JOURNAL OF EDUCATION FOR SUSTAINABLE INNOVATION | ISSN 3025-1052
Vol. 1, No. 1, 2023, 1-8
https://doi.org/10.56916/jesi.v1i1.477

Project-Based Learning through the STEM Approach in Elementary Schools: How to Improve Problem-Solving Ability

Abdur Rasyid*
Pendidikan Biologi, Universitas Majalengka, Indonesia

Rinto Rinto
Pendidikan IPA, Universitas Muhammadiyah Cirebon, Indonesia

Mulia Susanti
Akademi Analis Kesehatan, Pekalongan, Indoesia

***Corresponding Author:** abdurrasyid87@unma.ac.id

Keywords
Project-based learning
STEM
Problem-solving ability

Article History
Received 2023-05-15
Accepted 2023-07-29

Abstract
Problem-solving ability is a fundamental competence that must be mastered by students. Consequently, the educational orientation across various stages of learning should emphasize the development of this competence. The objective of this study is to enhance problem-solving skills among sixth-grade students at SDN Munjul 03 through the implementation of Project-Based Learning model with a STEM (Science, Technology, Engineering, and Mathematics) approach. The research approach employed is quantitative, employing a pre-experimental design with a one-group pretest-posttest design. The research sample comprises 41 sixth-grade students at SDN Munjul 03. Data for this study were collected through observation, interviews, and tests. The findings of the research reveal that the average scores in the problem-solving skills test after the implementation of the Project-Based Learning model with the STEM approach are significantly better than before. Descriptive analysis of these results indicates a notable enhancement in problem-solving skills among students following the Project-Based Learning treatment with a STEM approach. The results of the hypothesis testing, utilizing the paired sample t-test method, also indicate that the difference between pre-treatment and post-treatment problem-solving skills test scores is statistically significant. Consequently, it can be deduced that a tangible improvement has occurred in the problem-solving abilities among the experimental class students. The conclusion drawn from this study is that the Project-Based Learning model with a STEM approach is effective in elevating problem-solving skills. The implementation of the Project-Based Learning model through the STEM approach can be regarded as one of the alternative solutions available to educators for enhancing students' problem-solving capabilities.

INTRODUCTION

The ability to solve problems holds a pivotal role of utmost importance for individuals navigating the dynamic landscape of the contemporary era, characterized by rapid advancements in science and technology. The term "problem-solving" is defined as a cognitive process involving the analysis and transformation of information guided by specific objectives, particularly when solutions are not readily apparent to those grappling with the problem (Lovett, 2002; Mayer & Wittrock, 2006; Wang & Chiew, 2010). This competency lies at the heart of Science Education, aiming to cultivate critical, logical, and problem-solving skills (Nugraha, 2022; Prastiwi, 2018).

Science education extends beyond mere comprehension of concepts; it encompasses scientific literacy, where students apply their knowledge to resolve real-life issues (Hikmawati & Ningsih, 2020). These skills are instrumental in empowering students to independently confront challenges (Usmanov, 2021). Despite the dynamic and occasionally bewildering nature of problem-solving processes for students, these processes yield satisfying outcomes (Valdez & Bungihan, 2019).

In this context, an educational paradigm shift that encourages active student engagement in the learning process is imperative. Educators should meticulously select tools and strategies suitable for imparting lessons. These tools and strategies should align with learners' characteristics and foster an enriched learning process (Lynch et al., 2001; Schroeder et al., 2007). Teachers are not merely disseminators of information; they are facilitators of learning, nurturing active student participation (Amalia et al., 2022; Muyassaroh & Nurpadilah, 2021).

The ability to solve problems necessitates high-order thinking skills. As posited by Irwanto et al. (2018), this entails an individual's capacity to generate novel solutions. However, empirical data indicates that this capability remains deficient, particularly in the context of Indonesia (OECD, 2019). Despite various instructional models and methods, learning often centers on low-order thinking skills, such as rote memorization and passive information assimilation (Tong et al., 2020). Nonetheless, in this modern era, fostering high-order thinking skills, including information analysis, idea generation, and informed decision-making, has become a priority.

