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IMPROVING STUDENTS' MATHEMATICAL SKILLS THROUGH PROBLEM-BASED LEARNING: A LITERATURE REVIEW PERSPECTIVE

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Abstract

This study aims to explore the effectiveness of Problem-Based Learning (PBL) in improving students' mathematics skills through a literature review. PBL is a teaching method that places students at the centre of learning with an emphasis on solving contextual problems relevant to everyday life. The literature review showed that PBL can improve students' understanding of mathematical concepts and develop their critical and creative thinking skills. In addition, this method also strengthens students' collaborative and communication skills through structural group work. However, the successful implementation of PBL is influenced by several factors, such as the availability of resources, teachers' skills in implementing PBL, and the support of the school environment. To optimise learning outcomes, training for teachers and full support from all parties involved in the education process are required. The results of this study are expected to provide insights for educators about the potential of PBL as an effective method in improving students' mathematics skills.
Keywords: Maths Skills, Students, Problem Based Learning.

Introduction

Mathematics is one of the fundamental subjects in the education curriculum at various school levels. This subject has an important role in developing students' logical thinking, analytical, and problem-solving skills. Therefore, mathematics skills are very important for students because mathematics is a universal form of language used to understand and interpret various phenomena in the world (Sitopu et al., 2024); (Guna et al., 2024); (Fawait et al., 2024). These skills are required in various aspects of daily life, ranging from personal financial management to decision-making that deals with logic and statistics. Good mathematical skills not only help students in solving practical problems, but also develop critical and analytical thinking abilities that are indispensable in almost all future fields of work, including science, technology, engineering and mathematics (STEM) (Chu et al., 2021).

In addition to their practical benefits, maths skills also play an important role in students' cognitive development. The process of learning mathematics teaches

students how to identify patterns, understand relationships between abstract concepts, and formulate and test hypotheses. These abilities form a solid foundation for complex problem solving and logical thinking, which will be of great benefit in their future academic and professional lives (Juandi, 2021). With good mathematical skills, students will be better prepared to face the challenges of higher education and ready to compete in an increasingly complex and technology-based global job market. However, in reality, many students still have difficulties in understanding basic mathematical concepts and applying them in solving problems. This is reflected in the low student mathematics learning outcomes often reported by several national studies and surveys (Wijaya, 2021).

Traditional teacher-centred ways of teaching mathematics are often ineffective in optimising students' abilities. Learning that is dominated by lectures and working on routine problems tends to make students passive and less actively involved in the learning process. As a result, students often feel bored, lack motivation, and have difficulty applying mathematical concepts in the context of everyday life (Saad & Zainudin, 2022).

Problem-Based Learning (PBL) comes as one of the innovative alternatives to overcome these problems. This method emphasises on providing real problems that students must solve through a critical and collaborative thinking process. PBL is designed to combine theoretical knowledge with practical skills so that students not only understand concepts, but are also able to apply them in concrete situations (Hussein, 2021).

Various studies have shown that PBL has a number of benefits in improving students' mathematical skills. It increases students' motivation to learn, critical thinking and problem-solving skills more effectively than traditional methods. In addition, PBL also encourages students' active involvement in the learning process, both individually and in groups, so that they are better prepared to face challenges in the real world (Arici & Yilmaz, 2023).

In the context of the literature review, it is important to explore more deeply how PBL can be applied in mathematics learning and the extent of its effectiveness based on various previous studies (Hossein-Mohand et al., 2021); (Altan & Tan, 2021). Thus, this study will review the relevant literature to provide a comprehensive overview of the potentials and challenges in applying PBL as a strategy to improve students' mathematical skills.

This study is expected to provide insights for educators and educational policy makers on the advantages of using PBL and the direction of its further development in an effort to improve the quality of mathematics education.

Research Methods

The study in this research uses the literature method. The literature research method is an approach that is carried out by collecting, reviewing, and analysing various written sources that are relevant to the research topic being studied. This process involves searching for and evaluating academic articles, books, reports, and other publications that can provide a theoretical basis, strengthen hypotheses, or offer new perspectives on an issue. Literature research not only aims to identify what is already known and gaps in existing knowledge, but also to establish a deep foundation for future research. This method is crucial in ensuring that the study conducted is based on a comprehensive and actuarial understanding of the topic at hand. (Sugiyono, 2010); (Nasution, 1996).

