

The Evolution, Application, and Impact of Problem-Based Learning on Critical Thinking in Medical Education: A Review

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Abstract:

This review investigates the progression and utilization of Problem-Based Learning (PBL) within medical education, accentuating its historical context, theoretical bases, and essential role in fostering critical thinking and interdisciplinary collaboration. PBL has emerged as a prominent educational approach that encourages learner-centered education and tackles practical challenges, thus improving cognitive growth in medical students. This review consolidates empirical findings indicating PBL's advantage over conventional pedagogies in enhancing critical thinking and problem-solving abilities. Additionally, it underscores the significance of interdisciplinary collaboration in healthcare education, illustrating how PBL fosters teamwork and communication among aspiring healthcare practitioners. Despite its merits, logistical issues, inadequate faculty preparation, and limited resources impede the extensive implementation of PBL. The study offers suggestions for technology integration, highlighting practical applications and encouraging cooperative learning within PBL structures. Ultimately, PBL is recognized as a pivotal method in medical education, crucial for preparing students to address the intricacies of contemporary healthcare.

Keywords: Problem-Based Learning (PBL), Interdisciplinary Collaboration, Critical Thinking Skills, Medical Education, Healthcare Competencies

1. Introduction

1.1 Progression of Problem-Based Learning (PBL) in Medical Education: A Historical Perspective

Problem-Based Learning (PBL) is prevalent in diverse educational contexts, notably in medical training. (Johansson et al., 2022), The adoption of PBL in medical education is shaped by factors such as the social identities of students and the TPACK framework (Tanjung et al., 2022). Nonetheless, there exists a paucity of historical research on PBL's evolution in medical education (Salam, 2022). Although specific frameworks for PBL-CT implementation are lacking, its integration has been shown to improve learners' computational thinking abilities. Additional investigation is warranted to elucidate PBL's historical development in medical education and formulate effective implementation strategies.

1.2 The Significance of Interdisciplinary Collaboration in Healthcare

PBL promotes collaboration across different disciplines in healthcare by encouraging teamwork and effective communication among professionals. It helps students develop skills to tackle real-world challenges and leads to better patient outcomes through cooperative efforts. PBL brings together students from different healthcare fields, helping them understand each other's roles and responsibilities (Kwan & Chiang, 2021). In one study with nursing and medical students, PBL promoted active collaboration and discussion, improving their problem-solving abilities (Lestari et al., 2019). The use of PBL in gerontological nursing education shows how interdisciplinary teams can tackle the complex needs of older patients, especially those with multiple health conditions (Kwan & Chiang, 2021). However, challenges like scheduling conflicts and communication issues between disciplines can make PBL harder to implement.

Overcoming these obstacles is key to fully realizing the benefits of interdisciplinary collaboration in healthcare education.

1.3 Contextualizing Critical Thinking in Medical Curricula

PBL has become an important teaching method in medical education, especially for developing students' critical thinking skills. By incorporating PBL into medical programs, students improve their clinical reasoning, while also building stronger self-directed learning and problem-solving abilities. PBL engages students actively, fostering inquiry and understanding. This was often observed in PBL sessions (López et al., 2023). Studies reveal that PBL participants display significantly enhanced clinical reasoning skills compared to those in traditional educational frameworks (Zhou et al., 2023). Interns in a PBL-focused internal medicine course reported greater satisfaction and perceived it as more effective than conventional lectures, indicating that PBL not only facilitates learning but also elevates enjoyment (Ardoin et al., 2022).

2. Theoretical Foundations

PBL was introduced in the 1960s as a response to conventional teaching methods, placing a greater emphasis on student-centered learning through problem-solving (Rézio et al., 2022). It encourages students to combine their existing knowledge with new information, fostering a deeper understanding and better retention of the material (Rézio et al., 2022).

2.1 The Pedagogical Framework of Problem-Based Learning

The foundation of PBL lies in promoting collaborative inquiry and active participation, with a focus on solving real-world challenges. This method not only boosts critical thinking but also encourages teamwork and independent learning among students. For PBL to be effective, it

requires careful attention to four main components: preparation and planning, design and development, implementation and facilitation, and assessment (Ge & Huang, 2023).