One proposed solution is the adoption of the Project Based Learning (PjBL) model with a STEM (Science, Technology, Engineering, and Mathematics) approach. Prior research has demonstrated the potential of PjBL in enhancing students' problem-solving abilities (Fiteriani et al., 2021; Muzana et al., 2021; Nurhayati et al., 2021). Within the context of primary education, PjBL encourages students to solve problems through collaborative projects and investigations rooted in real-world situations (Sarwi et al., 2021; Afriana et al., 2016).

Against this backdrop, the objectives of this study are twofold: (1) to elucidate the steps of implementing PjBL with a STEM approach, and (2) to elevate problem-solving skills among elementary school students through the application of PjBL with a STEM approach. Thus, it is anticipated that this study will yield a substantial contribution to the development of effective instructional methods geared toward enhancing students' problem-solving capabilities.

METHODS

This research employed a quantitative methodology as its investigative approach. The study utilized a pre-experimental design with a one-group pretest-posttest pattern, involving a single group without a comparative group. Within this design, the assessment of problem-solving abilities was conducted twice: prior to the experiment (pre-test) and after the experiment (post-test), following the methodology outlined by Creswell (2012).

The research was conducted at SDN Munjul 03 and involved a sample of 41 sixth-grade students. The data collection approach encompassed observation, interviews, and tests. The research instruments utilized in this study consisted of an observation sheet using a rating scale format, a semi-structured interview sheet, and a test comprising 5 open-ended items directed towards problem-solving skill indicators. The test instrument was designed to offer insights into the students' ability to articulate solutions in alignment with the context of the problem.

Data analysis was carried out through inferential statistical methods, specifically the paired-sample mean difference test. The aim of this analysis was to assess the impact of the treatment, namely the application of the Project Based Learning (PjBL) model with a STEM approach in Science Education, on students' problem-solving abilities.

RESULTS AND DISCUSSION

This research focuses on enhancing students' problem-solving abilities through the implementation of the Project Based Learning (PjBL) model with a STEM approach. The instructional process spans across six sessions. Within the experimental group, learning was carried out by applying the PjBL model through the STEM approach. Through observation during the instructional process, it was revealed that the teacher effectively executed the PjBL steps with the STEM approach. The teacher managed to elicit the students' prior knowledge about alternative energy and link it to the upcoming material concepts. Furthermore, the teacher adeptly guided students in comprehending the problem and directed their investigative efforts. However, certain aspects during the "Application" phase require attention. The teacher had not completely guided students in relating the generalization of concepts to other problem situations. Motivation and appreciation for students during their project presentation and problem-solving solution still need enhancement. Students also have not fully grasped the underlying scientific concepts of the project and encountered confusion in systematically planning project execution. Additionally, the students' confidence level in presenting project outcomes remained limited.

Based on the identified constraints during the initial sessions, the researcher made adjustments and improvements to the subsequent instructional planning. Significant improvements were observed in the subsequent instructional sessions. Students were proficient in articulating the fundamental scientific concepts underlying the problem-solving project. Furthermore, students' self-confidence experienced tangible growth, supported by the motivation and guidance provided by the teacher.

Table 1. Data on Pre-Test and Post-Test Results

		Pre-Test	Post-Test
N	Valid	41	41
	Missing	0	0
Mean		44.95	79.37
Median		40.00	80.00
Std. Deviation		19.607	12.581
Range		70	51
Minimum		10	49
Maximum		80	100
Sum		1843	3254

To gather data on problem-solving abilities, a test was conducted twice, namely before (pre-test) and after (post-test) the intervention. The results of the pre-test and post-test problem-solving abilities are presented in Table 1.

Based on the information presented in Table 1, it is evident that there are average pretest and posttest data for the experimental class implementing the Project Based Learning model with a STEM approach. The average pretest score was found to be 44.95, while the average posttest score reached 79.37. Descriptively, this data indicates an improvement in students' problem-solving abilities after being subjected to treatment using the Project Based Learning model through the STEM approach. This improvement can be observed from the score difference between the posttest and pretest, which amounted to 34.42.

