

Cultivating creative thinking and problem-solving in high school through the STEM-6E learning model

Safira Nurishita Sugiarto^{a, 1}, Bea Hana Siswati^{a, 2*}, Nadia Fatimah Az Zahra^{a, 3}, Aulia Fitrotun Nurullah^{a, 4}

^{a,b,c,d} Biology Education, Faculty of Teacher Training and Education, Universitas Jember,
Jl. Kalimantan No. 37. Kabupaten Jember, Jawa Timur 68121, Indonesia

¹nurishita16@gmail.com; ²beahana.fkip@unej.ac.id*; ³nadiazahra069@gmail.com;
⁴auliafitrotunn@gmail.com

*author correspondences

Informasi artikel	ABSTRAK
Article history: Received May 13, 2023 Revised September 21, 2023 Accepted December 30, 2023	Penelitian ini dilakukan karena kemampuan berpikir kreatif dan <i>problem solving skill</i> yang masih rendah di Indonesia. Tujuan penelitian ini adalah untuk mengetahui pengaruh STEM-6E <i>Learning Model</i> terhadap kemampuan berpikir kreatif dan <i>problem solving skill</i> siswa SMA di Jember. Metode yang digunakan dalam penelitian ini adalah kuasi eksperimen dengan <i>pretest-posttest control group design</i> . Populasi dalam penelitian ini adalah siswa SMAN 2 Jember dengan sampel siswa kelas X yang terdiri dari 61 siswa. Kelompok kelas eksperimen diberi perlakuan STEM-6E <i>Learning Model</i> sedangkan kelas kontrol menggunakan pembelajaran konvensional. Pelaksanaan pembelajaran terdiri dari beberapa tahapan: <i>engage, explore, explain, engineer, enrich</i> , dan <i>evaluate</i> . Data dikumpulkan melalui hasil nilai <i>pre-test</i> dan <i>post-test</i> . Selanjutnya data dianalisis secara kuantitatif dan kualitatif. Kemudian membandingkan hasil belajar kedua kelompok untuk mengetahui pengaruh STEM-6E <i>Learning Model</i> terhadap keterampilan berpikir kreatif dan <i>problem solving skill</i> . Hasil menunjukkan bahwa skor signifikan 0,00 baik data keterampilan berpikir kreatif maupun <i>problem solving skill</i> . Dapat disimpulkan bahwa STEM-6E <i>Learning Model</i> berpengaruh signifikan terhadap kemampuan berpikir kreatif dan <i>problem solving skill</i> siswa SMA Jember.
Kata kunci: Model pembelajaran STEM-6E Berpikir Kreatif Kemampuan Pemecahan Masalah	
	ABSTRACT
Keywords: STEM-6E Learning Model Creative Thinking Problem Solving Skill	Cultivating creative thinking and problem-solving in high school students through the STEM-6E learning model. This study is motivated by Indonesia's weak ability to think creatively and problem solving. The aim of this study was to determine the effect of STEM-6E learning model for Jember High School students on students' creative thinking and problem solving. The population in this study were students of SMAN 2 Jember with a sample of class X students consisting of 61 students. The experimental class group was given the STEM-6E Learning Model treatment while the control class used conventional learning. Implementation of learning consists of several stages; <i>engage, explore, explain, engineer, enrich</i> , and <i>evaluate</i> . Data was collected

through pretest and posttest. Data were analyzed quantitative and qualitative. We then compared the learning outcomes of the two classes to determine the impact of the STEM-6E Learning Model on creative thinking and problem solving skill. As a result, the significant value is 0.00. The average posttest score experimental class is higher than control class. It can be conclusion that the STEM-6E learning model has significant impact on the creative thinking and problem solving skill of Jember High School students.

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



INTRODUCTION

The development of the 21st century requires students to possess a variety of essential skills, one of which is creative thinking ability. Creative thinking is the capacity to analyze new information and generate unique ideas to solve problems (Moma, 2015). Students with creative thinking skills tend to solve problems by engaging with factual data processing (Fitriyah et al., 2015). An important aspect of creative thinking is the ability to connect various bodies of knowledge (Handoko, 2017). Creative thinking needs to be continuously practiced by integrating it into problem-solving activities.

