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The Effectiveness of Project-Based Learning and Problem-Based Learning in Improving Student Achievement and Involvement in Learning Mathematics

Saddam Hussein* 

Sekolah Tinggi Agama Islam Al-Bahjah,
Indonesia

Muhammad Khoiruzzadittaqwa² 

Sekolah Tinggi Agama Islam Al-Bahjah,
Indonesia

Luthfiyah 

Sekolah Tinggi Agama Islam Al-Bahjah,
Indonesia

Muhammad Miftah Alhaq 

Yıldız Technical University, Turkey

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The Effectiveness of Project-Based Learning and Problem-Based Learning in Improving Student Achievement and Involvement in Learning Mathematics

Saddam Hussein^{1*}, Muhammad Khoiruzzadittaqwa², Luthfiyah³, Muhammad Miftah Alhaq⁴

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Abstract

This research examines the effectiveness of Project-based Learning (PjBL) and problem-based learning (PBL) in improving the involvement and achievements of students from elementary to high school. Using the Systematic Literature Review (SLR) method, we reviewed studies published from 2018 to 2023. The analysis results show that PjBL and PBL positively impacted students' cognitive, affective, and psychomotor aspects, facilitating active, collaborative, and independent learning. The use of interactive media in PjBL and PBL has been proven to increase student involvement in learning mathematics. This research contributed to developing effective mathematics teaching strategies at the elementary school level. It offered insights into using PjBL and PBL as alternative models that improve learning outcomes. Integrating interactive media in mathematics learning promises a deeper understanding of concepts, supporting educational practitioners and policymakers in designing innovative curricula and learning strategies for the future.

Introduction

Project-based learning (PjBL) and Problem-Based Learning (PBL) enrich the educational process with authentic experiences and constructivism. Both approaches integrate technology and skills relevant to the 21st century but differ in implementation and structure in the classroom environment.

PjBL, detailed by Thomas (2000), places projects at the center of learning activities and encourages students to undertake in-depth investigations and collaboration. In contrast, PBL, as described by Barrows (1986), focuses on complex problem-solving and challenges the learners to apply knowledge in contexts similar to real-world situations.

This study aims to critically analyze the similarities and differences between PjBL and PBL and evaluate

the effectiveness of each in the contemporary educational context. The hypothesis is that, although different, these two approaches provide rich and relevant learning experiences. PjBL is more suitable for developing creativity and collaboration, and PBL is more effective for honing problem-solving skills.

The main goal of this study is to understand in depth the characteristics, benefits, and challenges of PjBL and PBL, providing insight for educators to choose the methodology that best suits their needs. The results of this study can help education stakeholders, including teachers, administrators, and policymakers, design responsive curricula and innovative learning strategies and improve the overall quality of education.

Thus, this study tries to fill existing knowledge gaps, provide useful, practical recommendations for the educational community, and offer valuable guidance for stakeholders in developing effective and relevant educational practices.

Method

This research employs a Systematic Literature Review (SLR) approach, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. PRISMA is an internationally recognized standard designed to enhance the quality and transparency of systematic reviews and meta-analysis reporting. The SLR process commences with an exhaustive literature search across multiple scientific databases, including Google Scholar, using keywords closely aligned with the research topic. The search is confined to articles published between 2018 and 2023 to ensure the data's relevance and timeliness.

Subsequently, the collected articles are screened based on their titles and abstracts to exclude those not aligned with the research focus. Articles that pass this preliminary screening undergo further evaluation against predetermined eligibility criteria. These criteria encompass the topic's relevance, the research methodology's robustness, and the clarity and consistency of the results and conclusions.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication Year	2018 - 2023	Before 2018 or after 2023
Research Focus	PjBL and PBL in mathematics education	Topics outside PjBL and PBL
Language	Articles in English and Indonesian	Articles in other languages
Accessibility	Articles with full text available	Articles without full-text
Methodological Quality	Studies with clear and valid methodology	Studies with unclear or invalid methodology
Relevance	Articles relevant to mathematics education	Articles not relevant to mathematics education

Articles meeting the eligibility criteria are subjected to a detailed data extraction process. This process includes documenting the researchers' identities, journal titles, research instruments used, and the results obtained. The extracted data are systematically organized into tables for subsequent analysis and interpretation.

