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A Systematic Review: Challenges in Implementing Problem-Based Learning in Mathematics Education

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Abstract

Problem-Based Learning (PBL) stands as an educational approach highlighting active student involvement, centring learning on practical, real-world scenarios. It fosters the growth of critical thinking, teamwork, and problem-solving skills. Although PBL offers numerous advantages, its application presents specific challenges. Consequently, this study employs a systematic approach to assess the challenges encountered when implementing PBL in mathematics education. This research comprises a thorough analysis and synthesis of 20 articles published between 2017 and 2022, drawing from reputable sources such as Google Scholar and ERIC. The study's outcomes demonstrate that a quantitative methodology proved most suitable for conducting thorough data analysis and generating empirical results in this context. The study's findings underscore the necessity of proficient facilitators in PBL, as they assume a pivotal role in guiding and supporting students throughout their learning journey. In light of these challenges, educators must recognize and address them to ultimately enhance students' mathematical problem-solving skills, critical thinking abilities, and overall engagement in the educational process.

Keywords : Problem-Based Learning, Challenges, Systematic Approach

Introduction

Education 4.0 represents a transformative era in learning, driven by technological advancements and the integration of digital tools and resources in the educational landscape. As this paradigm shift reshapes the way students learn, teachers' teaching practices have been profoundly impacted. Education 4.0 fosters personalized and adaptive learning experiences, allowing educators to tailor their teaching methods to meet individual student needs. With abundant online resources and interactive platforms, teachers can now create engaging and interactive lessons catering to diverse learning styles, making the learning process more inclusive and accessible. Moreover, Education 4.0 emphasizes collaborative and

problem-based learning, encouraging teachers to adopt facilitator roles, and guiding students to explore and construct knowledge independently.

Problem-Based Learning (PBL) is an instructional method that prioritizes active learning and student engagement. This approach involves presenting students with complex, real-world challenges that require analytical thinking and problem-solving skills. Rather than being passive learners, students take an active role in their educational journey. The central tenet of PBL is to promote self-directed learning through inquiry and exploration. Instead of receiving predefined solutions, students are encouraged to proactively seek information and integrate ideas and skills from various academic disciplines to build their expertise. By analyzing, synthesizing, and applying knowledge to address practical situations, students are motivated to develop a deeper understanding of the subject matter.

Besides that, PBL also aims to foster student cooperation and teamwork by engaging them in collaborative investigations of issues within small teams or groups. Through this process, they share ideas, and perspectives, and jointly develop solutions. This collaborative aspect enhances their problem-solving skills and cultivates effective communication, interpersonal abilities, and adaptability in diverse organizational settings. PBL encourages active participation, critical thinking, and teamwork as a learner-centred approach. By placing students at the centre of their learning experience, PBL empowers them to take charge of their education and acquire the essential skills needed to thrive in real-world scenarios.

PBL has experienced a significant surge in popularity within the realm of mathematical education. The PBL approach in math focuses on actively involving students in tackling real-life mathematical problems that demand critical thinking, mathematical reasoning, and analytical skills. Rather than relying on rote memorization, this method prioritizes the practical application of mathematical concepts. In PBL math classes, students encounter open-ended questions that encourage them to delve deeper into various mathematical principles. They collaborate in small groups to explore the problem, identify relevant information, devise solution strategies, and then present their findings. Through this process, students are actively encouraged to deepen their comprehension of mathematical concepts and cultivate problem-solving abilities applicable to their daily lives.

While PBL is widely utilized, exploring its challenges in mathematics education during the teaching and learning process is essential. Ineffectively applying PBL may result from overlooking its proper utilization. Therefore, gaining insights into diverse perspectives on PBL in mathematics education can enhance its effectiveness and assist decision-makers in identifying optimal adoption conditions. Several empirical research studies have examined the use of PBL in mathematics instruction across various educational levels. These studies analyze strategies, challenges, and outcomes related to the implementation of PBL, offering valuable information to educators and decision-makers to enhance its application for improved mathematics education.

Despite the available research, there has been a lack of systematic reviews examining the challenges in the implementation of PBL in mathematics education. Thus, this review aims to consolidate the findings studies regarding the challenges in the implementation of PBL, specifically in the context of mathematics education. First, researchers defined PBL as an instructional strategy that focuses on students actively participating in real-world problem-solving to advance their grasp of mathematics. PBL encourages critical thinking, problem-solving abilities, and collaborative learning by presenting students with real-world mathematics issues. To identify relevant past research for their review, the researchers have identified one key research question: (1) What are the challenges faced by mathematics

teachers in the implementation of problem-based learning in mathematics education? Once the studies have been reviewed, the researchers will synthesize their findings to address the research question?

