The Effectiveness of STEAM-Based Science Learning to Improve Students' Problem-Solving Skills

Joko Siswanto[1*], Binar Kurnia Prahani[2], Indah Suminar[3], Suyidno Suyidno[4]

[1]Universitas PGRI Semarang, Indonesia
[2]Universitas Negeri Surabaya, Indonesia
[3]UIN Salatiga, Indonesia
[4]Universitas Lambung Mangkurat, Indonesia

*jokosiswanto@upgris.ac.id

Abstract. Problem-solving skills need to be taught to students at school. One type of learning that is considered appropriate for teaching problem solving skills is STEAM learning. The aim of this research is to analyze the effectiveness of STEAM-based science learning to improve students' problem-solving skills. The research method used was pre-experiment with a one group pre-test and post-test design. The data collection technique in this research uses tests, with instruments in the form of problem-solving skills test questions. The data that has been collected is then analyzed using paired t test statistics (α = 5%) and n-gain. The research results show that STEAM-based science learning effectively improves students' problem-solving skills with moderate criteria. Furthermore, research can be carried out by paying attention to students' initial abilities, including science process skills and using computers.

Keywords: science learning, STEAM, problem-solving skills

1 Introduction

One important part of the science learning process is problem solving. As many people know, problem solving has become a tradition and a goal to be achieved in science learning [1]. Problem-solving is necessary and important for life, and students must learn to problem-solve [2, 3]. Many studies have revised curricula to include integrated learning environments that encourage the use of higher-order thinking skills, especially problem-solving. Problem-solving has become a tradition in science learning and provides the experience needed for employment after graduation [4].

Among the skills of the 21st century, problem solving is a skill that students need to learn as a means of life. According to Greenstein [5], 21st century skills are grouped into 3, namely thinking skills (critical thinking and problem solving, creative thinking, and metacognitive); action skills (collaboration, communication, digital literation, and technology); and life skills (citizenship, global understanding, career readiness, and leadership). If students can apply their knowledge to solve problems, then it can be said

J. Handhika et al. (eds.), *Proceedings of the 4th International Conference on Education and Technology (ICETECH 2023)*, Atlantis Highlights in Social Sciences, Education and Humanities 25,
https://doi.org/10.2991/978-94-6463-554-6_64

that they are successful in learning science [3, 6]. This means that students master one of the thinking skills of the 21st century.

In order to master problem solving skills, students need to learn them. Apart from that, the role of the teacher is also important, namely teaching, training and getting used to problem solving. Indicators of problem-solving skills consist of understanding the problem, preparing a problem-solving plan, carrying out action, and evaluating. In solving science problems, it is necessary to focus more on conceptual aspects, providing motivation, and applying knowledge and understanding to solving problems related to everyday situations [8, 9]. Through learning, science teachers can facilitate students applying knowledge and understanding to real situations through the visualization process to connect with the right equations to solve problems. One learning that can facilitate student problem-solving is STEAM-based learning.

A learning approach that connects knowledge and skills in science, technology, engineering, arts, and mathematics with the goal of solving problems is STEAM-based learning [10]. Many previous studies have integrated the STEAM approach into the Problem Based Learning (PBL) model and the results have been satisfactory. As is known, PBL uses authentic and unstructured problems. In addition, the problems given are open-ended so they are expected to support problem-solving skills [11]. Problem solving activities in the context of science, technology, engineering, arts and mathematics can be achieved through learning phases that integrate the STEAM approach and the PBL model. These phases are: phase 1, orienting students to STEAM problems; phase 2, organizing students to learn; phase 3, guiding students in carrying out investigations individually or in groups; phase 4, developing and presenting results; and phase 5, analyzing and evaluating the problem-solving process that has been carried out [10]. Activities such as identifying and analyzing through aspects of science and mathematics as well as producing projects that use technological, engineering and artistic aspects of given problems, are the main characteristics of the STEAM learning approach [12, 13]. Projects are created according to solutions to problems that are or have occurred. The concept of the STEAM approach is student-centered learning; project-based, collaborative, design, and cooperative to encourage comprehensive education [14, 15, 16]. In this paper, the effectiveness of STEAM-based science learning for improving problem-solving skills will be described.