To examine whether a significant improvement in students' problem-solving abilities before and after the implementation of PjBL through the STEM approach exists, data analysis was conducted using the paired sample t-test. The analyzed data demonstrated that the data distribution is normal and possesses homogeneity of variance, satisfying the prerequisites for performing the paired sample t-test. The results of this test are provided in Table 2.

Table 2. Result of Paired Samples Test

		Paired Differences			t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Pair 1	pretest - posttest	-34.415	17.513	2.735	-12.583	40	.000

The results from the t-test, as presented in Table 2, reveal that the value of α is greater than 0.05 or 0.000 < 0.05. Therefore, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. This signifies that there is a significant difference between the test scores of problem-solving abilities before and after the intervention. Referring to the data in Table 1, it can be deduced that the average test score after the intervention is higher, indicating an improvement in problem-solving abilities among the experimental class students.

The findings from this study demonstrate that the Project Based Learning (PjBL) model implemented through the STEM approach effectively enhances students' problem-solving abilities. These results are in line with previous research conducted by Solong et al. (2022) and Winayah (2022), both of which indicate that the project-based learning model has a positive impact on students' problem-solving skills. The success in problem-solving is heavily influenced by students' thinking skills (Hafizah et al., 2018). Solving problems involves a thinking process that integrates various concepts and prior knowledge, rather than relying solely on a single approach (Ardiyaningrum & Retnowati, 2019). This process encompasses five stages: problem focus, concept description, solution planning, plan implementation, and solution evaluation (Gunawan et al., 2020). Thus, problem-solving skills require a deep understanding of concepts and higher-order thinking abilities (Hermansyah et al., 2019; Wawat, 2022). Creative and critical thinking skills are foundational for students to effectively tackle problems. Creative thinking is vital in generating ideas to address issues (Yayuk et al., 2020), while critical thinking serves as a basis for information retrieval. These skills aren't innate but need to be nurtured and cultivated through education, particularly within the learning process.

Problem-solving, from a psychological perspective, is seen as a situation containing challenges that prompt individuals to seek solutions. The path to finding solutions isn't confined to a single step; instead, it requires a multifaceted approach (Posamentier & Krulik, 2009; Seligman et al., 2009). While

problems are resolved to achieve defined goals, the process isn't accomplished through rote memorization of rules or predefined solutions (Schoenfeld, 2016; Schunk, 2012; Van de Walle et al., 2015). Problem-solving is a critical objective. Brookhart & Nitko (2014) explain that without critical thinking, tasks accomplished without substantial cognitive processing cannot be categorized as problem-solving; they are merely "no-brainers." Often, students struggle with problem-solving due to their unfamiliarity with learning materials and activities that demand higher-order thinking (Nurwulandari & Rofiq, 2021; Ridwan et al., 2023). Learning activities involving strategies and student engagement in problem-solving are vital to create meaningful education (Nur et al., 2022). Mashluhah et al. (2019) assert that science education necessitates a project-based learning model. Project Based Learning presents real-world problems related to concepts, enabling students to experiment and investigate (Sarwi et al., 2021). In this context, the STEM approach stands out as an appropriate instructional strategy for science education (Muzana et al., 2021). STEM education integrates Science, Technology, Engineering, and Mathematics. Implementing STEM encourages students to design, develop, utilize technology, sharpen cognitive and manipulative skills, and apply knowledge. Utilizing the PjBL model through the STEM approach has been substantiated in numerous studies to improve the quality of education, effectively enhancing students' problem-solving abilities (Nurhayati et al., 2021; Nurmaliah et al., 2021; Parno et al., 2020; Sarwi et al., 2021), creativity in problem-solving, metacognitive skills (Fiteriani et al., 2021), as well as aiding students in planning, communicating, problem-solving, and making informed decisions (Susanti et al., 2021). Laboy-rush (2010) adds that PjBL through the STEM approach yields benefits such as enhancing mastery and practical application of concepts, increasing student motivation, and elevating achievements in science and mathematics. These findings align with the perspective of Nurhayati et al. (2021), indicating that the collaborative approach of the PjBL model combined with STEM education provides opportunities for students to learn science by applying real-world problem-solving techniques. The collaboration of the PjBL model and STEM education assists students in collecting, analyzing, and solving problems while understanding the interconnections between various problems.