Problem-Based-Learning in Education

Problem-Based Learning (PBL) has emerged as a dynamic teaching method in the Education 4.0 era. Its implementation in mathematics education has gained recognition for enhancing students' critical thinking and analytical skills (Savery & Duffy, 1995). By involving students in authentic problem-solving scenarios, PBL deepens their understanding of mathematical concepts and their real-world applications (Ramadhani et al., 2019). The early adoption of PBL by McMaster University's faculty of medicine highlights its effectiveness in cultivating problem-solving abilities, paving the way for its integration across various disciplines, including mathematics.

According to Agustina (2018), PBL is a learning approach emphasizing critical and creative thinking and real problem-solving within complex situations, where students actively devise solutions, conduct research, and collaborate with peers. PBL is a group-based teaching and learning method (Hakim & Iksan, 2018) characterized by student-centeredness, real-world problems, student autonomy, and collaboration (Tinjol & Andin, 2020). This model promotes active engagement and a deeper understanding of the subject matter by connecting theory to practical applications in a collaborative environment.

Essentially, PBL enables students to actively engage in solving real mathematics problems (Siong & Osman, 2018), improving their problem-solving skills (Kadir & Ling, 2021) and understanding the relevance of math in real life (Yahya et al., 2020). Additionally, implementing PBL in mathematics education fosters critical thinking skills as students approach complex math problems (Aini et al., 2019) and enhances communication and teamwork abilities, preparing them for interdisciplinary problem-solving challenges.

Research indicates positive outcomes in the implementation of PBL in mathematics education for both students and teachers. Teachers report increased student engagement and motivation (Pohan et al., 2020), appreciating how PBL allows students to actively participate in problem-solving and apply math concepts in practical ways (Widyatiningtyas et al., 2015). Moreover, teachers observe improvements in students' creative thinking, problem-solving, and collaborative learning (Simarmata, 2022). These positive impacts highlight PBL's effectiveness in creating a dynamic and engaging learning environment.

In conclusion, PBL is an instructional approach that encourages active learning, critical thinking, and collaboration among students. It enables them to develop essential skills through real-world problem-solving, deepening their comprehension of the material. By embracing PBL, educators cultivate a setting that prepares students for real-world challenges and equips them with the knowledge and skills for future success.

Method

In this research, a systematic review was undertaken to identify previous studies pertaining to Problem-Based Learning (PBL) in mathematics education. The process involved a thorough search of relevant databases, including Google Scholar and ERIC, spanning from March 2023 to June 2023. The analysis aimed to establish a structured and replicable review following the guidelines proposed by Khan (2003), which have proven valuable for researchers in comprehensively examining, synthesizing, and critically evaluating intricate

concepts. Figure 1 provides an illustration of the different stages involved in conducting this systematic literature review.

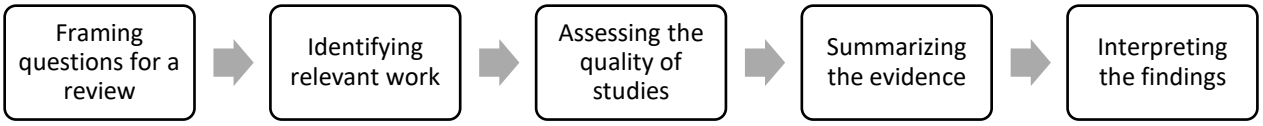

Figure 1: Phase in Systematic review

Phase 1 : Framing Questions for A Review

The review questions in this study were formulated by investigating relevant topics and concerns explored in previous research. The researcher began by searching for earlier systematic reviews that specifically addressed the challenges in the implementation of Problem-Based Learning in mathematics education. However, no studies directly addressed this specific inquiry. Consequently, to address this gap, the current study was undertaken to fill the gap by answering the following research question :

a) What are the challenges faced by mathematics teachers in the implementation of Problem-Based Learning in mathematics education?

Phase 2 : Identifying Relevant Work

The primary tasks undertaken in this phase involved gathering relevant studies through an initial search and evaluating their appropriateness based on inclusion and exclusion criteria. To ensure comprehensive coverage, "grey literature" sources susceptible to publication bias, such as dissertations, conference proceedings, and book chapters, were excluded following the guidelines by (Schopfel & Prost, 2021). Peer-reviewed materials and full-text publications were the sole focus of this investigation. The researcher conducted a month-long preliminary search on ERIC and Google Scholar, using various keywords like challenges faced by teachers in implementing problem-based learning," "exploring the difficulties encountered by teachers during the implementation of problem-based learning in math education," and "the obstacles teachers face in adopting problem-based learning in the math classroom". During this initial search, the study concentrated on two key aspects: the title and the abstract.