2 Method

The research method used in this research is a pre-experimental method using a one group pre-test – post-test design, namely: O1 X O2 [17]. In its implementation, students are first given a pre-test (O1) regarding problem solving skills, before learning. Then, STEAM-based science learning was implemented in class (X). Then, at the end of the lesson, a post-test (O2) of problem-solving skills is carried out. This research was conducted on 60 students (VIII-B and VIII-C) who were the research sample, who were studying science in the even semester of the 2022/2023 academic year. The sample was determined using a cluster random sampling technique. This technique is easier to apply in groups and does not take time [17].

The data collection technique in this research uses tests. The questions used in the test are prepared using indicators of problem-solving skills. In this research, the data that has been collected is then analyzed using the paired sample t-test (α = 5%) and calculating the average n-gain [18, 19]. The paired t test was used to analyze the difference in the average scores of pre-test and post-test problem solving skills. Meanwhile, calculating the average n-gain is used to categorize the increase in problem solving skills into high, medium and low. Through these data analysis techniques, the effectiveness of STEAM-based science learning will be known to improve students' problem-solving skills.

3 Result and Discussion

In Figure 1, the pre-test and post-test scores of students' problem-solving skills are presented. Pre-test scores are presented in unshaded bars, while post-test scores are in shaded bars.

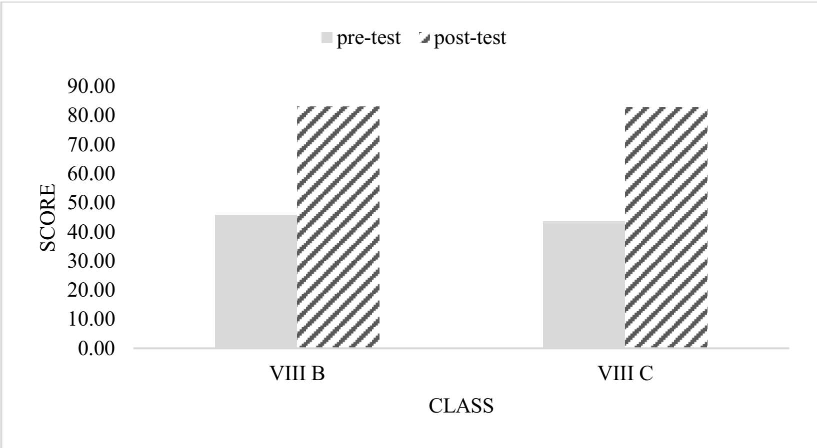

Fig. 1. Student problem solving skills score (average of pre-test and post-test scores)

Based on Figure 1, it can be seen the difference in the average scores of students' pre-test and post-test problem-solving skills. The post-test score is higher or better than the pre-test score. Next, to determine the effectiveness of the applied STEAM-based science learning, data analysis was carried out using the paired t test and calculating the average n-gain. Table 1, Table 2, and Table 3 present a summary of the data analysis.

Table 1. Results of normality and homogeneity calculations of data

Class	Test	∑ student	Average	Normality (α = 0.05)		Homogeneity (α = 0.05)	
				Asymp. Sig. (2-tailed)	Normally Distributed	Asymp. Sig. (2-tailed)	Homoge-nous
VIII-B	Pre	30	45.85	0.052	Yes	0.954	Yes
	Post	30	83.06	0.200	Yes		
VIII-C	Pre	30	43.65	0.140	Yes	0.603	Yes
	Post	30	82.86	0.079	Yes		

Table 2. Paired t-test results of students' problem-solving skills scores

Class	Test	∑ student	Average	Paired t-test (α = 0.05)		
				t	p	Decision
VIII-B	Pre	30	45.85	-64.83	< 0.001	Ho was rejected
	Post	30	83.06			
VIII-C	Pre	30	43.65	-52.26	< 0.001	Ho was rejected
	Post	30	82.86			