CONCLUSION

The findings of this study indicate a significant increase in the average scores of students' problem-solving abilities after being exposed to the intervention using the Project Based Learning model through the STEM approach, as compared to their performance prior to the intervention. This improvement is evident both descriptively and substantially, underscoring the enhanced problem-solving capabilities of students following the implementation of the Project Based Learning model with the STEM approach. The results of the hypothesis test, conducted through the paired sample t-test, also validate the presence of a significant difference between the pre-intervention and post-intervention scores of students' problem-solving abilities. Hence, it can be inferred that there has been a noteworthy enhancement in the problem-solving skills of the experimental class students.

In conclusion, the entirety of this study's results leads to the deduction that the implementation of the Project Based Learning model through the STEM approach proves effective in advancing students' problem-solving abilities. The application of Project Based Learning (PjBL) through the STEM approach emerges as a pertinent alternative solution for educators aiming to elevate students' problem-solving skills. This conclusion aligns with previous research findings that highlight the effectiveness of this model in enhancing students' problem-solving capabilities.

REFERENCES

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project based learning integrated to stem to enhance elementary school's students scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493

Amalia, A., Sucipto, & Hilyana, F. S. (2022). Konsentrasi Belajar Siswa Pada Mata Pelajaran IPA. *Jurnal Educatio FKIP UNMA*, *8*(4), 1261–1268. https://doi.org/10.31949/educatio.v8i4.3120

Ardiyaningrum, M., & Retnowati, T. H. (2019, December). Online Measurement to Assess A Problem Solving Skills Based on Multimedia Instrument. In *Journal of Physics: Conference Series* (Vol. 1339, No. 1, p. 012065). IOP Publishing.

Brookhart, S. M., & Nitko, A. J. (2014). *Educational assessment of students*. Pearson Higher Ed.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson Education, Inc.

Fiteriani, I., Diani, R., Hamidah, A., & Anwar, C. (2021). Project-based learning through STEM approach: Is it effective to improve students' creative problem-solving ability and metacognitive skills in physics learning? *IOP Conference Series: Earth and Environmental Science*, *1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012058

Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving students' problem-solving skills using inquiry learning model combined with advance organizer. *International Journal of Instruction*, *13*(4), 427–442. https://doi.org/10.29333/iji.2020.13427a

Hafizah, E., Putri, R. F., & Annur, S. (2018). Hubungan Kemampuan Pemecahan Masalah. *Seminar Nasional Pendidikan*, 185¯ 189.

Hermansyah, H., Gunawan, G., Harjono, A., & Adawiyah, R. (2019). Guided inquiry model with virtual labs to improve students' understanding on heat concept. *Journal of Physics: Conference Series*, *1153*(012116), 1–5. https://doi.org/10.1088/1742-6596/1153/1/012116

Hikmawati, V. Y., & Ningsih, Y. S. (2020). Blended-problem based learning: critical thinking skills and information literacy in cell learning. *Jurnal Bioedukatika*, *8*(2), 122. https://doi.org/10.26555/bioedukatika.v8i2.14315

Irwanto, Saputro, A. D., Rohaeti, E., & Prodjosantoso, A. K. (2018). Promoting critical thinking and Problem Solving Skills of Preservice Elementary Teachers through Process-Oriented Guided-Inquiry Learning (POGIL). *International Journal of Instruction*, *11*(4), 777–794. https://doi.org/10.12973/iji.2018.11449a

Laboy-rush, D. (2010). *Integrated STEM Education through game-Project-Based Learning*. https://doi.org/10.51272/pmena.42.2020-381

Lovett, M. C. (2006). Problem solving. *Encyclopedia of cognitive science*.