Problem-solving is the ability to investigate an issue and develop effective solutions. It represents a specific cognitive process through which students attempt to address real-life challenges (Husna & Burais, 2018). Problem-solving skills require students to analyze, identify, define, and understand problems while also developing a plan to resolve them (Setiyowati et al., 2018). Today, the goal of quality education goes beyond simply achieving grades as graduation requirements; it also emphasizes comprehensive understanding alongside 21st-century skills. Therefore, appropriate learning methods are needed to prioritize these competencies.

However, the critical thinking abilities of Indonesian high school students remain relatively low, which also affects their ability to solve problems (Siswati et al., 2024). The Global Creativity Index reported that Indonesia ranks 115th out of 139 countries, which may be attributed to the lack of opportunities for teachers to train students' creative thinking skills. Similarly, the PISA (Programme for International Student Assessment) 2018 results revealed that problem-solving skills in Indonesia were still low, placing the country 62nd out of 70 participating nations. These findings indicate that the current learning system in Indonesia has not been able to sufficiently improve students' creative thinking and problem-solving skills. One of the reasons is that traditional lecture-based teaching methods are still predominantly used. Continuous use of lecture methods tends to make students passive and disengaged (Laksana et al., 2019). Therefore, teachers must apply learning models aligned with students' characteristics and learning materials to create an engaging classroom environment that stimulates active participation (Rini et al., 2017). This, in turn, is expected to enhance students' creative thinking and problem-solving abilities.

One promising approach that can be utilized is STEM education, which integrates Science, Technology, Engineering, and Mathematics into real-world problem-solving contexts. STEM-based education emphasizes dynamic interactions between teachers and students, fostering a collaborative learning environment. It promotes contextual approaches that link theoretical concepts with real-world applications, encouraging critical thinking and problem-solving through engineering design challenges

(Khuyen et al., 2024). The use of STEM in education is vital, as it prepares students for future careers by strengthening critical skills and problem-solving abilities, while also fostering global innovation by generating new ideas and technologies. Furthermore, STEM education enhances comprehensive understanding and engagement for learners across diverse backgrounds (Siswati et al., 2024). Integrated STEM learning emphasizes conceptual understanding, critical thinking, creative thinking, and collaborative learning (Wahono et al., 2020).

The implementation of STEM frequently involves specific approaches or learning models, one of which is the 6E Learning Model. The 6E Learning Model was specifically designed for STEM education (Burke, 2014). The integration of STEM with the 6E framework makes learning more comprehensive, inclusive, and structured while strengthening the roles of technology and engineering in STEM (Chung et al., 2018). The 6E model consists of six phases: Engage, Explore, Explain, Engineer, Enrich, and Evaluate (Wahono et al., 2021). The Engage phase serves to spark curiosity by connecting real-life problems with the lesson topic. The Explore phase allows students to investigate the learning material through hands-on experiences, such as group worksheet activities. In the Explain phase, students present and discuss their findings. The Engineer phase provides opportunities for students to design products that address identified problems. During the Enrich phase, students deepen their conceptual understanding and apply it to various contexts. Finally, in the Evaluate phase, teachers assess students' progress and responses to determine the extent of their learning. Through the STEM approach, students are encouraged to solve various complex problems, conduct experiments, and analyze the results independently. This process requires them to think deeply to find the right solution, thus honing their critical thinking skills in problem-solving (Zalsa et al., 2025).

Based on the background described above, it is evident that education in Indonesia requires both 21st-century skills and comprehensive knowledge, integrating STEM approaches to foster students' interest in science, technology, engineering, and mathematics. Therefore, this study aims to enhance creative thinking skills and problem-solving abilities of students through the implementation of the STEM-6E Learning Model.

METHOD

Research Design

This study employed a quasi-experimental design with a pretest–posttest control group design. This approach was chosen because random assignment of students into different groups was not feasible in the school context; instead, intact classes were used. The design allowed for the comparison of learning outcomes between the experimental group, which was taught using the STEM-6E Learning Model, and the control group, which received conventional instruction. The use of pretest scores helped to control for initial differences in students' prior knowledge and skills, thereby strengthening the internal validity of the study. This type of design is widely used in educational research to measure the effectiveness of innovative instructional approaches in real classroom settings (Creswell, 2014). The control class utilized a conventional teaching method dominated by lectures and question-and-answer discussions, without the integration of STEM or the 6E phases.