Teachers play a vital role as facilitators, guiding students through discussions and helping them reflect on their learning (Rézio et al., 2022). While PBL offers many advantages, it does face challenges, especially in online settings where technology must align with educational objectives (Ge & Huang, 2023). Successfully implementing PBL requires balancing these elements.

2.2 Models and Approaches for Implementing PBL in Medical Education

The incorporation of Problem-Based Learning (PBL) within medical education employs various models and strategies that enhance student engagement and foster critical thinking skills. Innovative PBL Approaches: PBL focuses on solving real-world problems, promoting independent learning and critical thinking in students.(Kasarla et al., 2023). Constructive Feedback: Providing personalized feedback in PBL sessions enhances both students' and tutors' cognitive and behavioral outcomes, though issues with adaptability and resource limitations remain (Pangastuti et al., 2022).

2.3 The Interplay of Critical Thinking and Interdisciplinary Skills

The integration of critical thinking and interdisciplinary skills in PBL is deemed essential for 21st-century competency development. Evidence indicates that PBL enhances critical thinking and fosters interdisciplinary collaboration, both vital for addressing intricate real-world problems. PBL markedly enhances critical thinking skills in students. A study indicated that PBL participants achieved an average score of 85.83 in critical thinking, surpassing the 75.42 average of those in conventional educational frameworks. (Kusumawardani & Aminatun, 2024). Another

study confirmed that PBL encourages deeper engagement and understanding, leading to notable improvements in critical thinking (Chen, 2024).

Furthermore, interdisciplinary learning within PBL helps students develop vital skills like communication and collaboration. Those involved in real-world problem-solving tasks showed enhanced creativity and critical thinking (Ye & Xu, 2023).

Despite PBL's strong potential to enhance both critical thinking and interdisciplinary skills, challenges like cognitive overload and time constraints can restrict its effectiveness for certain students (Kertiyani et al., 2022). Educators must consider these factors in PBL strategy development.

3. PBL and its Influence on Critical Thinking

3.1 Assessing Critical Thinking Skills in PBL Environments

The assessment of critical thinking abilities in PBL environments presents benefits and challenges. PBL fosters critical thinking via collective problem-solving, yet difficulties persist in measuring and comprehending these skills. PBL environments engage students in solving real-world issues, which naturally promotes higher-order thinking and strengthens critical thinking abilities (Rahma Hidayati Darwis et al., 2024). Research shows that students using PBL techniques, like e-modules paired with Socratic dialogue, experience significant improvements in critical thinking compared to traditional approaches (Pitorini et al., 2024). PBL improves critical thinking in students of diverse abilities, particularly benefiting high-achieving individuals (Indrapangastuti et al., 2024).

Innovative approaches within PBL, such as probing prompts, effectively stimulate critical thinking by presenting students with real-world challenges and guiding their inquiry process (Pereira et al., 2023). Furthermore, incorporating technology, like digital posters in PBL projects, has demonstrated a significant impact on critical thinking, particularly in complex topics like climate change (Efwinda et al., 2023).

3.2 Empirical Evidence on the Impact of PBL on Critical Thinking

Research indicates that PBL significantly enhances critical thinking abilities across diverse educational contexts. By fostering increased engagement and facilitating the practical use of knowledge, PBL results in superior critical thinking achievements.

PBL demonstrates superior efficacy over conventional methodologies in enhancing critical thinking in English as a Foreign Language (EFL) students. This effectiveness is primarily attributed to PBL's focus on addressing authentic issues and encouraging cooperative engagement. (Song et al., 2024). Furthermore, A study found that PBL integrated into blended learning environments boosted high school students' critical thinking scores, with an average of 85.83, compared to 75.42 in traditional settings (Kusumawardani & Aminatun, 2024). Research also highlights that high school students who engaged in PBL showed substantial improvements in critical thinking compared to conventional teaching, largely due to increased involvement and comprehension (Chen, 2024).

