

Comparative Effectiveness of STEAM and Scientific Approaches on Elementary Students' Learning Outcomes in Social Studies: The Case of Indonesian Cultural Diversity

Suci Siti Lathifah*, Siti Nurhalisa, Bintang Ramadhani

Faculty of Teacher Training and Education, Universitas Pakuan, Bogor, Indonesia
suci.sitilathifah@unpak.ac.id*; snurhalisa173@gmail.com; bintaangrmd2310@gmail.com

*Corresponding author

Article Info

Article history:

Submission Mar 13, 2026
First Revised Apr 02, 2026
Accepted Apr, 29 2026
Published Apr 30, 2026

Keywords:

STEAM
Scientific approach
Learning outcomes
Social studies
Cultural diversity

ABSTRACT

Social Studies (IPS) instruction in elementary schools still faces challenges in fostering deep student understanding, particularly on contextual topics such as Indonesia's cultural diversity. This study aimed to compare the effectiveness of the STEAM (Science, Technology, Engineering, Arts, Mathematics) approach and the scientific approach in improving students' learning outcomes. A quasi-experimental method with a pretest-posttest control group design was employed. The participants were 50 fourth-grade students at SD Negeri Ciheuleut 2, Bogor City, divided into two groups of 25 students, with each group receiving a different instructional approach. Data were collected using a validated learning outcomes test (Cronbach's $\alpha = 0.781$) and analyzed through an independent sample t-test. The results showed that the STEAM approach produced higher learning gains than the scientific approach. The STEAM group achieved an average N-gain score of 0.65 (upper range of the moderate category), while the scientific group obtained 0.42 (moderate). The mean post-test score of the STEAM group (83.6) was also higher than that of the scientific group (76.4), with a statistically significant difference ($p = 0.003$). These findings indicate that the STEAM approach is more effective in enhancing students' understanding of cultural diversity. Therefore, it is recommended for elementary Social Studies instruction due to its ability to integrate multiple disciplines in a meaningful and contextualized learning process.

© 2026 Authors.

This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY-SA\)](#)



How to cite:

Lathifah, S. S., Nurhalisa, S., & Ramadhani, B. (2026). An Empirical Comparison of STEAM and Scientific Approaches toward Primary Students' Learning Outcomes on Indonesian Cultural Diversity Material. *Pedagonal : Jurnal Ilmiah Pendidikan*, 10 (1) 55-64. <https://doi.org/10.55215/pedagonal.v10i1.64>

Introduction

Twenty-first century education demands learning that not only focuses on content mastery but also on the development of critical thinking, creativity, collaboration, and communication skills (Salas-Pilco, 2024; Zakaria & Md Osman, 2024; Pahmi et al., 2022). In primary schools, Social Studies (IPS) plays a strategic role in helping students understand society and culture, yet its instruction still struggles with contextualization and low student engagement (Salamah & Susapti, 2025). This challenge is evident in topics such as Indonesia's cultural diversity, a competency that needs to be developed from elementary education onward so that students can understand diversity and carry out their roles as citizens (Suandari & Afrijal, 2026).

Over the past decade, the scientific approach has been widely implemented in the 2013 Curriculum as the primary instructional strategy. This approach emphasizes scientific processes through observing, questioning, exploring, associating, and communicating (Muhammad et al., 2022). Although it has advantages in promoting cognitive engagement (Siswati, 2023), a review conducted ten years after its introduction found that its implementation remains inconsistent, with a continued reliance on teacher-centered pedagogy in mathematics classrooms (Muhammad et al., 2023). Other work also notes that the approach is not fully capable of stimulating students' creativity or of addressing affective aspects and 21st-century skills holistically (Wanojaleni, 2021).

As an innovative alternative, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach has begun to be implemented in various educational contexts. STEAM is considered more adaptive to contemporary needs because it integrates disciplines contextually (Călin, 2022) and brings artistic exploration and real-world problem-solving into the learning process (Nguyen, 2025; Okwara & Pretorius, 2023). Previous studies report positive outcomes at primary and secondary levels, including increased motivation (Salas-Pilco, 2024), creativity (Gracia et al., 2024; Iffiani et al., 2024), critical thinking (Mansyur et al., 2024), and higher-order thinking and science achievement (Juliharti et al., 2024; Nasrah et al., 2021). These findings have also been synthesized in systematic reviews and meta-analyses (Muntazah et al., 2025; Asrizal et al., 2023), and research with young learners shows that STEAM can be realized through several different design processes (Temiz & Çevik, 2024).