Phase 3 : Assessing The Quality of Studies

To maintain the quality of the review, a study selection method was employed to identify relevant papers for inclusion. Potential primary studies were assessed based on specific inclusion and exclusion criteria, and only those that met the criteria were considered for analysis. Therefore, the selected studies had to meet the following prerequisites to be included in this review.

Inclusion criteria

1. Studies that used Problem-Based Learning in formal education.
2. Studies that used research methodology.
3. Studies that evaluated Problem-Based Learning in mathematics education.
4. Studies that used published and unpublished studies from 2018 to 2022.

5. Studies that used Problem-Based Learning as a pedagogical approach to teaching and learning.

Exclusion criteria

1. Problem-Based Learning was not used in mathematics education.
2. The articles were not published between 2018 and 2022.
3. The studies did not evaluate Problem-Based Learning.
4. Problem-Based Learning was not taken into consideration as a teaching and learning strategy.
5. Sources other than journal articles were excluded.

Phase 4 : Summarizing The Evidence

This review utilized the literature databases ERIC and Google Scholar to identify relevant papers. Several search phrases were employed, including "challenges faced by teachers in implementing problem-based learning," "exploring the difficulties encountered by teachers during the implementation of problem-based learning in math education," and "the obstacles teachers face in adopting problem-based learning in the math classroom." Through these databases, a total of 295 studies published between 2018 and 2022 were retrieved, with 170 from Google Scholar and 125 from ERIC. After excluding non-English texts and non-journal sources, 148 results remained. Subsequently, 48 results were removed due to incomplete access to full-text articles, and 43 duplicate results were also eliminated. Finally, the researchers identified 15 publications, and the entire content of these articles was thoroughly assessed. The search process is visually depicted in the PRISMA flow chart shown in Figure 2.

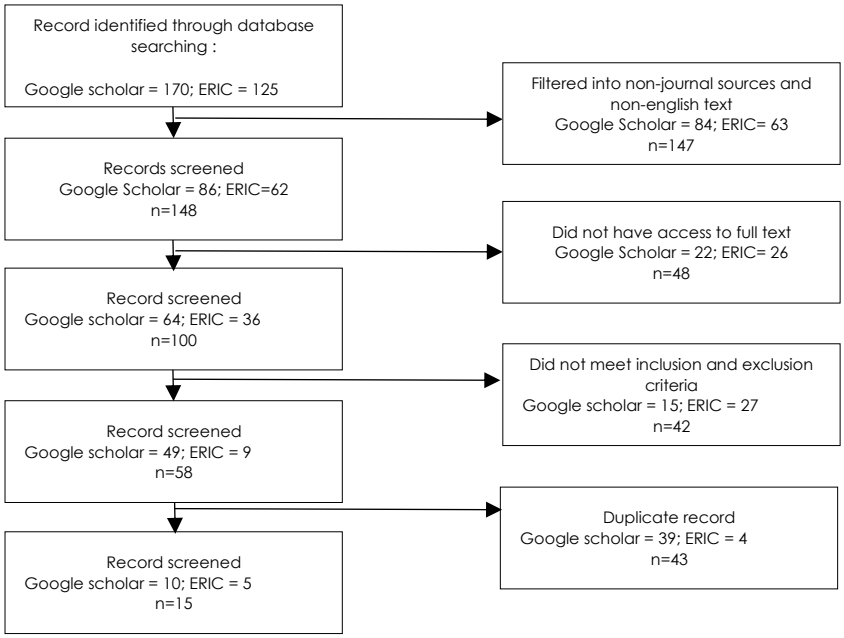

Figure 2: PRISMA flow chart

Phase 5: Interpreting The Findings

The researchers employed the content analysis method to analyze the results. They categorized previous studies based on their quantitative, qualitative, and mixed methodologies to identify trends. A systematic evaluation of educational studies published

between 2018 and 2022 was conducted to examine challenges in the implementation of Problem-Based Learning in mathematics education. Out of the 295 studies initially found, only 15 empirical studies met the inclusion criteria and were used to address the study objectives. The analysis technique applied to the previous publications from 2018 to 2022 is presented in Table 3. According to the table, the quantitative approach was more frequently utilized in the earlier research, followed by the qualitative and mixed methods.

Table 1
Numbers of study based on methods

Methods	Google Scholar	ERIC
Quantitative	7	2
Qualitative	1	
Mixed method	4	1

Results

The majority of research studies documented numerous challenges encountered when applying problem-based learning in mathematics education. Table 2 offers a comprehensive examination of these challenges, drawing insights from previous investigations.