Results and Discussion

The importance of maths skills in everyday life and the world of work

Mathematical skills are the ability to understand, analyse and solve problems involving mathematical concepts. This includes the ability to formulate and interpret numerical relationships and geometric shapes, as well as using logic and reasoning to solve complex problems (Saregar et al., 2021). These skills are not only limited to expertise in counting or algebra, but also include the ability to think critically, utilise statistical data, and apply mathematical principles in a variety of real-life situations. The importance of these skills lies in their ability to empower individuals to make better and more informed decisions (Verawati et al., 2022).

The components of mathematical skills include various elements, ranging from a basic understanding of arithmetic to more abstract concepts such as calculus and number theory. One of the main components is numerical skills, which includes the ability to perform basic operations such as addition, subtraction, multiplication and division. Another important component is an understanding of geometry, which involves the ability to recognise and analyse shapes and spaces (Hasanah & Fitria, 2021). In addition, proficiency in algebra, including manipulation of symbols and solving equations, is an important part of mathematical skills. Statistics and probability are also important components, as they enable individuals to interpret data and make predictions supported by statistical evidence. Overall, mathematical skills are a combination of various understandings and abilities that enable a person to engage effectively with mathematical concepts in various contexts (Hadiyanti et al., 2021).

Maths skills play an essential role in everyday life. At home, they help in managing budgets, spending wisely and making sound financial decisions. Someone who is proficient in maths will find it easier to manage household expenses, calculate discounts when shopping, and understand and compare financial products such as loans or investments. Not only that, these skills are also very useful in understanding graphs and

data that we often encounter in various media, allowing us to get more accurate information and make decisions based on the data (Sugianto et al., 2022).

In the world of education, maths skills form the basis for many other disciplines. Science, technology, engineering and maths (STEM) all rely on a strong understanding of mathematical concepts. For example, students planning to pursue studies in engineering will need skills in algebra and calculus, while those interested in social sciences may need skills in statistics to analyse research data. Therefore, early mastery of mathematics will open up many academic and professional opportunities in the future (Mutohhari et al., 2021).

In the world of work, maths skills are key to a career in various fields. Professions such as engineers, statisticians, data analysts, economists, computer scientists and many more rely heavily on these skills. For example, a data analyst needs to understand statistical methods to interpret data and develop models that can help in strategic decision-making (Hussein, 2021). In addition, finance professionals, such as accountants and investment managers, need to be able to perform a variety of complex calculations and analyses to devise effective strategies and properly manage risks. Even in fields that are not directly related to mathematics, these skills remain important for improving problem-solving and critical thinking (Ariyani & Prasetyo, 2021).

Moreover, maths skills also enhance an individual's ability to use modern technology. With rapid developments in technology, many tools and software require a basic understanding of mathematics to use effectively. An entrepreneur, for example, may use a calculation programme for profit and loss analysis, while a graphic designer may require knowledge of geometry to create precise work. So, not only do they create a competitive advantage in the world of work, maths skills also help individuals to adapt to the changes and various challenges that exist in this digital era (Widyastuti & Airlanda, 2021).

Measuring mathematical skills can be done through various methods and tools, given the nature of these skills that involve understanding concepts as well as problem-solving abilities. In educational settings, standardised tests and examinations such as the Logical Thinking Skills Analysis or the Programme for International Student Assessment (PISA) are often used to objectively measure the extent to which students understand mathematical material. These tests usually cover various aspects such as basic arithmetic, algebra, geometry and data analysis, to provide a comprehensive picture of students' mathematical competence (Ghani et al., 2021).

Besides traditional written tests, there are also other more practical and applicable approaches to measuring mathematical skills. For example, group projects, presentations and case study completion can be used to assess the extent to which students are able to apply mathematical concepts in real-life situations. This approach is often more effective in uncovering critical thinking and complex problem-solving

skills, as it allows students to demonstrate their abilities in a more dynamic context and not just limited to written answers (Simanjuntak et al., 2021).

In the professional world, measurement of mathematical skills often uses specific aptitude or skill tests relevant to the field. For example, technology companies might use programming tests that include algorithms and data structures, which require a deep understanding of discrete mathematics (Hwang & Tu, 2021). While finance companies may focus more on statistical analysis abilities and economic modelling in their hiring process. In addition, general performance appraisals and achievement reviews can be used to measure the extent to which maths skills are applied in daily tasks (Liu & Pásztor, 2022).