The final stage of the SLR involves data synthesis, where the researcher integrates and analyzes the findings from the extracted literature. This synthesis process produces a comprehensive and objective narrative on the latest trends and discoveries in mathematics education, focusing on Project-Based Learning (PjBL) and Problem-Based Learning (PBL) methodologies. The results of this synthesis aim to significantly contribute to developing innovative and effective mathematics teaching strategies, supporting educational practices responsive to 21st-century needs.

In conclusion, this research's methodological rigor and systematic approach provide a solid foundation for advancing the understanding of effective educational practices. By synthesizing the latest research on PjBL and PBL, this study offers an in-depth contribution that can inform and shape future educational strategies, ensuring they are well-suited to the evolving demands of learners and educators. This research is expected to enrich the discourse on mathematics education and serve as a valuable resource for those seeking to implement evidence-based innovations in teaching and learning.

Results

The Systematic Literature Review (SLR) has revealed various recent studies concentrating on mathematics learning media from 2018 to 2023. This analysis highlights that multimedia approaches, especially Project Based Learning (PjBL) and Problem-Based Learning (PBL), dominate the current learning context. As an illustration, a study conducted by Afifah, Wahyudi, and Setiawan (2019) indicated the superiority of PBL in strengthening critical thinking skills in grade 5 students compared to the Problem-Solving method.

The use of interactive media supported by technology has also received significant attention. Research conducted by Utami and Wahyudi (2021) shows that interactive media that uses articulate storylines effectively improves thematic learning outcomes. Likewise, the use of comic media integrated with the problem-posing model has been proven to increase mathematical problem-solving abilities in elementary school students, as shown by Gumilang et al. (2019)

These results provide comprehensive insight into the effectiveness of PBL in developing learning outcomes, which aligns with the perspective that project-based approaches can improve student motivation and involvement in the learning process. This SLR notes that these findings significantly contribute to understanding the effectiveness of various learning models and media in improving mathematics learning outcomes at the elementary school level. In general, these findings form the basis for developing more innovative and effective mathematics learning strategies that will meet the needs of the modern curriculum.

Table 1 below summarizes the characteristics of the selected studies, including the researchers, journals, instruments used, and research results. The selected studies consistently use PjBL as a medium for teaching mathematics at the elementary school level. These studies come from Indonesia and were published between 2018 and 2023. The mathematics material taught through PjBL covers various topics, including integers, geometry, fractions, statistics, etc. Instruments used to measure students' mathematics learning outcomes include tests, questionnaires, observations, and interviews. Research results consistently show that PjBL positively impacts students' mathematics learning outcomes, including cognitive, affective, and psychomotor aspects.

Table 2. Identification of Systematic Literature Review Research Results on Several Mathematics Learning Media Journals Between 2018-2023

Researcher	Journal	Instrument	Research results
Afifah, E. P., Wahyudi, W., & Setiawan, Y. (2019)	MUST: Journal of Mathematics Education, Science and Technology, 4(1), 95-107	Critical thinking ability tests, observation sheets, and questionnaires	The Problem-based Learning and problem-solving models have different effects on grade 5 students' critical thinking abilities in mathematics. The Problem-Based Learning model is more effective than the Problem-Solving model in improving students' critical thinking skills.
Gumilang, M. R., Wahyudi, W., & Indarini, E. (2019)	Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang, 3	Comic media with problem-posing models, validation sheets, observation sheets, questionnaire sheets, and mathematical problem-solving ability tests	Comic media with a problem-posing model developed for mathematics learning in elementary schools is valid, practical, and effective. This comic media can significantly improve students' mathematical problem-solving abilities.
Hapsari, D. I., Airlanda, G. S., & Kanzunudin, M. (2018)	Jurnal Pendidikan Dasar Nusantara, 3(2), 1-13	Observation sheets, questionnaires, and mathematics learning results tests.	The Project-Based Learning (PjBL) learning model effectively improves the mathematics learning outcomes of class V students at SDN 1 Sukorejo, Blitar City, during the 2017/2018 Academic Year. This learning model can significantly improve students' mathematics learning outcomes from