However, most of these studies focus on science, mathematics, or other STEM-related fields. Only a few recent studies have brought STEAM into Social Studies and cultural contexts, for example through local culture-based projects in Madrasah Ibtidaiyah social studies (Salamah & Susapti, 2025), a one-group design on cultural and civic literacy in fourth grade (Suandari & Afrijal, 2026), and a Madurese local wisdom-based STEAM learning model (Fadhilah et al., 2025). These studies generally examine a single approach and do not compare it directly with the scientific approach that remains dominant in classrooms. The research gap identified in this study therefore lies in the limited number of studies that directly compare the effectiveness of STEAM and scientific approaches in primary Social Studies. Theoretically, the STEAM approach is well aligned with the topic of cultural diversity, as it incorporates artistic elements and relevant social contexts.

Based on this background and research gap, this study aims to analyze and compare the effectiveness of STEAM and scientific approaches on elementary students' learning outcomes in the topic of Indonesia's cultural diversity. This study employs a quantitative quasi-experimental approach, focusing on students' learning outcomes as the primary indicator of instructional effectiveness. The scope of the study is limited to fourth-grade

students at SD Negeri Ciheuleut 2, Bogor City. The findings are expected not only to address the existing research gap but also to provide a conceptual contribution to contextual STEAM-based Social Studies learning, as well as practical recommendations for teachers in selecting instructional strategies that make Social Studies more creative, meaningful, and aligned with the needs of present and future education.

Method

This study employs a quantitative approach with a quasi-experimental pretest–posttest control group design to compare the effectiveness of STEAM and scientific learning approaches on elementary students' learning outcomes in the topic of Indonesia's cultural diversity. The research was conducted at SD Negeri Ciheuleut 2, Bogor City, from January to April 2025.

The participants consisted of 50 fourth-grade students divided into two groups, each comprising 25 students. Group A received instruction using the STEAM approach, while Group B was taught using the scientific approach. Participants were selected purposively, and a matching subject technique was applied to ensure equivalence in initial ability based on students' previous semester report card scores.

The research instruments included lesson plans, instructional media such as local culture videos and worksheets, and evaluation tools in the form of pre-tests and post-tests. The STEAM-based instructional design integrated elements of science, technology, engineering, arts, and mathematics into cultural project activities. Meanwhile, the scientific approach was implemented through activities involving observation, questioning, data collection, association, and communication. The learning outcome test consisted of multiple-choice items developed based on the competency indicators of the Merdeka Curriculum. Instrument validity and reliability were tested through a pilot study involving students outside the sample and processed with SPSS (Anggraini et al., 2022), yielding a reliability coefficient greater than 0.70, which indicates acceptable reliability.

The research procedure began with administering a pre-test to both groups to determine students' initial abilities. Each group then participated in three instructional sessions based on the assigned approach. The STEAM group engaged in project-based activities, including the creation of a mini cultural exhibition that emphasized critical and creative thinking skills. The scientific group participated in learning activities involving discussions, social experiments, and cultural reflections. After the treatment, both groups were given a post-test with equivalent items to measure learning improvement.

Data were analyzed statistically using SPSS version 25.0. Normality was tested using the Kolmogorov–Smirnov test, and homogeneity of variance was assessed using Levene's test. Differences in learning outcomes between the two groups were analyzed using an independent-samples t-test at a significance level of 5% ($\alpha = 0.05$). The effectiveness of each approach was further evaluated by calculating the normalized gain (N-gain) score using Hake's formula, as commonly applied in primary-school learning studies (Suandari & Afrijal, 2026). N-gain scores were interpreted as high ($g > 0.70$), moderate ($0.30 \leq g \leq 0.70$), or low ($g < 0.30$).

Results and Discussion

Instrument Validity and Reliability

Prior to data collection, the validity and reliability of the learning outcome test instrument were examined. The instrument was pilot-tested on 30 students who were not

part of the research sample. The purpose of this pilot test was to ensure that the instrument could be appropriately used to measure students' learning outcomes.

