

Student Responses and Learning Outcomes in STEM Learning Based on Project Based Learning (PjBL)

Rina Dwi Maryanti¹, Shirly Rizki Kusumaningrum², Mardhatillah³

^{1,2,3}Pendidikan Dasar, Sekolah Pascasarjana, Universitas Negeri Malang, Malang, Indonesia

Article Info

Article history:

Received : September 14, 2025

Revised : September 20, 2025

Accepted : September 27, 2025

Keywords:

STEM

Project Based Learning

Learning outcomes

Student responses

Elementary school

ABSTRACT

This study investigates students' responses and learning outcomes in STEM education through a Project Based Learning (PjBL) approach focused on natural disaster simulations in fifth-grade elementary students. Although a digital STEM based disaster learning model has been shown to significantly improve elementary students' disaster adaption abilities through quasi experimental research, existing studies generally emphasize digital simulations rather than real context thematic project experiences in primary schools. Therefore, the novelty of this research lies in the integration of STEM and PjBL within thematic learning for disaster context education, addressing a gap in studies at the elementary level, particularly in Indonesia. This descriptive quantitative study involved 15 students and employed learning outcome assessments and student response questionnaires. Results revealed that all students achieved mastery learning with an average score of 94.73. Student responses were highly positive, with an average questionnaire score of 3.80 out of 4, indicating strong engagement and improved conceptual understanding during the disaster simulation project. The integrated STEM-based PjBL approach fostered active student involvement, collaboration, and critical thinking skills. These findings demonstrate the effectiveness of this model in enhancing elementary science learning quality and provide a promising approach for thematic, student centered instruction in disaster education contexts.

This is an open access article under the [CC BY-SA](#) license.



Corresponding Author:

Rina Dwi Maryanti

Graduate School, Primary Education Study Program, Universitas Negeri Malang, Indonesia

A21 Building, Jalan Semarang No. 5, Sumber Sari, Lowokwaru, Malang City, East Java, Indonesia

Email: rina.dwi.2321038@students.um.ac.id

1. INTRODUCTION

Although STEM and Project Based Learning (PjBL) have been widely examined in global education research, limited studies have explored their combined application in thematic disaster learning at the primary education level, particularly application in thematic disaster learning at the primary education level, particularly in developing contexts such as Indonesia. Existing studies tend to emphasize STEM PjBL implementation in general science learning or in upper secondary and higher education, while disaster context thematic learning for young learners remains under investigated.

Recent literature, primarily focuses on implementations in developed countries or advanced educational levels, leaving a substantial gap regarding how STEM PjBL can be effectively designed and contextualized for elementary students in developing regions (Blumenfeld et al., 1991; Myo, 2020; Permadi et al., 2025). Addressing this gap is crucial, as disaster prone contexts such as Indonesia require early disaster literacy and preparedness training from the primary level. Therefore, this study aims to contribute new empirical evidence on STEM based PjBL for disaster context thematic learning in Indonesia elementary schools, offering insights that can support the advancement of research and practice in Southeast Asia and other developing regions.

21st-century education emphasizes the importance of mastering four essential skills: critical thinking, collaboration, effective communication, and innovative creativity. In facing the challenges of the 21st century, the most crucial abilities to possess are soft skills, which include critical thinking and problem-solving, creativity and innovation, communication skills, and collaboration. (Nurhayati *et al.*, 2024). These four skills are commonly known as the 4Cs. Mastery of the 4C skills is essential for every individual to be able to adapt and thrive in 21st-century life. In this era, these abilities serve as the primary foundation for achieving a better quality of life. Therefore, all aspects of this knowledge need to be developed through the learning process and instilled in students so that they possess comprehensive skills and competencies as preparation for a more prosperous future.