Table 3. Results of n-gain calculations on students' problem-solving skills

Class	Test, n-gain	Problem-solving skills indicators				n-gain
		Identification	Set-Up	Execute	Evaluation	
VIII-B	Pre	1.28	0.92	0.79	0.62	0.60
	Post	2.43	2.04	2.02	1.82	
	n-gain	0.70	0.62	0.58	0.51	
VIII-C	Pre	1.28	1.14	0.78	0.67	0.62
	Post	2.53	2.29	2.05	1.94	
	n-gain	0.72	0.63	0.57	0.56	

Analysis of the normality and homogeneity of research data (average pre-test and post-test scores of students' problem-solving skills) shows that the data is normally distributed and homogeneous (Table 1). These results meet the requirements for conducting a paired t-test. From the results of the paired t test that was carried out, a p-value <0.001 was obtained for classes VIII-B and VIII-C (Table 2). This means that there is a significant difference between the pre-test and post-test scores of students' problem solving-skills. Table 2 also shows that the average post-test score is greater than the average pre-test score. This means that there is a significant increase in the average score (α = 5%) from the average of the pre-test and post-test. This shows an increase in students' problem-solving skills after being given STEAM-based science learning.

The increase in students' problem-solving skills can also be seen from each indicator, as presented in Table 3. Each indicator of students' problem-solving skills has increased, and the average n-gain score for both classes is 0.60 (in the medium criteria) and 0.62 (in the medium criteria) in medium criteria). The highest increase occurred in problem identification skills. This supports the results of previous research that problem identification skills are the key to success in the problem-solving process [6].

The results of research data analysis show that STEAM-based science learning is effective in improving students' problem-solving skills. This is in accordance with the characteristics of STEAM-based learning, namely that it is contextual and based on problems so that it can train students' problem-solving abilities by identifying and analyzing activities through aspects of science and mathematics, and can produce projects that utilize aspects of technology, engineering and art in their creation [12, 13]. Projects are created according to solutions to current or existing problems, student-centered and collaborative to encourage comprehensive education [14, 15, 16].

This is in line with STEAM which can train and improve students' skills in solving problems [20, 21, 22]. In phase 2, giving questions with a STEAM nuance using a collaborative setting allows students to develop collaboration skills in solving problems. Problem solving activities start from facilitating learning needs or organizing students to study (phase 2) and guidance in individual and group investigations (phase 3). Then, provide opportunities for students to practice communication skills regarding problem solving results, through developing and presenting results (phase 4). Then evaluate the results to determine the suitability of the solution and problem. The integration of STEAM in learning provides new opportunities for students to develop good problem-solving skills [23].

The research results also show that every indicator of problem-solving skills has increased. This provides additional evidence to previous studies that STEAM-based science learning syntax through the PBL model can train every indicator of problem solving. However, in the learning process there are a few obstacles related to students' initial abilities. These abilities are related to the skills of carrying out investigations/scientific process skills and using computers. It is necessary to make initial efforts to provide science process skills and use of computers.

4 Conclusion

The research results show that STEAM-based science learning effectively improves students' problem-solving skills with moderate criteria. Each indicator of problem-solving skills experienced a significant increase, with moderate criteria. Furthermore, research can be carried out by paying attention to students' initial abilities, including science process skills and using computers.

References

1. Rojas, S.: Enhancing the process of teaching and learning physics via dynamic problem-solving strategies: a proposal. Revista Mexicana de Fisica, 58(2), 7-17 (2012).
2. Phumeechanya, N., Wannapiroon, P.: Design of problem-based with scaffolding learning activities in a ubiquitous learning environment to develop problem-solving skills. Procedia - Social and Behavioral Sciences, 116, 4803-4808 (2014).
3. Bellanca, J., Brandt, R.: 21st century skills: Rethinking how students learn. Solution Tree Press, Bloomington (2010).
4. Heller, K., Heller, P.: Cooperative problem-solving in physics. The National Science Foundation University of Minnesota and the U.S. Department of Education, Minnesota (2010).
5. Greenstein, L.: Assessing 21st Century Skills: A Guide to Evaluating Mastery and Authentic Learning. Sage, Corwin. (2012)