Researcher	Journal	Instrument	Research results
Izati, S. N., Wahyudi, W., & Sugiyarti, M. (2018)	Jurnal Pendidikan : Teori, Penelitian, Dan Pengembangan, 3(9), 1122-1127	Observation sheets, questionnaires, and mathematics learning results tests	cycles I to II. Using literacy-based project-based Learning can improve the thematic learning outcomes of class V students at SDN Salatiga 05. Applying this learning model can significantly increase the activity and completeness of students' thematic learning outcomes from cycle I to cycle II.
Kurniawan, A., & Surya, E. (2019)	Jurnal Pendidikan Matematik a Raflesia, 4(2), 141-148	Observation sheets, questionnaires, and mathematics learning results tests	The project-based learning model positively and significantly influences the mathematics learning outcomes of class VIII students at SMP Negeri 1 Pancurbatu for the 2018/2019 academic year. This learning model can significantly improve student mathematics learning outcomes from pretest to posttest.
Panjaitan, S. M. (2019)	Sepren, 1 (01), 48-62	Observation sheets, questionnaires, and mathematics learning results tests.	The project-based learning model is highly effective in improving the learning outcomes of mathematics education study program students at FKIP, HKBP Nommensen University, Medan. This learning model can significantly improve student learning outcomes from pretest to posttest.
Pratiwi, R., & Wijaya, A. (2018)	Jurnal Pendidikan IPA dan Pembelajaran an, 2(1), 1-7	Observation sheets, questionnaires, and mathematics learning results tests.	The Project Learning (PjBL) learning model positively and significantly influences the mathematics learning outcomes of class V students at SDN 19 Cakranegara, Mataram City. This learning model can significantly improve student mathematics learning outcomes from pretest to posttest.
Rizwan, M. (2023).	Skripsi, Universitas Borneo Tarakan	Observation sheets, questionnaires, and mathematics learning results tests	The Project Based Learning (PjBL) learning model has high effectiveness on the mathematics learning outcomes of class V students at SDN 018 Tarakan. This learning model can significantly

Researcher	Journal	Instrument	Research results
			improve student mathematics learning outcomes from pretest to posttest. The analysis results of the average n-gain obtained a value of $g = 0.71$, which is in the high category with a value of n-gain percent = 71.4856, which is in the interpretation criteria quite effective.
Setiyaningrum, M., & Wahyudi, W. (2018)	Jurnal Riset Teknologi dan Inovasi Pendidikan, 1(2), 99-108	Observation sheets and learning outcomes test.	The Problem-Based Learning (PBL) model can improve the learning outcomes of 5th-grade elementary school students on plane material; this learning model can significantly increase the activity and completeness of student learning outcomes from cycle I to cycle II.
Utami, Y. S., & Wahyudi, W. (2021)	JRPD (Jurnal Riset Pendidikan Dasar), 4(1), 62-71	Interactive media based on articulate storylines, validation sheets, observation sheets, questionnaires, and thematic learning results tests	The Problem-Based Learning (PBL) model can improve the learning outcomes of 5th-grade elementary school students on plain material. This learning model can significantly increase the activity and completeness of student learning outcomes from cycle I to cycle II.
Wulandari, R., & Widiastuti, I. (2019)	Jurnal Pendidikan Matematik a Unila, 7(9), 1035-1044	Interactive media based on articulate storylines, validation sheets, observation sheets, questionnaires, and thematic learning outcomes tests	The project-based learning model positively and significantly influences the ability to understand mathematical concepts of class VIII students at SMP Negeri 1 Metro for the 2018/2019 academic year. This learning model can significantly improve students' understanding of mathematical concepts from pretest to posttest.

Discussion

Based on research results that have been identified through a Systematic Literature Review (SLR), it can be concluded that active and project-based learning approaches such as Project Based Learning (PjBL) and Problem-Based Learning (PBL) have significant effectiveness in improving learning

outcomes in student mathematics. Research by Afifah et al. (2019) confirmed that PBL is more effective than Problem-Solving in improving the critical thinking skills of grade 5 students, consistent with Savery & Duffy's (1995) theory of problem-based learning.