Table 3
Challenges in the implementation of Problem-Based Learning in mathematics education

No	Authors	Discussions
1.	Linda et al (2020)	Teachers faced challenges to ensure that PBL activities align with the required mathematics curriculum and learning objectives.
2.	Rahmi et al (2020)	Schools faced challenges to provide professional development and support for mathematics teachers to effectively implement PBL.
3.	Tekad et al (2020)	Teachers faced challenges to allocate sufficient time for in-depth problem-solving while covering essential mathematics content.
4.	Asep (2019)	Teachers faced challenges to provide relevant mathematics resourses, technology and materials to support PBL.
5.	Erna et al (2020)	Teachers faced challenges to develop appropriate and reliable assessment measures to evaluate students' mathematics problem-solving skills and understanding.
6.	Amaludin et al (2021)	Students shows initial resistance to the shift from traditional mathematics instruction to PBL.
7.	Lovika and Henry (2020)	Teachers faced difficulties to manage group work dynamics and fostering productive collaboration among students during mathematics PBL activities.
8.	Indah and Iman (2020)	Teachers faced challenges to address the diverse needs and learning styles of students in mathematics PBL settings.

9.	Aenullael and Eddy (2019)	Teachers faced difficulties to integrate mathematics concepts with other subject areas in PBL scenarios.
10.	Suriana et al (2020)	Teachers faced challenges to measure the effectiveness of PBL in enhancing students' mathematics comprehension and problem-solving abilities.
11.	Nurhalimah et al (2017)	Teachers faced challenges to incorporate appropriate technology tools to enhance mathematics learning experiences during PBL.
12.	Rusdiyanto and Muhlisatul (2019)	Schools faced challenges to facilitate collaboration among mathematics teachers to share best practices and experiences with PBL.
13.	Lisya et al (2018)	Teachers faced challenges to change from a teacher-centered to a student-centered approach.
14.	Derry et al (2018)	Teachers faced challenges to support students in overcoming mathematics anxiety and building confidence in problem-solving.
15.	Henry and Immatul (2019)	Teachers faced difficulties to maintain students' motivation and engagement throughout mathematics PBL activities.

Discussion

The implementation of problem-based learning (PBL) in mathematics education brings forth a multitude of challenges for teachers and schools. Teachers encounter hurdles in aligning PBL activities with the required mathematics curriculum and learning objectives, striving to strike a balance between in-depth problem-solving and covering essential content (Fidan & Tuncel, 2019). The provision of relevant mathematics resources, technology, and materials to support PBL poses another challenge. Additionally, assessing students' mathematics problem-solving skills and understanding in a reliable and appropriate manner requires careful consideration (Siagan et al., 2019).

Furthermore, the shift from traditional mathematics instruction to PBL may initially meet resistance from students. Managing group work dynamics and fostering productive collaboration among students during mathematics PBL activities presents its difficulties (Simarmata, 2022). Addressing the diverse needs and learning styles of students within a mathematics PBL setting demands adaptable teaching strategies. Integrating mathematics concepts with other subject areas in PBL scenarios is yet another challenge, calling for innovative approaches to ensure interdisciplinary connections (Jabarullah & Iqbal, 2019). Measuring the effectiveness of PBL in enhancing students' mathematics comprehension and problem-solving abilities requires thoughtful evaluation methods.

Incorporating technology tools effectively into mathematics learning experiences during PBL necessitates continuous exploration of suitable resources (Saputra et al., 2019). Facilitating collaboration among mathematics teachers to share best practices and experiences with PBL proves to be an ongoing challenge for schools. Moreover, teachers must transition from a teacher-centered to a student-centered approach, which may require further professional development and support (Zamir et al., 2022). Supporting students in

overcoming mathematics anxiety and fostering their confidence in problem-solving is an essential aspect that demands teacher attentiveness.

Finally, sustaining students' motivation and engagement throughout mathematics PBL activities is a dynamic challenge, necessitating ongoing efforts to foster an engaging and stimulating learning environment (Bosica et al., 2021). Addressing these issues requires collaborative efforts from educators, schools, and institutions to effectively integrate problem-based learning into mathematics education and maximize its benefits for students' learning experiences.

Conclusion

In conclusion, problem-based learning (PBL) is a student-centered instructional approach that fosters active learning, critical thinking, and collaboration among students. Through engaging in authentic, real-world problems, students develop problem-solving skills, analytical thinking, and a deeper understanding of the subject matter. PBL empowers students to take ownership of their learning process, encourages self-directed inquiry, and facilitates meaningful connections between theoretical knowledge and practical applications. Despite its challenges in implementation, PBL has been recognized as an effective method to prepare students for the complexities of the 21st-century world, equipping them with essential skills for success in their academic pursuits and future careers. By promoting a dynamic and interactive learning environment, PBL enables students to become lifelong learners and active contributors to society. As educators and institutions continue to embrace PBL and address its challenges, it holds the promise of transforming education and empowering students to become critical thinkers, problem solvers, and engaged global citizens.

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