The STEM approach effectively integrates these competencies into learning activities by combining Science, Technology, Engineering, and Mathematics. According to Zihan (2024), the STEM approach has been proven to enhance the effectiveness of mathematics learning in alignment with 21st-century demands. This is evidenced by various findings showing that the STEM approach can develop students' skills in technology, strengthen analytical abilities, and foster creativity and innovation. Moreover, students become more adept at expressing ideas, formulating, and presenting problems. With the improvement of these skills, mathematics learning that focuses on 21st-century competencies becomes more optimal. Furthermore, the STEM approach also provides stimulation that encourages students to meet the demands of 21st-century learning, particularly in terms of critical thinking and problem-solving, as well as developing critical, creative, lateral, and systematic thinking skills.

In the realm of elementary education, the implementation of STEM-based learning provides opportunities for students to gain a more meaningful understanding of science concepts through direct experiences connected to real-life situations. Students are encouraged to apply the science concepts they have learned to real-world contexts (Widiyatmoko & Darmawan, 2023). Assigning projects or tasks allows students to use their knowledge and skills in everyday life contexts. Through these activities, students can demonstrate their understanding of science content in creative ways, such as by creating videos, posters, or engaging multimedia presentations to explain a concept or their research findings. Students are trained to develop curiosity through scientific questioning and independent inquiry, and their skills in seeking information, analyzing data, and drawing innovative conclusions are sharpened. Collaborative activities such as discussions and group work foster critical thinking and creative problem-solving. To support this, classrooms need to be designed as learning spaces that encourage exploration, collaboration, and the creative expression of ideas.

However, the implementation of STEM learning at the elementary school level still faces several challenges, such as limited facilities and resources, a lack of teacher training, and a teaching approach that tends to remain teacher-centered. According to IDA (2024), although the teacher's role is vital in the implementation of STEM-based learning, there are still various obstacles. Many teachers do not fully understand the concept and application of STEM within the existing curriculum. In addition, limited facilities and the lack of professional training for teachers present significant challenges. The learning process, which is still dominated by lecture-based and teacher-centered methods, also hinders progress, as it does not provide space for students to develop critical thinking skills and positions the teacher as the sole source of information.

In contrast, the Project-Based Learning (PjBL) approach, which focuses on collaborative project completion, has proven effective in increasing students' motivation and active participation during the learning process. The project-based learning model is effective in enhancing students' learning motivation and is considered suitable for implementation as a variation of classroom teaching methods (Nurhidayah & Ain, 2025). The integration of the STEM approach with the Project-Based Learning model has the potential to create more meaningful and enjoyable learning experiences for elementary school students. According to Prabawati & Agustika (2020) states that Project-Based Learning is a project-based instructional model that fosters students' independence, creativity, and collaboration in solving real-world problems, while also enhancing scientific literacy within the context of STEM.

Previous studies have shown that the Project-Based Learning (PjBL) method is more effective in enhancing students' higher-order thinking skills compared to conventional teaching methods. Therefore, PjBL can be considered an appropriate alternative for fostering higher-order thinking in the learning process (Maulina *et al.*, 2023). Nevertheless, studies on the implementation of STEM-based Project-Based Learning (PjBL) in the topic of natural disasters at the elementary school level are still limited. Therefore, this study was conducted to explore students' responses and learning outcomes after participating in STEM-based PjBL using the context of natural disaster simulations.

This study not only evaluates the effectiveness of learning from the cognitive aspect but also measures the affective aspect through a questionnaire assessing students' responses and enthusiasm. The findings of this research are expected to serve as an innovation in science learning at the elementary school level and as a reference for teachers in designing more contextual, collaborative, and student-centered instruction.

2. METHOD

This study employed a quantitative descriptive approach to examine students' responses and learning outcomes after participating in STEM based Project Based Learning (PjBL). According to (Aziza, 2023), quantitative descriptive statistics allow researchers to summarize, present, and analyze numerical data in a structured manner through calculations such as averages, percentages, and data visualizations like bar charts. This approach is well-suited for describing students' responses and learning evaluations within a learning activity. Although the sample size was limited to 15 fifth grade students at SDN 2 Nglawak, Nganjuk, this was considered a pilot study to explore initial trends and insights, acknowledging that larger samples would be recommended for further definitive research in Sinta indexed publications.