Lynch, S., Kuipers, J., Pyke, C., & Szesze, M. (2001). Examining the effects of a highly rated science curriculumun on diverse students: Results from a planning grant. *Journal of Research in Science Teaching*, 42, 921-946.

Mashluhah, M. I., Prahani, B. K., Suryanti, S., & Jatmiko, B. (2019). The effectiveness of OrDeP2E learning model to train the natural science problem-solving skills of primary school students. *Journal of Physics: Conference Series*, *1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022011

Mayer, R. E., Runco, M. A., & Pritzker, S. R. (1999). Problem solving. *Handbook of Educational Psychology*, 2, 287-303.

Muyassaroh, I., & Nurpadilah, D. (2021). Implementasi Problem Based Learning dengan Pendekatan Saintifik Dalam Peningkatan Kemampuan Berpikir Kritis Siswa Kelas IV SD. *Dikoda: Jurnal*

Pendidikan Sekolah Dasar, *2*(2), 23–31. https://jurnal.pelitabangsa.ac.id/index.php/JPGSD/article/view/994

Muzana, S. R., Jumadi, Wilujeng, I., Yanto, B. E., & Mustamin, A. A. (2021). E-STEM project-based learning in teaching science to increase ICT literacy and problem solving. *International Journal of Evaluation and Research in Education*, *10*(4), 1386–1394. https://doi.org/10.11591/IJERE.V10I4.21942

Nugraha, I. D. (2022). Students' Mathematical Problem-Solving Ability on Social Arithmetic Material. *Journal of Innovation and Research in Primary Education*, *1*(2), 33–39. https://doi.org/10.56916/jirpe.v1i2.171

Nur, A. S., Kartono, K., Zaenuri, Z., & Rochmad, R. (2022). The learning trajectory construction of elementary school students in solving integer word problems. *Participatory Educational Research*, *9*(1), 404–424. https://doi.org/10.17275/per.22.22.9.1

Nurhayati, Priatna, N., & Juandi, D. (2021). Improving students' mathematical problem solving abilities through online project-based learning models with the STEM approach. *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012213

Nurmaliah, C., Azmi, T. N., Safrida, Khairil, & Artika, W. (2021). The impact of implementation of STEM integrating project-based learning on students' problem-solving abilities. *Journal of Physics: Conference Series*, *1882*(1). https://doi.org/10.1088/1742-6596/1882/1/012162

Nurwulandari, I., & Rofiq, M. A. (2021). Developing HOTS-based Model to Improve Mathematical Problem Solving Skill of Elementary School Teacher Education (PGSD) Students. *Journal of Physics: Conference Series*, *1842*(1), 012043. https://doi.org/10.1088/1742-6596/1842/1/012043

OECD. (2019). PISA 2018 Results. In *OECD Publishing*. https://doi.org/10.1787/g222d18af-en

Parno, Yuliati, L., Munfaridah, N., Ali, M., Rosyidah, F. U. N., & Indrasari, N. (2020). The effect of project based learning-STEM on problem solving skills for students in the topic of electromagnetic induction. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022025

Posamentier, A. S., & Krulik, S. (Eds.). (2009). *Problem solving in mathematics, grades 3-6: powerful strategies to deepen understanding*. Corwin Press.

Prastiwi, M. D. (2018). Kemampuan Pemecahan Masalah pada Siswa Kelas VII SMP. *E-Journal-Pensa*, *6*(02), 98–103.