Participants and Sampling

The research was conducted at SMA Negeri 2 Jember during the second semester of the 2022/2023 academic year. The participants were Grade X students, consisting of two intact classes. One class was assigned as the experimental group and the other as the control group. The number of students in each class sequentially was experimental class 32 students and control class 29 students. The class determination is done by drawing lots to determine the control and experimental classes. Prior to the treatment, tests of normality and homogeneity were performed to ensure that the two groups were statistically comparable. In addition, an equivalence test based on the students' average scores was conducted to confirm that both groups were at a similar academic level. Such sampling and grouping procedures are important to minimize selection bias and enhance the validity of findings.

Research Instruments

The research employed a test instrument in the form of essay questions, developed to assess creative thinking and problem-solving skills. Each construct was measured using six items, resulting in a total of 12 items. The items were designed according to a well-defined rubric that had been validated through expert judgment and pilot testing to ensure reliability and validity. The rubric provided detailed descriptors for different performance levels, ensuring objectivity and consistency in scoring. The use of essay tests was considered appropriate because they allow students to demonstrate higher-order thinking skills, including creativity and problem-solving, which are not easily captured through multiple-choice tests (Brookhart, 2010).

Research Procedure

The study was conducted over three meetings for each class:

1. First Meeting (Pretest and Initial Lesson): The pretest was administered before the learning process to measure students' baseline knowledge. Following the pretest, the experimental group received instruction using the STEM-6E Learning Model, which lasted for three lesson hours (3×45 minutes).
2. Second Meeting (Continuation of STEM-6E Lessons): The experimental group continued learning with the STEM-6E Learning Model for another three lesson hours, while the control group continued with conventional instruction.
3. Third Meeting (Posttest): The posttest was conducted for both groups to measure the effects of the instructional treatments on students' creative thinking and problem-solving skills.

Arrohman et al. (2022) describe the activities that students can do at each stage, including the following:

Table 1. Activities in STEM-6E stages

Stages	Activity
Engage	Students identify the scientific phenomena presented.
Explore	Students conduct scientific investigations while practicing scientific process skills, including observing, predicting, reading measuring instruments, and interpreting data.
Explain	Students communicate the results of scientific investigations.
Engineer	Applying all knowledge in the engage, explore, and explain stages to solve existing problems.
Enrich	Students identify scientific issues and integrate science into societal fields.
Evaluate	Learning evaluation is carried out by asking students to work on questions that have been prepared to measure students' knowledge.

The STEM-6E Learning Model involves six integrated stages Engage, Explore, Explain, Engineer, Enrich, and Evaluate which emphasize inquiry, creativity, engineering design, and reflection. These stages were carefully implemented to provide students with hands-on, inquiry-based learning experiences, in contrast to the teacher-centered approach used in the control group.

Data Collection and Analysis

The data collection process consisted of administering the pretest and posttest to both groups. The data were then analyzed using a series of statistical procedures conducted with SPSS software. The steps included:

1. Normality Test: To examine whether the data followed a normal distribution, ensuring the appropriateness of parametric statistical tests.
2. Homogeneity Test: To test the equality of variances between groups, a prerequisite for ANCOVA analysis.
3. ANCOVA (Analysis of Covariance): Chosen as the main analysis technique because it allows the comparison of posttest scores between the experimental and control groups while controlling for students' pretest scores as a covariate. This method increases the precision of the analysis and accounts for any initial group differences (Field, 2013).

The use of ANCOVA was particularly important in this research, as it adjusted for baseline variations and provided a more accurate estimation of the treatment effect. Significance levels were set at $p < 0.05$.

RESULTS AND DISCUSSION

Creative Thinking Ability

The analysis of creative thinking ability was obtained from students' pretest and posttest scores. The normality test yielded a significance value of 0.433, indicating that the data were normally distributed. This was followed by a homogeneity test, which showed a significance level of 0.557 for pretest scores and 0.062 for posttest scores, confirming that the data variances were homogeneous. Subsequently, hypothesis testing was conducted using ANCOVA, and the results are presented in Table 2.

