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Unleashing Problem-Based Learning Method among Mathematics Teachers

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Abstract

In the era of Industry 4.0, Problem-Based Learning (PBL) has emerged as a groundbreaking and transformative teaching approach. As technological advancements continue to reshape education, PBL goes beyond traditional methods by adopting a student-centric methodology. In this context, our research aimed to explore how mathematics teachers perceive the integration of PBL into their teaching practices. We conducted a survey involving 350 mathematics teachers and used a questionnaire for data collection. The analysis of the data, presented using descriptive statistics, revealed a notably positive perception among mathematics teachers toward the implementation of PBL (Mean=4.22, Standard Deviation=0.27). The findings also underscored teachers' specific focus on key PBL activities, including synthesis and application, problem identification, reflection and assessment, self-directed learning, idea generation, and group collaboration. In conclusion, this study underscores the significant impact of PBL in the Industry 4.0 era, as evidenced by the favorable perceptions of mathematics teachers and their emphasis on crucial activities within the PBL framework.

Keywords: Problem-Based Learning, Mathematics Teachers, Survey, Positive Perception

Introduction

An effective teaching and learning process is instrumental in creating an engaging classroom environment. Past research indicates a strong correlation between effective teaching methods and students' academic achievement (Kadir & Ling, 2021; Ramadhani et al., 2019). This correlation stems from the ability of effective teaching methods to enhance the overall quality of learning. The diverse range of teaching methods and strategies contributes to students' problem-solving skills, theoretical understanding, and application of knowledge and skills (Agustina, 2018). When teachers deliver content effectively, it not only elevates the quality of learning but also fosters active participation among students. Actively involved students have the opportunity to explore, acquire knowledge and skills, instill values, and develop into competent individuals.

Moreover, the effectiveness of teaching methods and strategies creates a transformative learning environment where students actively focus on acquiring knowledge,

values, and skills. This approach enables students to identify problems, analyze facts, ask questions, view learning issues from diverse perspectives, engage in independent learning, explore various sources, comprehend information, and make informed decisions and solutions (Tinjol & Andin, 2020). The key to cultivating successful students lies in the effectiveness of teachers and their ability to teach proficiently (Siong & Osman, 2018). Strengthening teachers' teaching methods is crucial, as it directly influences the quality of learning in the classroom and positively impacts educational success.

Nevertheless, enhancing teachers' teaching methods requires exploring new paradigms in education. Watson (2014) suggests that a constructivist approach can enhance the quality of learning among students. Effective learning occurs when students and teachers engage in meaningful communication, employing a constructivist strategy, materials, and effective training (Yahya et al., 2020). Constructivist teachers, in the classroom, utilize various teaching practices such as experiments and real-world problem-solving to encourage students to explore, create knowledge, reflect on their understanding, and discuss information. Problem-Based Learning (PBL) is a constructivist method that can significantly enhance the quality of learning in the classroom.

Problem-Based Learning (PBL) is an active learning method grounded in social constructivism (Pohan et al., 2020). Numerous studies have examined its role in improving learning quality, emphasizing skills in generating diverse ideas and practical solutions (Widyatiningtyas et al., 2015). PBL is a novel educational philosophy applicable at both primary and secondary levels (Hmelo-Silver, 2004). It promotes active student participation, enabling them to acquire knowledge and exchange ideas with peers, diverging from traditional one-way knowledge transfer between teachers and students.

In the context of mathematics education, PBL is viewed as a learning approach that fosters inquiry by placing emphasis on problem-solving and collaboration among students (Simarmata, 2022). It involves a planned process, wherein educational content is structured around real-life and problem-oriented scenarios, stimulating students' interest in problem-solving (Graaff & Kolmos, 2003). Three key features characterize PBL: real-life problems, a group-based process, and student control. This method is perceived as a simultaneous integration of problem-solving strategies and a knowledge base in the teaching and learning system (Barrows et al., 1980). Kilroy (2004) contends that PBL centers on issues or problems as the starting point of the learning process.

Therefore, it is essential to understand the implementation of PBL among mathematics teachers is crucial for optimizing its effectiveness in the context of mathematics education. While there have been numerous reviews and studies exploring PBL in various educational settings, there is a noticeable scarcity of research specifically focused on its application in the field of mathematics education. This research could contribute not only to the refinement of PBL methodologies tailored to the unique characteristics of mathematics but also to the broader discourse on innovative teaching strategies in STEM (Science, Technology, Engineering, and Mathematics) education. It may open avenues for the development of best practices, resources, and professional development initiatives aimed at enhancing the integration of PBL in mathematics classrooms, ultimately benefiting both teachers and students in their pursuit of mathematical proficiency and problem-solving skills.