Thus, mathematical skills are a key component that supports various aspects of daily life and professions. To effectively measure these skills, a variety of methods can be used in a variety of standardised test formats, practical evaluation through projects and case studies, and specialised professional tests in the world of work. Thus, a comprehensive and diverse measurement of mathematical skills can provide a clear picture of the understanding and application of these skills, which in turn will prepare individuals for future academic and professional challenges.

Problem Based Learning (PBL)

Problem-Based Learning (PBL) is a pedagogical approach that focuses on using real-world problems as a stimulus for learning. In PBL, learners are exposed to complex, open-ended problems that do not have a single right answer. Through this process, they are encouraged to identify what needs to be learnt to understand and solve the problem (Cai et al., 2022). This method emphasises the active role of learners in the learning process by emphasising the development of problem-solving skills, critical thinking, and independent research abilities (Adipat et al., 2021).

The basic principles of PBL include learning that is student-centred, collaborative, and occurs in a context relevant to real situations. In a PBL setting, the facilitator or teacher acts as a guide or discussion leader, assisting students in determining the direction of exploration and ensuring that the learning experience remains focused and productive (Owens & Hite, 2022). The main focus of PBL is process learning, where students undergo iterative cycles of investigation, reflection and application of their newly acquired knowledge. In this way, PBL aims to equip students with skills that can be transferred to new situations, making it a relevant approach for education in the 21st century (Wilson, 2021).

Problem-Based Learning, or PBL, was first implemented in 1969 at McMaster University School of Medicine in Canada in response to the need to change more traditional ways of teaching. Since then, PBL has undergone rapid development and is applied in various disciplines and levels of education, ranging from elementary school to higher education (Mann et al., 2021). Universities around the world, including in the

United States, Europe, and Asia, have adopted this approach as an important part of their curriculum. The popularity of PBL continues to increase along with the growing belief that this method not only improves understanding of concepts but also develops essential skills such as teamwork, communication, and critical thinking (Cardinot & Fairfield, 2022).

Along with technological advancements and innovations in education, PBL has also evolved to become more flexible and accessible through digital platforms and online learning. This provides more opportunities for learners to collaborate in more diverse groups and access a wider range of resources. Campuses and schools are now using technologies such as simulations, virtual labs and online collaborative tools to facilitate the PBL experience (Juandi, 2021). In addition, many studies have been conducted to measure the effectiveness of PBL and the results show that this method can produce more profound and satisfying learning achievements than traditional teaching methods. Through continuous adaptation and innovation, PBL continues to play an important role in supporting educational reforms orientated towards the development of 21st century skills (Cruz et al., 2023).

The implementation of Problem-Based Learning (PBL) in the classroom context begins with the selection and design of problems that are appropriate and relevant to the material to be learnt. Teachers need to identify real-world problems that are complex and challenging, yet still within the range of student understanding. This problem should not have a clear answer, thus encouraging students to think critically and creatively (Wijaya, 2021). Once the problem is determined, the teacher can divide students into heterogeneous small groups to ensure a variety of perspectives and complementary skills. Each group is then tasked with identifying what they know, what they need to learn, and how they will find the necessary information (Tay et al., 2021).

During the learning process, the teacher acts as a facilitator who guides and supports students, instead of being the main information provider. The teacher can help students formulate research questions, suggest resources, and give constructive feedback. On the other hand, students work collaboratively in their groups to collect data, discuss, and develop potential solutions to the problems they face. The emphasis in PBL is on the process of developing problem-solving skills and continuous reflection on what has been learnt and how it can be applied (Dita et al., 2021).

At the end of a PBL unit or project, groups of students will present their findings to the class or a wider audience. These presentations can take many forms, such as written reports, posters, videos, or even physical models, demonstrating their ability to communicate their ideas and solutions clearly and effectively. After the presentation, teachers and classmates provide feedback that helps students reflect on their learning process and understand areas that can be improved (Tarigan, 2022). In this way, PBL not only provides new knowledge, but also hones a series of important skills such as teamwork, presentation, and the ability to receive and utilise feedback. Effective

implementation of PBL in the classroom can create a dynamic, interactive and student-centred learning environment.