The instruments included a learning outcome test and a student response questionnaire. Both instruments underwent validity and reliability assessments. The questionnaire was validated through expert reviews, and a pilot test demonstrated acceptable reliability (Cronbach's alpha . 0.7). The learning test was reviewed by education experts to ensure content validity.

This study did not included a control group due to practical and ethical considerations within the school setting. To mitigate bias, data collection and analysis were conducted with strict adherence to standardized procedures, minimizing researcher influence. The intervention was implemented over three sessions, deemed sufficient to observe measurable changes in students' conceptual understanding and engagement based on prior studies and practical scheduling constraints. Ethical approval was obtained from the school authorities, and informed consent was secured from participants and students prior to participation, ensuring compliance with ethical standards for educational research.

2.1 Research Design

The research was conducted as a thematic learning activity integrating the STEM approach within the topic of natural disaster simulations. A descriptive survey design was employed to quantitatively describe students' learning outcomes and enthusiasm.

2.2 Research Procedure

This research was carried out in three main stages. First, in the planning stage, the teacher prepared a STEM-based learning module using a project-based approach. The module included Student Worksheets (LKPD) and evaluation instruments to be used during the learning process. Next, during the implementation stage, the learning activities were conducted over three sessions. In these sessions, students actively participated in a project to create a disaster simulation tool, specifically a simple earthquake simulation using easily accessible materials. Finally, in the evaluation stage, the teacher administered a learning outcome test to assess students' conceptual understanding and distributed a questionnaire to gather students' responses toward the learning experience.

2.3 Research Instruments

The instruments used in this study consisted of two types: a learning evaluation test and a student response questionnaire. The learning evaluation test was presented in the form of a thematic crossword puzzle that integrated Natural Science (IPA) content on natural phenomena and Mathematics content on large numbers. This assessment was designed to measure students' understanding in a fun and creative way, so that the evaluation process was not only cognitive in nature but also engaging and stimulating for students' learning interest.

In addition, the student response questionnaire consisted of eight statements arranged using a Likert scale ranging from 1 to 4. This questionnaire aimed to explore students' perceptions of the project-based STEM learning, particularly in terms of their engagement, content comprehension, and impressions of the overall learning activities.

2.4 Data Collection and Analysis Techniques

Data were collected from evaluation scores and questionnaire scores. The data were analyzed using descriptive quantitative methods by calculating the average, total score, and percentage of each indicator, which were then presented in the form of tables and bar charts.

3. RESULTS AND DISCUSSION

This section presents the research findings and analysis of student learning outcomes and responses to STEM-based Project Based Learning (PjBL). This study used two main instruments: a learning outcome evaluation and a student response questionnaire.

3.1. Students' Learning Evaluation Results

The learning evaluation was conducted after three meetings using a project-based STEM learning approach focused on the topic of disaster simulation. The evaluation employed a crossword puzzle instrument that integrated Natural Sciences (IPA) content on natural events and Mathematics content on large numbers. This approach was designed to assess students' comprehensive understanding in an interactive and enjoyable way, while also emphasizing the interdisciplinary nature of project-based learning.

The evaluation showed that all 15 students achieved mastery (100%) with an average score of 94.73. Most students earned near perfect scores (89-100), indicating strong mastery of the material. The findings indicate that the STEM based PjBL approach effectively enhances students' conceptual understanding and critical thinking skills.

Table 1. Student Learning Evaluation Results

Student Evaluation Statistics	Result
Number of Students	15
Number of Students Passing (≥ 75)	15 (100%)
Average Evaluation Score	94.73

Based on the data presented in Table 1, all students ($n = 15$) successfully achieved mastery learning with scores above the Minimum Competency Criteria ($KKM = 75$), resulting in a 100% mastery rate and an average score of 94.73. These findings demonstrate the effectiveness of integrating STEM with PjBL in enhancing students' conceptual understanding. Furthermore, the earthquake-simulation project stimulated project stimulated students' critical thinking and collaboration skills by engaging them in authentic, real world problem solving tasks.