The Implementation of Problem-Based Learning

Problem-Based Learning (PBL) originated at McMaster University, Canada, in 1969 and has since gained widespread application across various disciplines such as management, engineering, agriculture, and law. Howard Barrows, a pioneering academic, played a significant role in its early development. According to Barrows et al. (1980), PBL is centered around learning activities that are applicable to solving real-life problems, offering students a focus on issues that are pertinent to understanding future challenges (Linda et al., 2022). This method is characterized as a student-centered instructional model, drawing from learning theories such as Kolb's experiential learning, Piaget's cognitive development, Vygotsky, Lave, and Wenger's constructivism and social learning, as well as Schon's theory emphasizing reflection (Sadlo, 2007). The synthesis of these theories forms the Problem-Based Learning Model.

PBL stands out as an educational approach that not only imparts knowledge but also empowers students to take charge of their learning journey. Rahmi et al. (2020) emphasizes that PBL is meticulously crafted to enable students to tackle assigned challenges or problems by harnessing a diverse array of learning resources. Within the educational context, teachers step into the role of facilitators, guiding students by presenting them with pertinent problems that demand active problem-solving engagement. Tekad et al. (2020) sheds light on how PBL goes beyond traditional teaching methods by fostering a profound commitment to learning among students. This commitment is cultivated through the collaborative nature of PBL, where teamwork becomes a cornerstone. Students are encouraged to work together, engaging in effective communication and pooling their collective research and information assimilation skills (Asep, 2019). In the PBL setting, students aren't just passive recipients of information; they are active participants in the learning process, working together to unravel complex problems and acquire a deeper understanding of the subject matter.

In addition, PBL plays a transformative role in shaping students as independent and responsible learners. Grant (2011) underscores how PBL instilling a profound sense of accountability within each student for their own learning. This pedagogical approach motivates students to take ownership of their educational journey, fostering a commitment to actively engage with the material and contribute meaningfully to the problem-solving process. Piaget (1983) contributes key insights into the fundamental elements of PBL implementation. Students, under the PBL framework, are not mere recipients of information. They actively engage in planning their own learning. The centrality of the problem becomes a focal point, steering students towards a deeper understanding of the subject matter. Teachers play a facilitative role, guiding and supporting students as they navigate the intricacies of the problem-solving process (Erna et al., 2020). Reflection is an integral part of this journey, prompting students to evaluate their own learning experiences and refine their approaches for future problem-solving endeavors. Ultimately, the acquisition of knowledge is not a passive process but a dynamic and iterative one, evolving through the active engagement of students in the PBL environment.

In conclusion, PBL emerges as an innovative and student-centric teaching approach, placing the learner at the epicenter of their educational experience. This method thrives on presenting students with problems that are not just theoretical but authentic, challenging, complex, and often unexpected. The deliberate choice of such problems serves as a catalyst, propelling students into a dynamic learning environment where they grapple with real-world challenges, fostering a deeper understanding of the subject matter. The transformative

power of PBL extends beyond the individual learner to impact the overall quality of education. This approach aligns with the demands of contemporary society and the skills needed for success in a globalized, knowledge-driven economy. As such, the adoption of PBL has the potential to bring about a paradigm shift in education, elevating the standards to those seen in developed countries. In essence, PBL doesn't just teach students; it equips them with the tools and mindset needed to thrive in the complexities of the 21st century.

Research Methodology

This study was conducted using the survey research method. Survey research is a suitable method for identifying variables that are related to a particular phenomenon (Creswell 2014). It is also the most appropriate way to measure opinions, perceptions, attitudes, beliefs, orientations, and practices involving a large population size (Creswell, 2014). The study involved 350 samples consisting of mathematics teachers who are currently in service. The selection of this sample size aligns with Chua's (2006) view that the minimum sample size for survey research is 100 individuals. The researcher selected the sample using the Simple Random Sampling Method, following Morgan's (2017) perspective, which includes (1) identifying the study sample by the researcher, (2) randomly drawing sample members from the population, and (3) selecting sample members based on the likelihood and probability of individuals becoming samples.

In this study, the researcher utilized a questionnaire as the research instrument. This instrument is highly suitable for use because the study involves a large and comprehensive sample size (Babbie, 2010; Hussin et al., 2014). The questionnaire was developed from the Problem-Based Learning (PBL) Model proposed by Wee (2004), which consists of seven processes: group division, identifying problems, generating ideas, learning issues, self-directed learning, synthesis and application, and reflection and assessment. Four experts were appointed to validate the questionnaire (Polit, 2014). At the same time, a pilot study was conducted to test the reliability of the instrument. As a result, the obtained Cronbach's alpha value was 0.978, indicating high consistency of the instrument. Data and information obtained from the questionnaires, which were answered by mathematics teachers, were processed using IBM SPSS Version 20 programming. The data analysis involved the use of descriptive statistics such as frequency, percentage, and mean scores. The researcher utilized a mean score scale divided into three categories: high level ($3.68 \leq M \leq 5.00$), moderate ($2.34 \leq M \leq 3.67$), and low ($1 \leq M \leq 2.33$), as suggested by (Jamil, 2002).