In teacher education, PBL significantly enhanced the critical thinking skills of prospective elementary school teachers, with high-ability students scoring an average of 83.16% (Indrapangastuti et al., 2024)). Additionally, PBL combined with digital tools notably improved critical thinking in junior high students, especially in complex subjects such as climate change (Efwindi et al., 2023).

3.3 PBL and Cognitive Development in Medical Students

PBL enhances medical students' cognitive and analytical abilities. Engagement with authentic clinical scenarios fosters deeper and enduring comprehension of the subject matter. PBL is rooted in cognitive constructivism, encouraging students to merge new concepts with what they already know, making the learning experience more meaningful (Chun, 2024). Educators are advised to relate new lessons to students' existing knowledge, sparking greater cognitive involvement and curiosity (Chun, 2024).

Research has found that students in PBL programs showed significantly stronger clinical reasoning skills than those following traditional curricula (Zhou et al., 2023). Moreover, these

PBL students achieved higher scores on critical thinking evaluations, demonstrating a clear link between PBL participation and enhanced cognitive abilities (Zhou et al., 2023).

4. Enhancing Interdisciplinary Collaboration through PBL

4.1 Strategies for Integrating Multiple Disciplines in PBL Modules

Curriculum Design: Integrating STEAM principles (Science, Technology, Engineering, Arts, and Mathematics) into PBL modules creates a more hands-on learning experience that helps students gain a deeper, cross-disciplinary understanding (J. Li, 2024). Faculty Training: Offering professional development opportunities for educators is essential for shifting teaching methods and better equipping them to guide students through interdisciplinary projects (Kamaruddin et al., 2024). Collaborative Tools: Using digital tools like MS Teams and Blackboard fosters collaborative learning and improves communication between students from various fields (Zambelli et al., 2024). Assessment Innovations: Introducing new assessment methods that account for teamwork and interdisciplinary results can motivate students and enhance engagement (J. Li, 2024).

Although PBL is promising for fostering collaboration, issues such as differences in student preparedness and logistical challenges must be addressed for it to reach its full potential ((Kamaruddin et al., 2024).

4.2 Case Studies Demonstrating Successful Interdisciplinary PBL

Interdisciplinary PBL has demonstrated notable success across various educational contexts, fostering innovative skills and collaborative problem-solving among students. The following case studies highlight effective implementations of interdisciplinary PBL.

Course Design and Implementation

A study by Jarrah et al. presents a PBL course based on Hung's 3C3R model, which emphasizes addressing real-world problems and promoting diverse student groupings. Feedback from this course helped create a guide for future instructors, highlighting the significance of allocating time for in-class projects and encouraging self-reflection (Jarrah et al., 2023).

Innovative Skills Development

Research by Kilburn Scott and White suggests that interdisciplinary education enhances critical thinking and adaptability, with strong institutional support being vital for success. Their mixed-methods approach revealed that active learning strategies play a crucial role in boosting student engagement (Scott & White, 2024).

Community Engagement

Bowen's case study showcased students tackling social issues within diverse communities through service-learning projects, empowering them to act as agents of social change (Bowen, 2020).

Collaborative Problem Solving

MacLeod and van der Veen illustrated the effectiveness of interdisciplinary teams from various bachelor programs in addressing complex planning issues, demonstrating the practical benefits of interdisciplinary PBL (MacLeod & van der Veen, 2020).

Challenges and Opportunities

Braßler's research discusses the organizational hurdles encountered in implementing interdisciplinary PBL, emphasizing the need for collective learning and training to overcome resistance (Braßler, 2020).

4.3 Challenges and Solutions in Fostering Collaboration

Enhancing interdisciplinary collaboration through project-based learning (PBL) involves navigating several challenges and finding effective solutions. Successful collaboration

necessitates addressing barriers while utilizing structured frameworks to promote creativity and engagement among diverse participants. Cultural and Organizational Barriers: Institutions often encounter cultural obstacles that impede collaboration, such as differing disciplinary languages and priorities (Pryor & Steinberg, 2023).