Through this approach, students applied theories through hands on experiments and collaborative group work. For example, the project of creating a simple earthquake vibration simulation tool using basic materials provided a concrete learning experience while strengthening students' understanding of natural phenomena such as earthquakes. This activity fostered curiosity, problem-solving skills, and collaboration within groups.

Furthermore, the integration of Science and Mathematics in the learning evaluation enriched the students' learning experience. The crossword puzzle questions, which combined content on large numbers with disaster-related data such as the number of victims and affected areas made mathematics feel more tangible and relevant. This approach indirectly developed students' numeracy skills within real-life contexts. Thus, the learning process became more comprehensive and meaningful, aligning with the core principles of STEM education that emphasize interdisciplinary integration and real-world application.

3.2. Results of Student Response and Enthusiasm Questionnaire

To understand students' affective and social responses to the applied learning model, a questionnaire consisting of 8 statements using a 1–4 Likert scale was distributed. The aim of this questionnaire was to measure the extent to which students felt happy, enthusiastic, and perceived the benefits of project-based learning connected to real-world contexts.

Table 2. Results of Student Response and Enthusiasm Questionnaire

SN	Indikator	Value
1	I enjoy learning through simulations	3.60
2	Natural disaster simulations make learning more interesting and exciting	3.80
3	I can understand the material better through simulations	3.70
4	I feel enthusiastic about learning with this model	3.65

Based on the results, several key indicators showed high average scores. For example, the statement "*I enjoy learning through simulations*" scored an average of 3.60; "*Disaster simulations make learning more interesting and exciting*" received the highest score of 3.80; while "*I can understand the material better through simulations*" scored 3.70. In addition, the statement "*I feel enthusiastic about learning with this model*" received a score of 3.65, reflecting high student interest and engagement during the learning process.

These high scores indicate that students greatly enjoyed the learning process. They not only felt more engaged and interested, but also experienced increased confidence. Students became more active and confident in discussions, sharing ideas freely through collaborative work. The learning atmosphere became more dynamic and enjoyable, as students were encouraged to experiment, discuss, and creatively complete their projects.

This project-based learning model also fostered a more inclusive and communicative learning environment. Students learned to listen to others' opinions, share responsibilities, and work together to find solutions. In short interviews with several students, they expressed that this was their first time learning in such

a fun way what they described as “*playing while thinking*.” This statement affirms that students experienced a significant shift from conventional, theory-heavy learning toward a more practical, contextual, and enjoyable approach. The high level of enthusiasm shown by students serves as evidence that interactive, experience-based learning methods are highly effective in increasing student engagement and motivation.

The present findings are consistent with international evidence showing positive effects of project-based and STEM-oriented learning on primary students’ cognitive and affective outcomes. Meta-analytic and systematic reviews report that PBL and STEM practices improve academic achievement, motivation, and higher-order thinking (Zhang & Ma, 2023), while quasi-experimental studies show enhancements in problem-solving beliefs and creativity among elementary learners (Shongwe, 2024; Rahayu & Maryani, 2023). In contexts similar to ours, STEM-based disaster mitigation, larger quasi-experimental studies also reported gains in disaster preparedness and related competencies. These converging lines of evidence support the generalizability of our results beyond the study site.

