but also build important interpersonal skills in the world of work (Abid et al., 2022; Mendo-Lázaro et al., 2022). Collaboration in PBL allows students to share perspectives, discuss ideas, and reach solutions together, ultimately improving their understanding of the material being studied (Lin & Wang, 2024a).

3.3   Independent Learning

One of the main goals of PBL is to create independent learners. Students are given the freedom to manage their own learning process, from searching for information, determining problem-solving strategies, to evaluating results (Mickwitz & Suojala, 2020). This approach encourages students to become more responsible for their learning and develop lifelong learning skills (English & Kitsantas, 2013; Puangpunsi, 2021).

3.4   Experiential Based Learning

PBL puts students in situations that resemble the real world, where they must connect theory with practice to solve problems (Ali, 2019; Kök & Duman, 2023). This makes learning more relevant and applicable (Almulla, 2020; Lavado-Anguera et al., 2024). Hands-on experience in solving problems helps students understand concepts more deeply and strengthen their memory of the material studied (Hulaikah et al., 2020; Lavado-Anguera et al., 2024).

3.5   The Role of Technology in Online Learning

Technology has become a key element in supporting the transformation of learning from traditional formats to online learning (Dziuban et al., 2018; Sato et al., 2023). In online learning, technology plays a role as a facilitation medium that not only delivers material but also creates an interactive learning experience (Muir et al., 2020; Querol-Julián & Crawford Camiciottoli, 2019). Some of the main technologies that are often used in learning include video conferencing, learning management systems (LMS), Online Discussion Forums, and Online Collaboration Tools (Hasumi & Chiu, 2024; Hidayat et al., 2022; Kerimbayev et al., 2023)

Video conferencing allows direct interaction between teachers and students (Adipat, 2021; Bailey et al., 2022; Camilleri & Camilleri, 2022). The technology supports real-time communication, provides a learning experience that resembles a physical classroom, and allows for more interactive synchronous teaching (Nadire & Daniel, 2021). Some of the video conferences used so far are Zoom, Microsoft Teams, and Google Meet (Hove & Watson, 2022).

Some of the Learning Management Systems (LMS) applications currently in use are Moodle, Blackboard, and Google Classroom (Bradley, 2021; Gamage et al., 2022; Padohinog et al., 2022). This LMS provides an integrated platform for delivering materials, assigning assignments, and monitoring student progress (Sanchez et al., 2024). With features such as quizzes, assignment collection, and discussion forums, LMS supports structured and collaborative learning (Hasanah et al., 2022; Nisak, 2024).

Online Discussion Forums that can be used e.g. Edmodo or discussion features in LMS allow students to participate in asynchronous learning (de Lima et al., 2019a; Gasmi, 2022; Onyema et al., 2019). The forum encourages more in-depth discussions, where students can share ideas, provide feedback, and learn from each other.

In addition to being held interactively, the technology that can be used is collaborative learning. A number of collaborative apps such as Google Docs, Padlet, and Trello allow students to work together virtually in completing projects or group assignments. This technology supports collaboration-based learning which is the core of Problem-Based Learning (PBL).

A study by Dhawan (2020) shows that technology plays an important role in improving the accessibility and flexibility of online learning. With technology, students can learn anytime and anywhere, providing convenience for those with time or location constraints. In addition, technology also allows for the delivery of more varied material through videos, simulations, or game-based learning, which can increase students' interest and motivation in learning.

However, the effectiveness of technology in online learning depends heavily on the right learning design. Technology must be used as a tool that supports interaction, collaboration, and problem-solving, not just a medium for conveying information. In the context of Problem-Based Learning (PBL), technology can be used to support group discussions, problem-solving simulations, and access to relevant learning resources. By utilizing technology optimally, online learning can be an effective and immersive learning experience for students.

3.6 Integration of PBL and Technology

The integration of Problem-Based Learning (PBL) and technology in online learning is an innovation that offers great potential in increasing the effectiveness of the teaching-learning process, especially in terms of developing critical thinking and collaboration skills.

3.7 The Effectiveness of PBL in Improving Critical Thinking Skills with Technology Support

Various studies show that PBL has a positive impact on developing students' critical thinking skills. This approach puts students in situations that require them to analyze information, evaluate alternative solutions, and make decisions based on data and logic. When supported by technology, the effectiveness of PBL becomes more optimal. Technology tools such as Learning Management Systems (LMS), online collaboration applications, and simulation tools provide a means that makes it easier for students to access information, communicate, and solve problems together. A study by Gikas and Grant (2013) states that technology supports the success of PBL by providing a dynamic, interactive, and flexible learning environment.