Table 2. Results of Creative Thinking Ability Test

Class	N	Pretest	Std.	Posttest	Std.	F	Sig.
		Mean	Deviation	Mean	Deviation		
Experimental	32	35.78	13.222	63.41	22.708	20.066	0.000
Control	29	33.97	10.452	41.66	15.960		

As shown in the table, the experimental class with 32 students achieved a pretest mean score of 35.78 with a standard deviation of 13.222. After the intervention, the posttest mean increased substantially to 63.41 with a standard deviation of 22.708. In contrast, the control class of 29 students obtained a mean pretest score of 33.97 (SD = 10.452), which only improved modestly to 41.66 (SD = 15.960) in the posttest. The ANCOVA analysis revealed an F-value of 20.066 and a significance level of 0.000, which is lower than 0.05, indicating a statistically significant difference between the experimental and control classes.

These results suggest that the students in the experimental group showed a considerable improvement in their creative thinking ability compared to their peers in the control group. The percentage comparison between the two groups indicated that the STEM-6E Learning Model contributed to an improvement of approximately 52.2%. The data confirm that structured STEM-6E instruction provided greater opportunities for students to generate original ideas, explore multiple approaches, and elaborate their thoughts more effectively than traditional teaching.

Creative thinking ability improved when the STEM-6E Learning Model was applied. This improvement occurred because the model guided students through principles and technology at each stage, encouraging continuous exploration when solving problems. Consequently, students' ability to generate and address problems fostered higher-level thinking. This finding aligns with Chung et al. (2018), who emphasized that the 6E model is student-centered, integrating conceptual understanding with inquiry. By following the STEM-6E learning stages, students refine their cognitive processes to generate ideas, develop plans, and implement practices (Lin et al., 2019). Wahono et al. (2021) also found that the STEM-6E Learning Model enhances student motivation, creative thinking, critical thinking, and problem-solving skills. Similarly, Lin et al. (2020) demonstrated that STEM activities focusing on the 6E framework positively impact students' technological inquiry skills, thereby fostering creative thinking more effectively (Wan et al., 2021). Sternberg (2019) further highlighted that STEM education is beneficial for cultivating student understanding and competencies. Likewise, Suratno et al. (2020) found that integrated STEM education supports creativity by combining four disciplines to address diverse problems. A student with strong problem-solving skills inherently develops creative thinking. Thus, the STEM-6E Learning Model is effective in enhancing creativity, scientific literacy, and problem-solving skills needed in the 21st century.

Problem-Solving Skills

The analysis of students' problem-solving skills was also based on pretest and posttest scores. The normality test produced a significance value of 0.536, indicating that the data were normally distributed. The homogeneity test yielded values of 0.728 for the pretest and 0.068 for the posttest, confirming that the data variances were homogeneous. Based on these assumptions, the data were further analyzed using ANCOVA, and the results are presented in Table 3.

Table 3. Results of Problem-Solving Skills Test

Class	N	Pretest Mean	Std. Deviation	Posttest Mean	Std. Deviation	F	Sig.
Experimental	32	34.09	16.023	62.66	23.087	16.705	0.000
Control	29	28.69	17.426	42.14	14.973		

The experimental class (N = 32) had a mean pretest score of 34.09 with a standard deviation of 16.023, which improved significantly to 62.66 (SD = 23.087) on the posttest. Meanwhile, the control class (N = 29) recorded a mean pretest score of 28.69 (SD = 17.426) and a posttest mean of 42.14 (SD = 14.973). The ANCOVA results yielded an F-value of 16.705 with a significance level of 0.000, well below the threshold of 0.05. This indicates a significant difference in posttest results between the experimental and control classes.

The percentage comparison shows that the problem-solving skills of students in the experimental group were approximately 48.7% higher than those in the control group. This suggests that the STEM-6E Learning Model provided a structured pathway for students to identify problems, design solutions, and evaluate outcomes more effectively than in conventional learning environments. The improvement was not only reflected in quantitative scores but also in the increased ability of students to engage with complex tasks and systematically approach solutions.

The STEM-6E Learning Model improved students' problem-solving skills by engaging them in processes such as identifying problems, planning and describing solutions, and conducting evaluations. As a result, the learning process became more effective in enhancing problem-solving skills. Manafe et al. (2017) stated that the STEM-6E Learning Model actively involves students in various classroom activities and interactions, enabling them to develop their own understanding of learning outcomes. This is supported by Sanjayati et al. (2019), who reported that the implementation of the STEM-6E Learning Model encouraged active student participation in answering teacher questions. Kaniawati and Suryadi (2016) also emphasized that integrating STEM into the 6E model can improve the problem-solving skills of high school students. Similarly, Chung et al. (2018) examined the effectiveness of STEAM-6E and found that it strengthened students' ability to integrate knowledge and improved learning efficiency across multiple subjects. Therefore, the structured stages of the STEM-6E Learning Model allow students to generate solution ideas and implement practices, ultimately enhancing their problem-solving skills.