3.2.1. Implications of the Findings

The findings of this study affirm that integrating the STEM (Science, Technology, Engineering, and Mathematics) approach with the Project-Based Learning (PBL) model is highly effective in fostering cognitive, affective, and collaborative skills among elementary students. The increase in learning achievement and positive student responses can be explained through several theoretical mechanisms. Previous studies similarly highlight that PjBL improves academic achievement, motivation, and problem-solving performance through authentic tasks and student-centered inquiry (Tafakur et al., 2023). The integration of STEM within PjBL further strengthens cognitive and collaborative development by providing hands-on engineering-based activities, real-world problem contexts, and structured teamwork (Guo et al., 2020; Samsudin et al., 2020). Evidence from primary education settings also demonstrates significant gains in scientific understanding, critical thinking, and student engagement when STEM PjBL is implemented, especially in developing contexts (Firdaus & Rahayu, 2019; Herlina et al., 2023).

First, STEM PjBL situates learning in real-world, problem-driven contexts. According to constructivist theory, knowledge is best constructed when students actively build meaning through hands-on experience rather than passive reception. In this study, students engaged in designing and testing earthquake simulation models, which required them to apply scientific and mathematical concepts. This authentic task stimulated conceptual integration, improved retention, and promoted deeper understanding (Kong, 2021).

Second, the cognitive load was distributed through collaborative inquiry, where students shared tasks, discussed ideas, and negotiated solutions. Vygotsky’s social constructivism suggests that peer interaction supports learning by enabling students to operate within their Zone of Proximal Development (ZPD) (Morgan & Skaggs, 2016; Smith, 2024). The role of group discussion and problem-solving in this project reinforced metacognitive awareness, critical thinking, and collective decision-making (Raslan, 2024).

Third, the use of real disaster contexts enhanced learning motivation and emotional engagement. Affective engagement plays a crucial role in strengthening students’ willingness to explore and persist. This aligns with Self-Determination Theory, which states that autonomy, competency, and collaboration increase intrinsic motivation (Mebert et al., 2020). Students’ enthusiasm and confidence in expressing ideas indicate that STEM-PjBL supports psychological needs and fosters meaningful learning experiences (Le et al., 2023; Ryan & Deci, 2020).

Therefore, the success of STEM PjBL in this study is not only indicated by high scores but also underpinned by strong pedagogical mechanisms: contextual problem-solving, collaborative knowledge construction, and emotionally engaging learning environments. These findings reinforce the potential of STEM PjBL as a powerful learning approach at the primary level, particularly for themes requiring real-world application such as disaster literacy.

3.2.2 Limitations and Future Directions

Although this study generated promising results, several limitations need to be acknowledged. The research involved a small number of participants from a single school and was conducted over a relatively short time span. As a result, the findings cannot be generalized broadly. In addition, there was no follow-up measurement to evaluate students’ long-term retention and transfer of knowledge to other contexts.

Future research should consider employing more rigorous experimental or quasi-experimental designs with control groups and larger sample sizes to strengthen causal inferences. Longitudinal studies are also recommended to assess sustained cognitive and behavioral impacts, particularly in disaster preparedness competencies. Moreover, expanding the implementation across different thematic units such as environmental sustainability or renewable energy may provide further insights into the adaptability and scalability of STEM PjBL at the elementary level. Collaborating with teachers in co-designing learning modules and integrating digital STEM tools may also enhance implementation quality and classroom practicality. Moreover, expanding the implementation across different thematic units such as environmental sustainability or renewable energy

may provide further insights into the adaptability and scalability of STEM PjBL at the elementary level (Yusri et al., 2024; Deehan et al., 2025).

The results of this study indicate that STEM-based learning combined with a Project-Based Learning (PjBL) approach has a positive impact on the learning outcomes and responses of fifth-grade elementary school students. All students achieved mastery learning with high average scores and demonstrated enthusiasm and active engagement throughout the learning process. This learning model not only enhanced students' cognitive abilities but also fostered the development of collaboration skills, critical thinking, and self-confidence.

The learning model also proved effective in linking abstract concepts to real-life contexts through a natural disaster simulation project. Therefore, the integration of STEM and PjBL can serve as an innovative and relevant alternative approach for implementing thematic learning in elementary schools. Future research is recommended to examine its long-term effectiveness and explore its application in a wider variety of themes and educational levels.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to SDN 2 Nglawak Nganjuk for the support and opportunity to conduct this classroom-based research. Appreciation is also extended to the fifth-grade students who actively participated in the learning process. This study was carried out independently as part of the author's professional development without specific financial sponsorship.