Gumilang et al. (2019) show that using interactive media in learning also positively impacts elementary school students' mathematical problem-solving abilities. Creative approaches such as comic media with a problem-posing model can increase student involvement and understanding of concepts, which aligns with Ainsworth's (2006) concept of multimedia learning.

Hapsari et al. (2018) and Izati et al. (2018) show that PjBL, focusing on collaborative projects and literacy integration, improves the understanding and application of mathematical concepts and thematic learning outcomes. This supports Thomas's (2000) view about the importance of collaborative projects in learning.

Pratiwi and Wijaya (2018) and Rizwan (2023) also reported the effectiveness of PjBL in improving mathematics learning outcomes, emphasizing the importance of student activity in projects and developing critical thinking skills. Setyaningrum and Wahyudi (2018) have shown that PBL improves student learning outcomes in plain material, showing that solving real problems can motivate an in-depth understanding of concepts.

Overall, the findings from the SLR provide strong evidence of the effectiveness of PjBL and PBL in mathematics education. This innovative and engaging learning approach meets the demands of the modern curriculum and increases student engagement and understanding. Therefore, educational practitioners recommend integrating PjBL and PBL in their learning strategies and utilizing interactive media to enrich students' learning experiences. This discussion highlights the importance of innovative and engaging learning approaches in mathematics education to meet the demands of modern curricula and student needs.

Conclusion

Research shows that learning models such as problem-based learning (PBL), project-based Learning (PjBL), and interactive media significantly contribute positively to student learning outcomes, especially in mathematics and thematic learning. PBL effectively strengthens students' critical thinking skills, especially in mathematics, supporting its role in developing these skills. PjBL, with its focus on collaborative projects, enhances the understanding and application of mathematical concepts, demonstrating its effectiveness in motivating students to participate actively and creatively in the learning process.

Interactive media, including articulate storylines, are important in increasing student engagement in thematic learning, with well-designed media being a key factor. Creative media such as comics also increase student engagement and understanding of mathematical concepts. Integrating literacy in

learning, as implemented in literacy-based PjBL, provides additional value and strengthens understanding of concepts.

Thus, these findings confirm that choosing the right learning model and using creative methods and interactive media can substantially impact student learning outcomes. This literature review indicates that the PBL approach and the use of interactive media have positively influenced students' mathematics learning outcomes. These findings provide a strong basis for developing more innovative mathematics learning strategies, especially at the elementary school level. The practical implications of these findings support educators and policymakers in improving the quality of mathematics learning.

Recommendations

Based on the results of the Systematic Literature Review (SLR), several directions can be taken to improve mathematics education practices at the elementary school level. First, increasing teacher competency through adequate training and support is the main key. This includes selecting relevant project topics, efficient time management, appropriate use of learning resources, constructive assessment methods, and the ability to facilitate productive collaboration in the classroom.

Furthermore, research suggests developing and utilizing technology-based interactive media in mathematics learning. Innovations in media design, including articulate storylines and comics, provide interesting stimuli for students, increasing their involvement in learning and deepening their understanding of mathematical concepts.

In addition, developing creative learning resources that support the learning models implemented is highly recommended. A learning approach that integrates literacy can provide added value in understanding concepts and developing students' critical thinking skills.

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Author Information

Saddam Hussein

Sekolah Tinggi Agama Islam Al-Bahjah
 Blok Gudang Air, Cirebon, 45611, Jawa Barat
 Indonesia
 Contact e-mail: hussein.saddam01@gmail.com

Muhammad Khoiruzzadittaqwa

Sekolah Tinggi Agama Islam Al-Bahjah
 Blok Gudang Air, Cirebon, 45611, Jawa Barat
 Indonesia
 Contact e-mail: muhzadit@gmail.com

Luthfiyah

Sekolah Tinggi Agama Islam Al-Bahjah
 Blok Gudang Air, Cirebon, 45611, Jawa Barat
 Indonesia
 Contact e-mail: uviluthfiyah2802@gmail.com

Muhammad Miftah Alhaq

Yıldız Technical University
 Davutpaşa Mah. Davutpaşa Caddesi
 34220, Esenler, Istanbul
 Turkey
 Contact e-mail: muhammad.alhaq@std.yildiz.edu.tr