Limited Emotional and Interactive Engagement: Faculty may struggle with low cognitive engagement, which can impact the collaborative process (Pryor & Steinberg, 2023). Structured Workshops: Organizing structured workshops can boost participation and creativity, allowing for the effective blending of diverse methodologies (Ridge & Manchester, 2023). Shared Cognitive-Emotional Frameworks: Implementing frameworks like the SCEI can help identify and enhance emotional and interactive markers that facilitate collaboration (Pryor & Steinberg, 2023). Scaffolding Techniques: Using scaffolding strategies in PBL can assist participants in navigating complex interdisciplinary projects, ensuring that all voices are acknowledged (Ridge & Manchester, 2023).

5. Comparative Analyses and Syntheses

5.1 Cross-Institutional Variances in Implementing PBL

The implementation of Problem-Based Learning (PBL) differs across institutions, influenced by unique educational settings, teaching methods, and technological advancements. Recognizing these differences is key to improving collaborative learning experiences between institutions. Translation Theory: The variations in PBL implementation are often analysed through the lens of translation theory, which suggests that local practices can differ from the original models due to necessary contextual adjustments (Scholkmann, 2022). Online Problem-Based Learning (COPBL): Research involving HKU and CDUTCM revealed successful cross-institutional collaboration through blended learning, where students participated in online discussions, highlighting the effective role of technology in enhancing PBL (Yum et al., 2016).

5.2 Meta-Analytic Insights on PBL Efficacy in Medical Education

Research indicates that Problem-Based Learning (PBL) provides substantial advantages in medical education relative to conventional lecture approaches. This methodology markedly improves medical students' critical thinking, problem-solving capabilities, and comprehensive clinical competencies.

Efficacy in Knowledge and Skills Acquisition:

PBL has been found to enhance mastery of medical theoretical knowledge, with a weighted mean difference (WMD) of 7.14, and operational skills, with a WMD of 6.54, compared to conventional lecture-based learning (T. Li et al., 2022). Furthermore, a study demonstrated that students who participated in a PBL curriculum showed higher clinical thinking abilities after the intervention, underscoring its effectiveness in developing critical thinking skills (Zhou et al., 2023).

Student Satisfaction and Engagement:

PBL methods result in high student satisfaction, encouraging self-directed learning and active involvement in the educational experience (Trullàs et al., 2022). The collaborative aspect of PBL encourages teamwork and strengthens problem-solving abilities, both of which are essential for aspiring medical professionals (Kasarla et al., 2023).

6. Future Directions and Recommendations

6.1 Technology Integration

The use of technology in PBL is crucial, with a significant increase in publications highlighting its role in enhancing student engagement and learning outcomes (Wahyudi et al., 2024). Future research should explore innovative technological tools that facilitate collaborative projects and problem-solving in diverse educational settings (Wahyudi et al., 2024).

6.2 Real-World Applications

PBL should focus on real-world challenges, allowing students to apply theoretical knowledge in practical contexts, which is essential for developing critical thinking and problem-solving skills (Id et al., 2014; Kwietniewski et al., 2017). Engineering education, in particular, must incorporate projects that reflect industry needs, fostering skills that align with professional expectations (Id et al., 2014).

6.3 Collaborative Learning

Emphasizing collaborative group work in PBL encourages self-directed learning and enhances interpersonal skills, preparing students for future teamwork in professional environments (Kwietniewski et al., 2017; Roopashree, 2014). Educators are encouraged to adopt a facilitative role, guiding students through complex problem-solving processes while promoting autonomy (Id et al., 2014).

7. Conclusion

In conclusion, Problem-Based Learning (PBL) has become a key teaching method in medical education, helping students develop critical thinking, teamwork, and problem-solving skills. Its history shows a move away from traditional teaching to more interactive, student-centered learning environments. Many studies confirm that PBL effectively enhances critical thinking and cognitive growth, especially in real-world clinical situations. Additionally, PBL encourages collaboration across different healthcare fields, which can lead to better patient care and more comprehensive approaches. However, challenges like limited resources, inadequate faculty training, and the need for better coordination between disciplines still exist and can hinder the smooth implementation of PBL. Overall, PBL is essential for preparing future healthcare professionals to handle the complexities of modern healthcare.

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Author contribution

The authors were involved in drafting and reviewing the manuscript and have seen the final text.

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