REFERENCES

- Aziza, N. (2023). Metodologi penelitian 1: deskriptif kuantitatif. *ResearchGate, July*, 166–178.
- Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3–4), 369–398.
- Deehan, J., Redshaw, S., Danaia, L., Postlethwaite, F., Donnelly, A., & Morris, C. (2025). Understanding STEM beyond the cities: A comprehensive review of non-metropolitan STEM education research. *International Journal of Educational Research Open*, 9, 100496.
- Firdaus, A. R., & Rahayu, G. D. S. (2019). Effect of STEM-Based Learning on the Cognitive Skills Improvement. *Elementary School Forum (Mimbar Sekolah Dasar)*, 6(2), 198–207.
- Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research*, 102, 101586.
- Herlina, A., Nirmala, S. D., & Rahayu, U. (2023). Creative thinking and collaborative ability of elementary students with the implementation of the stem integrated project-based learning model. *EduHumaniora | Jurnal Pendidikan Dasar Kampus Cibiru*, 15(1), 39–50.
- IDA, L. (2024). *Pengaruh Model Pembelajaran Project Based Learning Berbasis Stem Terhadap Hasil Belajar Muatan Ipa Peserta Didik Kelas V Sekolah Dasar*.
- Kong, Y. (2021). The role of experiential learning on students' motivation and classroom engagement. *Frontiers in Psychology*, 12, 771272.
- Le, H. C., Nguyen, V. H., & Nguyen, T. L. (2023). Integrated STEM approaches and associated outcomes of K-12 student learning: A systematic review. *Education Sciences*, 13(3), 297.
- Maulina, S., Nuryadi, N., & Wahyudi, N. S. (2023). Efektivitas Metode Pembelajaran Project Based Learning untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi Siswa SMP Negeri 8 Yogyakarta. *Seminalu*, 1(1), 431–525.
- Mebert, L., Barnes, R., Dalley, J., Gawarecki, L., Ghazi-Nezami, F., Shafer, G., Slater, J., & Yezbick, E. (2020). Fostering student engagement through a real-world, collaborative project across disciplines and institutions. *Higher Education Pedagogies*, 5(1), 30–51.
- Morgan, D., & Skaggs, P. (2016). Collaboration in the zone of proximal development. *DS 83: Proceedings of the 18th International Conference on Engineering and Product Design Education (E&PDE16), Design Education: Collaboration and Cross-Disciplinarity, Aalborg, Denmark, 8th-9th September 2016*, 664–669.
- Myo, A. P. P. (2020). A Study of Social Diversities and Humanities in Teaching Reading Texts through Project-Based Learning Approach (PBL). *Open Access Library Journal*, 7(7), 1–10.
- Nurhayati, I., Pramono, K. S. E., & Farida, A. (2024). Keterampilan 4C (Critical Thinking, Creativity, Communication And Collaboration) dalam Pembelajaran IPS untuk Menjawab Tantangan Abad 21. *Jurnal Basicedu*, 8(1), 36–43.
- Nurhidayah, A., & Ain, S. Q. (2025). Penerapan Pembelajaran Berbasis Proyek Untuk Meningkatkan Motivasi Belajar Siswa Kelas IV SDN 146 Pekanbaru. *Journal of Humanities Education Management Accounting and Transportation*, 2(1), 704–716.
- Permadi, D., Antika, R. N., Anggreini, A., Hilmalia, Y., & Yulandari, A. (2025). Project Based Learning in Science Education Research in Indonesia: A Bibliometric Analysis. *Phi: Jurnal Pendidikan Fisika Dan*