Results

Descriptive analysis in Table 1 illustrates the distribution of mean scores for mathematics teachers' perceptions regarding the implementation of Problem-Based Learning (PBL) in mathematics. The analysis results indicate that the overall perception level of teachers towards the implementation of PBL is high (M=4.22, SD=.27) based on the five-point scale used. Teachers' perceptions are more focused on synthesis and application (M=4.26, SD=.40), followed by problem identification (M=4.25, SD=.36), reflection and assessment (M=4.23, SD=.28), self-directed learning (M=4.21, SD=.34), generating ideas and learning issues (M=4.20, SD=.31), and group division (M=4.18, SD=.29).

Table 1
The Implementation of PBL Among Mathematics Teachers

PBL Processes	M	SD
Group division	4.18	.29
Problem identification	4.25	.36
Generating idea and learning issues	4.20	.31
Self-directed learning	4.21	.34
Synthesis and application	4.26	.40
Reflection and assessment	4.23	.28
Overall PBL implementation	4.22	.27

Discussion

The study revealed that mathematics teachers have a high level of perception regarding the implementation of Problem-Based Learning (PBL) method. In detail, the seven activities involved in PBL, namely synthesis and application, problem identification, reflection and assessment, self-directed learning, generating ideas and learning issues, and group division, are at a high level. This indicates that more than 90% of teachers have a positive perception of the implementation of this method. These findings are supported by the study of Lovika and Henry (2020) indicating that the level of PBL implementation by mathematics teachers is highly satisfactory in schools. Consequently, teachers can guide students using various strategies to solve problems, enhancing students' understanding of mathematical concepts. This perspective aligns with the findings of the study by Indah and Iman (2020) affirming that teachers are capable of guiding students to share ideas with other group members, thereby improving their communication skills.

However, these results are not supported by the findings of the study by Aenullael and Eddy (2019), which indicate that mathematics teachers are unable to effectively use the PBL method in schools. If teachers cannot use the PBL method effectively, they may not enhance students' creative and critical thinking. This leads to students facing challenges in solving complex mathematical problems. This perspective is in line with the findings of the study by Suriana et al (2020), indicating that teachers cannot implement the PBL method well in schools. Therefore, they are unable to guide students to make informed judgments with the existing knowledge.

The study also shows that synthesis and application are the most crucial teaching activities in the PBL method, followed by problem identification, reflection and assessment, self-directed learning, generating ideas and learning issues, and group division. All these activities are recommended PBL activities by (Wee, 2004). In this study, synthesis and application involve the teacher guiding students through activities such as discussion, planning solutions, implementation, and justifying solutions. These findings do not align with the study by Zuwaidah (2016), where problem identification and generating ideas and learning issues were considered the most important activities in the PBL method. All three activities influence the effectiveness of the PBL method and impact the improvement of thinking skills among high school students. However, these differing findings are influenced by variable exploration factors. This study only focuses on three activities without involving the entire PBL activities as suggested by (Wee, 2004). Additionally, this study only involves the context of secondary education.

Nevertheless, Maimunah's (2017) study, which explores all activities in PBL, found that self-directed learning is the most crucial activity in the PBL method. This is because students who are active in learning are considered to have mastered other processes, such as problem identification, linking problems with existing knowledge, generating ideas and learning issues, synthesis, and application (Nurhalimah et al., 2017). At the same time, students who exhibit self-directed learning practices are seen to successfully build motivation to understand a learning concept well. Moreover, Rusdiyanto and Muhlisatul (2019) study identified two activities that influence the effectiveness of the PBL method, namely problem identification and linking problems with existing knowledge. The PBL process will not be effective without involving these two activities. This is because the PBL method focuses on authentic problem-solving questions and students' ability to connect existing knowledge with the given problems (Lisya et al., 2018). Thus, students can use this knowledge to plan solutions for the problems presented to them.

Conclusion

In conclusion, the study highlights a high level of positive perception among mathematics teachers regarding the implementation of Problem-Based Learning (PBL). The findings reveal that teachers are particularly focused on activities such as synthesis and application, problem identification, reflection and assessment, self-directed learning, generating ideas and learning issues, and group division within the PBL framework. While these results align with some prior research, it's important to acknowledge contrasting views suggesting challenges in effective PBL implementation. Further exploration of specific PBL activities and their impact on students' critical thinking and problem-solving skills may offer valuable insights for refining educational practices. Overall, the study underscores the importance of understanding teachers' perspectives and challenges in adopting innovative teaching methods for the continuous improvement of mathematics education.

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