6. Siswanto, J., Susantini, E., Jatmiko, B.: Practicality and effectiveness of the ibmr teaching model to improve physics problem-solving skills. Journal of Baltic Science Education, 17(3), 381-394 (2018).
7. Selcuke, GS., Caliskan, S., Erol, M.: The effects of problem-solving instruction on physics achievement, problem-solving performance, and strategy use. Latin American Journal of Physical Education, 2 (3), 151-166 (2008).
8. Taasoobshirazi, G., Farley, J.: A multivariate model of physics problem-solving. Learning and Individual Differences,24, 53-62 (2013).
9. Walsh, LN., Howard, RG., Bowe, B.: Phenomenographic study of students' problem-solving approaches in physics. Physical Review Special Topics - Physics Education Research, 3(1), 1 – 12 (2007).
10. Sari, SN., Nurdianti, D., Maulana, BS.: Telaah pengintegrasian STEAM pada Model Problem Based Learning Terhadap Adversity Quotient Siswa dalam Pembelajaran Matematika. Prisma 5, 598-605 (2022).
11. Hosnan, M., Pendekatan saintifik dan kontekstual dalam pembelajaran abad 21. Ghalia Indonesia, Bogor (2014).
12. Putri, SU., Taqiudin, AA.: Steam-PBL: Strategi Pengembangan Kemampuan Memecahkan Masalah Anak Usia Dini. Jurnal Obsesi. 6 (2) 856-867 (2022).
13. Tan, WL., Samsudin, MA., Ismail, M E., Ahmad, NJ., Talib, C.: A. Exploring the Effectiveness of STEAM Integrated Approach via Scratch on Computational Thinking. Eurasia Journal of Mathematics, Science and Technology Education, 17(12), 99-112 (2021).
14. Cook, KL., Bush, SB.: Design thinking in integrated STEAM learning: Surveying the landscape and exploring exemplars in elementary grades. School Science and Mathematics, 118(4), 93–103 (2018).
15. Nuragnia, B., Nadiroh, Usman, H. Pembelajaran STEAM Di Sekolah Dasar : Implementasi dan Tantangan. Jurnal Pendidikan dan Kebudayaan, 6(2), 187–197 (2021).
16. Estriyanto, Y. Menanamkan Konsep Pembelajaran Berbasis STEAM (Science, Technology, Engineering, Art, And Mathemathics) pada Guru-Guru Sekolah Dasar di Pacitan. Jurnal Ilmiah Pendidikan Teknik dan Kejuruan, 13(2), 87-96 (2020).
17. Fraenkel, JR., Wallen, NE.: How to Design and Evaluate Research in Education. Mc.Graw-hill: Boston (2012)
18. Gibbons, JD., Chakraborti, S.: Nonparametric statistical inference (5 edition). CRC Press, Tuscaloosa (2011).
19. Hake, R.: Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66 (1), 64-74 (1998)
20. Wijaya, AD., Karmila, N., Mahmudah, R.: Implementasi Pembelajaran Berbasis STEAM (Science, Technology, Engineering, Arts, and Mathematics) pada Kurikulum Indonesia. Prosiding Seminar Nasional Fisika Dan Aplikasinya, 85–88 (2015).
21. Budiyono, A., Hotimatul H., Arin W. Pengaruh Penerapan Model Pbl Terintegrasi Steam Terhadap Kemampuan Berpikir Kreatif Ditinjau Dari Pemahaman Konsep Siswa. Edusains, 12(2), 2020, 166-176 (2020).
22. Niam, M., Asikin, M. Pentingnya aspek stem dalam bahan ajar terhadap pembelajaran matematika. PRISMA, Prosiding Seminar Nasional Matematika, 4, 329-335 (2021).
23. Buinicontro, J K.: Gathering STE(A)M: Policy, Curricular, and Programmatic Developments in Arts-Based Science, Technology, Engineering, and Mathematics Education, Introduction to Special Issue of Art Education Policy Review: STEAM Focus, Art Education Policy Review-Journal, 119(1), 73-76 (2018).