Effectiveness of PBL in Maths Education

Problem-based learning (PBL) has significant potential in improving the effectiveness of mathematics learning. One of the main reasons is because PBL encourages students to understand mathematical concepts in a real-world context. Rather than simply memorising formulas and procedures, students are exposed to problems that require in-depth understanding and application of the concepts they have learnt (Gafurova, 2022). For example, students can be asked to solve problems involving budget planning or analysing statistical data from real events. By doing so, students can see the relevance and importance of mathematics in everyday life, which in turn increases their motivation and engagement in the learning process (Tadjer et al., 2022).

In the context of PBL, collaboration between students is an integral part of the learning process. In small groups, students discuss, exchange ideas and seek solutions together to solve complex mathematical problems. This collaboration not only helps them in understanding different approaches but also develops important social and communication skills. Sharing knowledge and strategies also allows students to learn from each other, improving understanding through collective discussion and reflection. This creates a supportive learning environment where students feel more confident to take risks and ask questions (Wijaya, 2021).

PBL in mathematics also helps improve critical thinking and problem-solving skills. Students are not only required to find the correct answer, but also to explain their thought process and consider different ways to reach a solution. This fosters their analytical abilities, as well as the ability to identify and correct errors. When students are used to facing problems that don't have immediate or unique solutions, they learn to develop flexible and adaptive strategies. They are also encouraged to continuously reflect and evaluate their approach, which leads to deeper and more meaningful learning (Bosica et al., 2021).

In addition, PBL provides opportunities for teachers to integrate technology and digital resources in mathematics teaching. By using digital tools such as mathematical modelling software, interactive applications or online resources, students can undergo a richer and more interactive learning experience. These technologies can help students visualise mathematical problems, conduct virtual experiments and obtain instant feedback (Jaafar et al., 2022). This not only adds didactic value but also creates a more interesting and diverse learning experience. Thus, PBL not only prepares students for exams, but also for the real challenges they will face in the future.

Factors that influence the success or failure of PBL

Several important factors influence the success or failure of implementing Problem-Based Learning (PBL) in education. One of the main factors is the readiness of teachers in designing and implementing PBL. Teachers must have a deep understanding of the principles of PBL, as well as the ability to design problems that are authentic and relevant to students' real lives (Vankúš, 2021). They need to be skilled in facilitating discussions, encouraging collaboration and giving constructive feedback. Adequate training and professional development are essential for teachers to adapt their teaching approaches and effectively manage PBL classroom dynamics (Ferrero et al., 2021).

The second factor is the diverse characteristics of students in the classroom. PBL demands a high level of independence, motivation and critical thinking skills from students. If students are not used to a more independent and less structured approach to learning, they may face difficulties in navigating the PBL process. For this reason, it is important for teachers to recognise individual differences in terms of students' learning styles, initial skills and interest levels. By providing appropriate support, such as additional guidance or scaffolding, teachers can help all students actively participate and succeed in PBL activities (Zulyusri et al., 2023).

Resources and institutional support also play an important role in the success of PBL. Schools need to provide enough resources, such as adequate learning materials, access to technology, and learning spaces that support group collaboration (Handayani & Koeswanti, 2021). In addition, support from school administrators, including understanding and commitment to the PBL approach, can reduce operational barriers and provide morale boost to teachers. Parental participation is also important to ensure that students get the support they need outside the school environment, especially in projects that require research or work outside school hours (Rahman et al., 2023).

Finally, evaluation and assessment in PBL need to be carefully designed to match the learning objectives. Traditional assessments that are only test-based may not reflect the skills and understanding that students acquire through PBL. In contrast, authentic assessments, such as rubrics for project assessment, presentation and self-reflection, are more suitable for evaluating PBL outcomes. Teachers' ability to holistically evaluate the process as well as the product of student learning will provide a more precise picture of the effectiveness of the PBL approach and areas for improvement. A reflective and supportive assessment environment allows students to continue learning and developing through the PBL experience.

Comparison between PBL and traditional learning methods

Problem-based learning (PBL) and traditional learning methods have different characteristics and approaches in educating students. PBL focuses on authentic problem solving as the centre of the learning process, where students take an active role in discovering and investigating problems relevant to real life (Juandi, 2021). In PBL, students work collaboratively, using critical and analytical thinking skills to find solutions

(Adi Asmara, Anisya Septiana, 2024). In contrast, traditional learning methods often centre on the teacher as the main source of knowledge, where learning is more direct and structured, with an emphasis on memorisation and teaching through lectures or texts (Minarti et al., 2022).