CONCLUSION

The findings of this study demonstrate that the STEM-6E Learning Model effectively enhances senior high school students' creative thinking ability and problem-solving skills in Jember. The mean pretest scores were relatively low, as students had not yet received instructional treatment. However,

the application of the STEM-6E Learning Model showed a significant impact, as indicated by the ANCOVA analysis with a significance value of 0.000. These results confirm that the implementation of the STEM-6E Learning Model has a significant effect on improving both creative thinking and problem-solving skills among high school students.

ACKNOWLEDGEMENT

The researchers would like to express their sincere gratitude to SMA Negeri 2 Jember for providing the opportunity to conduct this study. Special thanks are also extended to the research team and all parties who contributed to the successful implementation of this research.

REFERENSI

- Arrohman, D. A., Wahyuni, A. L. E., Wilujeng, I., Suyanta. (2022). Implementasi penggunaan LKPD pencemaran air berbasis STEM dan model learning cycle 6E terhadap kemampuan literasi sains. *Jurnal Pendidikan Sains Indonesia*, 10(2): 279-293. <https://doi.org/10.24815/jpsi.v10i2.23584>
- Burke, D. (2014). The ITEEA 6E learning by design™ model, maximizing informed design and inquiry in the integrative STEM classroom. *Technology and Engineering Teacher*, 73(6), 14–19. <https://eric.ed.gov/?id=EJ1049196>
- Chung, C. C., Lin, C. L., dan Lou S. J. (2018). Analysis of the learning effectiveness of the STEAM-6E special course: a case study about the creative design of IoT assistant devices for the elderly. *Sustainability*, 10(9), 3040. <https://www.mdpi.com/2071-1050/10/9/3040>
- Dewi, H. R., Mayasari, T., dan Handhika J. (2019). Increasing creative thinking skills and understanding of physics concepts through application of STEM-based inquiry. *Jurnal Penelitian Pendidikan IPA*, 4(1), 25–30. <https://journal.unesa.ac.id/index.php/jppipa>
- Fathoni, A., Muslim, S., Ismayati, E., Rijanto, E., Munoto, Nurlaela, L. (2020). STEM: inovasi dalam pembelajaran vokasi. *Jurnal Pendidikan Teknologi dan Kejuruan*, 17(1), 33-42.
- Fitriyah, N., Hariani, S. A., dan Fikri, K. (2015). Pengaruh model pembelajaran creative problem solving dengan mind mapping terhadap kemampuan berpikir kreatif dan hasil belajar IPA biologi. *Jurnal Edukasi*, 2(2), 44-50. <https://doi.org/10.19184/jukasi.v2i2.4305>
- Handoko, H. (2017). Pembentukan keterampilan berpikir kreatif pada pembelajaran matematika model savi berbasis discovery strategy materi dimensi tiga kelas X. *EduMa*, 6(1), 1-6. <https://www.neliti.com/id/publications/89691/pembentukan-keterampilan-berpikir-kreatif-pada-pembelajaran-matematika-model-sav>
- Husna, dan Burais, F. F. (2018). Penggunaan problem solving untuk meningkatkan kemampuan pemecahan masalah matematis siswa SMP. *Jurnal Peluang*, 6(2), 1-7.
- Kaniawati, D. S., & Suryadi, S. (2016). Integration of STEM education in learning cycle 6E to improve problem solving skills on direct current electricity. *Proceeding of ICMSE*, 3(1), M106–M-109.
- Khuyen, N. T. T., Van Bien, N., Chang, Y. H., Lin, P. L., & Chang, C. Y. (2024). Exploring teachers' epistemological framing through classroom discourse in 6E-STEM classes: From perception to practice. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(9), 2-18.