Purwaningsih, E., Sari, A. M., Yuliati, L., Masjkur, K., Kurniawan, B. R., & Zahiri, M. A. (2020). Improving the problem-solving skills through the development of teaching materials with STEM-PjBL (science, technology, engineering, and mathematics-project based learning) model integrated with TPACK (technological pedagogical content knowledge). *Journal of Physics: Conference Series*, *1481*(1), 0–7. https://doi.org/10.1088/1742-6596/1481/1/012133

Ridwan, M. F. A., Anjarini, T., & Ngazizah, N. (2023). Multimedia Interaktif Berbasis Problem Based Learning Pada Materi Ciri–Ciri Makhluk Hidup Bagi Siswa Sekolah Dasar. *Edukasiana: Jurnal Inovasi Pendidikan*, *2*(1), 56–63. https://doi.org/10.56916/ejip.v2i1.218

Sarwi, S., Baihaqi, M. A., & Ellianawati, E. (2021). Implementation of Project Based Learning Based on STEM Approach to Improve Students' Problems Solving Abilities. *Journal of Physics: Conference Series*, *1918*(5). https://doi.org/10.1088/1742-6596/1918/5/052049

Schoenfeld, A. H. (2016). Research in mathematics education. *Review of Research in Education*, *40*(1), 497-528.

Schroeder, R.G., Linderman, K.W., & Choo, A.S. (2007). Method and context perspectives on learning and knowledge creation in quality management. *Journal of Operations*, 25(4), 918-931. https://doi.org/10.1016/j.jom.2006.08.002

Schunk, D. H. (2012). *Learning theories an educational perspective*. Pearson Education, Inc.

Seligman, M. E., Ernst, R. M., Gillham, J., Reivich, K., & Linkins, M. (2009). Positive education: Positive psychology and classroom interventions. *Oxford review of education*, *35*(3), 293-311.

Solong, A., Nasir, M., & Ferawati, F. (2022). Pengaruh Model Pembelajaran Project Based Learning (PJBL) Terhadap Kemampuan Pemecahan Masalah Siswa SMPN 5 Kota Bima Tahun Pelajaran 2022/2023. *JUPENJI: Jurnal Pendidikan Jompa Indonesia*, *1*(3), 12-17.

Susanti, E., Maulidah, R., & Makiyah, Y. S. (2021). Analysis of problem-solving ability of physics education students in STEM-based project based learning. *Journal of Physics: Conference Series*, *2104*(1), 0–6. https://doi.org/10.1088/1742-6596/2104/1/012005

Tong, D. H., Loc, N. P., Uyen, B. P., & Truc, C. Le. (2020). A case study of developing students' problem-solving skills through addressing real-world problems related to fractions in primary schools. *International Journal of Scientific and Technology Research*, *9*(2), 2809–2818.

Usmonov, M. (2021). Problem Solving In Primary Schools. *Scienceweb academic papers collection*.

Valdez, J. E., & Bungihan, M. E. (2019). Problem-based learning approach enhances the problem solving skills in chemistry of high school students. *JOTSE*, *9*(3), 282-294.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2015). *Elementary and middle school mathematics: Teaching developmentally*. Pearson.

Wan, Z. H., So, W. M. W., & Zhan, Y. (2022). Developing and Validating a Scale of STEM Project-Based Learning Experience. *Research in Science Education*, *52*(2), 599–615. https://doi.org/10.1007/s11165-020-09965-3

Wang, Y., & Chiew, V. (2010). On the cognitive process of human problem solving. *Cognitive systems research*, *11*(1), 81-92.

Wawat, W. (2022). Meningkatkan Kemampuan Pemecahan Masalah Siswa Dengan Menerapkan Model Problem Posing. *Edukasiana: Jurnal Inovasi Pendidikan*, *1*(2), 59–65. https://doi.org/10.56916/ejip.v1i2.19

Winayah, S. (2022). *Pengaruh Model Pembelajaran Project Based Learning (PjBL) Terhadap Kemampuan Memecahkan Masalah Peserta Didik Pada Mata Pelajaran IPA Kelas 5 MI Mazro'atul Huda Bonang Demak* (Doctoral dissertation, IAIN KUDUS).

Yayuk, E., Purwanto, As'Ari, A. R., & Subanji. (2020). Primary school students' creative thinking skills in mathematics problem solving. *European Journal of Educational Research*, *9*(3), 1281–1295. https://doi.org/10.12973/eu-jer.9.3.1281