One of the main differences between PBL and traditional methods lies in the roles of teachers and students. In PBL, the teacher acts as a facilitator or guide who encourages students to explore and discover knowledge on their own. This approach emphasises learning that is driven by students' needs and interests, motivating them to engage deeply in the learning process. In contrast, in traditional learning methods, the teacher usually acts as a conveyor of information, while students act as passive recipients of knowledge. This approach emphasises the one-way transfer of information from teacher to student (Mamolo, 2022).

Assessment methods also differ between PBL and traditional learning. In PBL, assessment is more formative and holistic, looking at both the process and the final product of students' work. Evaluation not only assesses content knowledge, but also students' ability in critical thinking, teamwork, and presentation skills. Meanwhile, traditional learning methods often use summative assessments, such as tests and exams, which focus more on measuring mastery of the content taught and the ability to recall information (Gusteti & Neviyarni, 2022).

In terms of learning outcomes, PBL is more likely to produce deeper understanding and applicable skills for students, as they learn through real experiences and application of concepts in practical contexts. This approach prepares students to face real-world challenges more effectively. On the other hand, traditional learning methods are usually more effective in teaching basic facts and information that can be memorised (Widiastuti & Kurniasih, 2021). While it may lack analytical and practical skills, it is still useful for providing the necessary knowledge base before students are able to engage in more in-depth learning such as PBL (Hasanah & Fitria, 2021).

Besides the fundamental differences in approach and assessment, PBL and traditional learning methods also have their own advantages and disadvantages. In PBL, students often feel more motivated and actively engaged as they are directly involved in the learning process that is relevant to their lives. However, PBL also demands more time and resources in planning and implementation, and requires teachers who are skilled in managing a more dynamic classroom. Traditional learning methods, on the other hand, may be less motivating for some students due to the passive approach, but their efficiency in conveying information can still be useful in certain contexts (Effendi et al., 2021).

PBL also allows the integration of cross-disciplinary learning, where students can connect concepts from different subjects to solve a specific problem. This contrasts with traditional methods which may be more fragmented, with each subject taught separately without many connections between disciplines. The ability to see

connections between different areas of knowledge can assist students in developing more holistic and integrative thinking skills. However, a key challenge in PBL implementation is ensuring each student still gains a solid understanding of the underlying concepts across multiple subjects (Sun et al., 2021).

Institutional context and school culture also influence the effectiveness of PBL and traditional learning methods. PBL may be better suited in school environments that support collaborative and innovative learning and have access to adequate resources (Smith et al., 2022). Schools that still adhere to standardised assessment methods and rigid curricula may find implementing PBL a major challenge. In contrast, traditional learning methods are easier to implement in diverse school contexts due to their simpler structure and direct goal orientation (Rohman, 2022).

Overall, both Problem-Based Learning (PBL) and traditional learning methods have their own roles and benefits in the educational process. PBL offers a more interactive, student-centred and real-life relevant approach, enabling the development of analytical, collaborative and problem-solving skills (Tay et al., 2021); (Lee, 2022). On the other hand, traditional learning methods provide a solid knowledge base in a more structured and efficient manner, ideal in teaching contexts that require mastery of factual information. The choice between these two methods should be tailored to the learning objectives, school context, as well as student characteristics, to achieve optimal educational outcomes.

Conclusion

Problem-based learning (PBL) has been proven to be effective in improving students' mathematics skills based on various literature reviews. This method emphasises concept discovery through solving real problems that are relevant to students' lives, thus making students more engaged and motivated in the learning process. This approach not only helps students in understanding mathematical concepts more deeply, but also improves their critical and creative thinking skills, which are essential in facing challenges in the real world.

In addition, PBL facilitates the development of collaborative and communication skills, as students are often invited to work in small groups. Through interaction and discussion in groups, students learn to listen to others' views, put forward their opinions, and ultimately reach the best solution through co-operation. This collaborative aspect also prepares students to participate in a work environment that requires good teamwork skills. The mathematical literacy developed through PBL also tends to be more easily applied and remembered by students as they are directly involved in a contextualised and practical learning process.

However, the successful implementation of PBL in improving students‘ mathematical skills also depends on various factors, including the availability of resources, teachers’ skills in managing PBL, and support from the school environment.

To optimise the benefits of PBL, it requires full support from all parties involved in education, as well as adequate training for teachers to master PBL techniques effectively. Thus, PBL can be a strong and effective alternative in an effort to improve students' mathematics skills, in accordance with the demands of modern educational development.

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