3.8 Technology as a Support for Collaboration and Interaction in Online PBL

Collaboration and interaction are key elements in PBL. Technology enables cross-border collaboration through online communication tools such as Zoom or Google Meet, as well as collaboration applications such as Google Docs and Padlet. Additionally, asynchronous discussion forums on LMS provide opportunities for students to share ideas, provide feedback, and learn from each other. Technology-based simulations also make a

great contribution in supporting PBL. For example, computer-based simulations allow students to practice realistic problem-solving scenarios, providing a real-world-based learning experience.

3.9 Challenges of Implementation of PBL and Technology Integration

While the integration of PBL and technology has many benefits, its implementation has not been without its challenges. One of the main obstacles is technical limitations, such as uneven internet access and adequate device availability, especially in areas with minimal digital infrastructure. In addition, there is an urgent need for teacher training so that they are able to design and implement problem-based learning by utilizing technology effectively. The lack of technological literacy among educators is often an obstacle to the application of technology in online learning. By addressing these challenges, the integration of PBL and technology can provide maximum benefits in creating online learning that is interactive, collaborative, and oriented towards 21st century skill development.

3.10 Summary of Findings from the Literature Related to PBL and Technology

The results of the literature analysis show that Problem-Based Learning (PBL) has consistently been proven to be effective in improving students' critical thinking, problem-solving, and cooperative skills. PBL provides students with an active and contextual learning experience by engaging them in relevant problem-solving (Halean et al., 2021).

On the other hand, technology plays an important role in supporting online learning. Technologies such as Learning Management Systems (LMS), online collaboration tools, and video conferencing platforms have helped create an interactive, flexible, and collaborative learning environment (Dhawan, 2020). The literature also shows that the integration of PBL with technology was able to overcome some of the limitations of traditional online learning, such as the lack of interaction and engagement of students (Erdogan & Senemoglu, 2017).

3.11 Benefits of Technology Integration in Supporting the Implementation of PBL

The integration of technology with PBL provides a variety of significant benefits, including easy access to information and increased interaction. Technology allows students to access rich and varied learning resources, such as scientific articles, educational videos, and digital simulations (Hadinezhad et al., 2024; Lin et al., 2024). Tools such as Zoom or Google Meet support direct communication between students and teachers, while discussion forums within LMS allow for in-depth asynchronous interaction (Badaruddin et al., 2023; de Lima et al., 2019b; Gasell et al., 2022; Ong & Quek, 2023; Setyawan et al., 2020). This technology encourages effective collaboration and discussion between students, even though it is done online (Baanqud et al., 2020; Oyarzun & Martin, 2023).

3.12 Obstacles Faced in Implementation

Despite the many benefits offered, the integration of PBL and technology also faces a number of obstacles, some of which are in technology adaptation and technological infrastructure. In technology adaptation, teachers often need additional training to design effective problem-based learning using technology (Aidoo, 2023; Kirabo et al., 2024). The lack of digital literacy among educators can be a major obstacle. The lack of technological infrastructure, the uneven availability of internet access, especially in remote areas, and the limited technology devices for students and teachers are still major challenges in the implementation of online learning (Kennedy et al., 2022).

3.13 Improving Critical Thinking and Collaborative Learning Skills

The integration of PBL and technology has great potential to improve critical thinking skills and collaborative learning. With technology, students can work together in teams virtually to analyze problems, formulate solutions, and present results (Darban, 2024; Kohut, 2012; Morrison-Smith & Ruiz, 2020). Collaboration tools such as Google Docs or Trello allow students to share ideas and contribute simultaneously in group projects, creating a collaborative learning environment (Andrade & Roshay, 2024; Darban, 2024).

In addition, technology supports the development of critical thinking skills by providing computer-based simulations or analytics software that allow students to practice problem-solving in real-world situations (Le, 2019). For example, environment-based problem simulations can provide a more immersive and relevant learning experience (Amin et al., 2020; Cahyadini et al., 2024; Rianti et al., 2024). However, to ensure the success of this integration, holistic support is needed, including ongoing teacher training, relevant curriculum development, and technological infrastructure upgrades (Green, 2018; Price, 2015) With the right approach, the integration of PBL and technology can create more meaningful and effective online learning for students (Green, 2018; Hoesny et al., 2024; Lin & Wang, 2024).

4.   CONCLUSION

This study highlights the effectiveness of the integration of Problem-Based Learning (PBL) and technology in online learning. Overall, this integration has been proven to be able to improve the quality of learning by encouraging students' critical thinking, collaboration, and problem-solving skills. Technology provides significant support in creating an interactive and flexible learning environment, allowing students to access information, communicate, and collaborate virtually. However, the success of this integration is highly dependent on the right learning design, educator competence, and the availability of technological infrastructure.

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