<https://www.ejmste.com/article/exploring-teachers-epistemological-framing-through-classroom-discourse-in-6e-stem-classes-from-15023>

- Laksana, A. D. S., Prihatin, J., dan Novenda, I. L. (2018). The development of collaborative learning based on brain-based learning (BBL) model for the junior high school science learning in the agroecosystem area. *Jurnal Biologi dan Pembelajarannya*, 17(2), 82-91. <https://repository.unej.ac.id/xmlui/handle/123456789/99695>
- Manafe, H. E., Ibnu, S., & Fajaroh, F. (2017). Pengaruh penerapan learning cycle 6E think pair share terhadap hasil belajar kognitif peserta didik dengan kemampuan awal berbeda. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 2(2), 252–260. <https://journal.um.ac.id/index.php/jptpp/article/view/8539>
- Moma, L. (2015). Pengembangan instrumen kemampuan berpikir kreatif matematis untuk siswa SMP. *Delta-Pi: Jurnal Matematika dan Pendidikan Matematika*, 4(1), 27–4.
- Nurhaliza, L., Siswati, B. H., & Wahono, B. (2024). Pengaruh Model Pembelajaran Problem Based Learning Berbantuan Liveworksheets terhadap Kemampuan Metakognitif dan Kemampuan Berpikir Kritis Siswa SMA di Kawasan Pertanian Industrial. *JURNAL PENELITIAN PENDIDIKAN MATEMATIKA DAN SAINS*, 8(1), 1-6. <https://doi.org/10.26740/jppms.v8n1.p1-6>
- Rini, Prihatin, J., dan Pujiastuti. (2017). Pengaruh penerapan model pembelajaran course review horay berbasis pendekatan problem-based learning terhadap kemampuan berpikir kritis dan hasil belajar biologi. *Jurnal Biologi dan Pembelajarannya*, 15(1), 43-53. <https://www.neliti.com/id/publications/58092/pengaruh-penerapan-model-pembelajaran-course-review-horay-berbasis-pendekatan-pr>
- Sanjayati, A., Rustaman, N. Y., & Hidayat, T. (2019). 6E learning by design in facilitating logical thinking and identifying algae. *AIP Conference Proceedings*, 2194, 020109-1–020109-6.
- Setiyowati, L., Wijonarko, dan Sulianto, J. (2018). Penerapan metode problem solving model polya terhadap kemampuan memecahkan masalah pada materi operasi hitung campuran kelas 3 SD. *Jurnal Sekolah (JS)*, 2(2), 32- 37. <https://doi.org/10.24114/js.v2i2.9510>
- Siswati, B. H., Prihatin, J., & Aloysius, D. C. (2024). The Effectiveness of E-Module STEM Biotechnology to Empower Metacognitive Skill s and Science Process Skills of High School Students with Low Academic Ability in Industrial Agriculture Areas. *Jurnal Penelitian Pendidikan IPA*, 10(1), 133-142. <https://jppipa.unram.ac.id/index.php/jppipa/article/view/5890>
- Sternberg, R.J. (2019). Teaching and assessing gifted students in STEM disciplines through augmented theory of success intelligence. *High Ability Studies*, 30(1-2), 103-126. <https://psycnet.apa.org/record/2018-50793-001>
- Suratno, Wahono, B., Chang, C. Y., Retnowati, A., Yushardi. (2020). Exploring a direct relationship between students’ problemsolving abilities and academic achievement: a STEM education at a coffee plantation area. *Journal of Turkish Science Education*, 17(2), 221-224. <https://eric.ed.gov/?id=EJ1264688>
- Wahono, B., Lin, P. L., dan Chang, C. Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, 7(36), 1-18. <https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-020-00236-1>
- Wahono, B., Chang, C., dan Khuyen, N. T. T. (2021). Teaching socio-scientific issues through integrated STEM education: an effective practical averment from Indonesian science lessons.

International Journal of Science Education. 1-21.
<https://doi.org/10.1080/09500693.2021.1983226>

Wan, Z. H., So, W. M. W, & Hu, W. (2021). Necessary or sufficient? the impact of epistemic beliefs on STEM creativity and the mediation of intellectual risk-taking. *International Journal of Science Education*, 1-21. <https://eric.ed.gov/?id=EJ1303000>

Zalsa, T., Fitri, A., Nurdin, F. A., Shita, L. D., Ramadaniah., N. A. (2025). Studi literature : Efektivitas pendekatan STEM dalam meningkatkan kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Jendela Pendidikan*, 5(01) : 174-183.
<https://ejournal.jendelaedukasi.id/index.php/JJP/article/view/1254/284>