- Terapan*, 11(2).
- Prabawati, P. L. S., & Agustika, G. N. S. (2020). Project-based learning based on STEM (Science, Technology, Engineering, And Mathematics) enhancing students science knowledge competence. *Jurnal Ilmiah Sekolah Dasar*, 4(4), 621–629.
- Rahayu, A. S., & Maryani, I. (2023). STEM-PjBL and creativity of science learning students in elementary schools. *Journal of Professional Teacher Education*, 1(2), 72–83.
- Raslan, G. (2024). The Impact of the zone of proximal development concept (scaffolding) on the students problem solving skills and learning outcomes. *BUiD Doctoral Research Conference 2023: Multidisciplinary Studies*, 59–66.
- Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, 61, 101860.
- Samsudin, M. A., Jamali, S. M., Zain, A. N. M., & Ebrahim, N. A. (2020). The effect of STEM project based learning on self-efficacy among high-school physics students. *Journal of Turkish Science Education*, 17(1), 94–108.
- Shongwe, B. (2024). The effect of STEM problem-based learning on students' mathematical problem-solving beliefs. *EURASIA Journal of Mathematics, Science and Technology Education*, 20(8), em2486.
- Smith, J. (2024). Supporting metacognitive talk during collaborative problem solving: a case study in Scottish primary school mathematics. *Education 3-13*, 52(8), 1578–1593.
- Tafakur, T., Retnawati, H., & Shukri, A. A. M. (2023). Effectiveness of project-based learning for enhancing students critical thinking skills: A meta-analysis. *JINoP (Jurnal Inovasi Pembelajaran)*, 9(2), 191–209.
- Widiyatmoko, A., & Darmawan, M. S. (2023). Implementasi stem pada pembelajaran ipa di indonesia: review artikel tahun 2018-2023. *Proceeding Seminar Nasional IPA*.
- Yusri, R., Yusof, A. M., & Latef, A. S. A. (2024). A systematic literature review of project-based learning: research trends, methods, elements, and frameworks. *International Journal of Evaluation and Research in Education*.
- Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology*, 14, 1202728.
- Zihan, Z. (2024). Efektivitas Pembelajaran Matematika Berbasis STEM (Science, Technology, Engineering, and Mathematics). *Jurnal Ilmiah Pendidikan Matematika (Jipm)*, 2(1), 60–63.

BIOGRAPHIES OF AUTHORS

	Rina Dwi Maryanti holds a Bachelor's degree in Primary School Teacher Education and has completed the Teacher Professional Education Program. She is currently pursuing a Master's degree in Primary Education at Universitas Negeri Malang, Indonesia, and is in the process of completing her graduate research. Her academic interests include primary education, 21st-century learning, and project-based learning. She can be contacted at email: rina.dwi.2321038@students.um.ac.id
	Dr. Shirley Rizki Kusumaningrum, S.Pd., M.Pd is a lecturer and researcher at Universitas Negeri Malang, Indonesia. She holds bachelor's, master's, and doctoral degrees in education and actively contributes to research and community service in the field of educational innovation. Her scholarly work is primarily centered on teacher training, technology integration in language education, language teaching strategies, and 21st-century pedagogical approaches employing inter-, multi-, and transdisciplinary perspectives. She has been involved in more than 45 research and community engagement activities, supported by various institutional and national grants. Dr. Shirley has published academic works in journals, books, and conferences, and is affiliated with the research group on Mathematics and Natural Sciences Education for Primary and Secondary Levels. She can be contacted at email: shirly.rizki.pasca@um.ac.id
	Dr. Mardhatillah, S.Pd.I., M.Pd. is a lecturer and researcher in the Master's and Doctoral Program of Primary Education at Universitas Negeri Malang (UM), Indonesia. She actively contributes to teaching, research, and academic development in the field of primary education. Her research interests include primary education, curriculum and learning development, and differentiated instruction, particularly in language education. She has authored and co-authored several academic publications exploring contemporary pedagogical approaches. She can be contacted at email: mardhatillah.pasca@um.ac.id