The validity test results indicated that all test items had a corrected item-total correlation value above 0.30. This suggests that each item had a sufficiently strong correlation with the overall test score and met the commonly accepted validity criteria in educational research. Therefore, all items in the instrument were considered valid and suitable for use. Meanwhile, the reliability of the instrument was tested using Cronbach's alpha, yielding a value of 0.781. This value exceeds the minimum acceptable threshold of 0.70, indicating good internal consistency. The results of the instrument testing are presented in Table 1.

Table 1. Instrument Testing Results

Measured Aspect	Assessment Indicator	Result	Criteria	Conclusion
Validity	Corrected item-total correlation > 0.30	All items > 0.30	Valid	Suitable for use
Reliability	Cronbach's alpha > 0.70	0.781	Reliable	Consistent and appropriate

These findings indicate that the instrument is suitable for measuring students' learning outcomes on the topic of cultural diversity. Validity ensures that the assessment instrument accurately measures the intended competencies, so that the results reflect students' actual abilities (Gupta, 2023). Reliability ensures that the assessment produces consistent results, and it is commonly examined with Cronbach's alpha in SPSS (Anggraini et al., 2022). Both aspects are crucial for maintaining the integrity of assessment: without validity, results may be misleading, and without reliability, they become untrustworthy (Ofori Bekoe, 2023). Therefore, assessment instruments for primary Social Studies must be developed and implemented carefully and systematically to ensure that both criteria are met.

Pre-Test and Post-Test Results

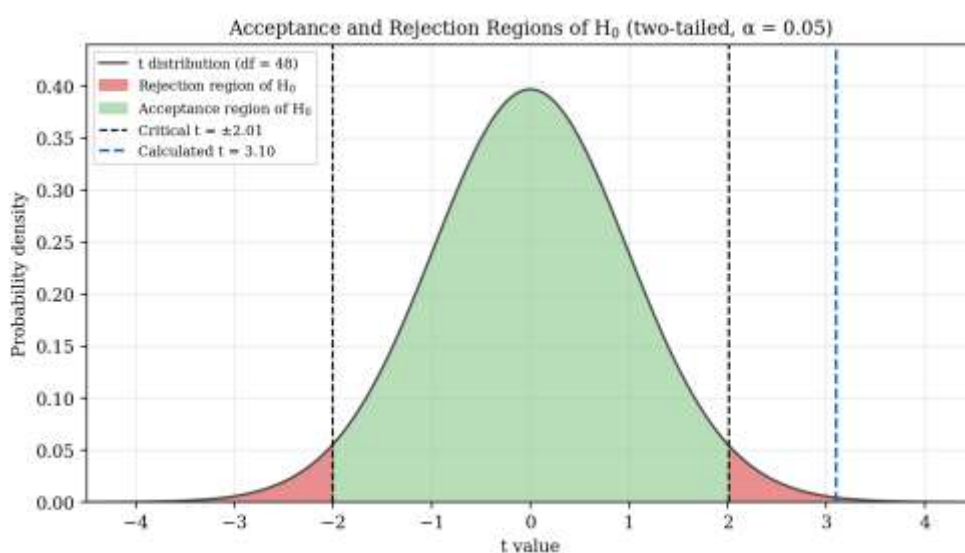
This study began with the administration of a pre-test to both groups to determine students' initial abilities on the topic of Indonesia's cultural diversity. The pre-test results were analyzed using SPSS version 25.0. The Kolmogorov–Smirnov test indicated that the data in both groups were normally distributed ($p > 0.05$), and Levene's test showed that the variances were homogeneous ($p > 0.05$). The mean pre-test score of the STEAM group was 58.4 (SD = 4.2), while the scientific group scored 59.2 (SD = 4.5). An independent-samples t-test revealed no significant difference between the two groups ($p = 0.521 > 0.05$), indicating that both groups were equivalent prior to treatment.

After the instructional intervention, a post-test was administered. The mean score of the STEAM group increased to 83.6 (SD = 5.1), while the scientific group reached 76.4 (SD = 5.3). Subsequent tests of normality and homogeneity confirmed that the data remained normally distributed and homogeneous (Table 2).

Table 2. Descriptive Statistics, Normality, and Homogeneity Test Results

Group	Test Type	Mean	SD	Normality Test (p)	Homogeneity Test (p)
STEAM	Pre-test	58.4	4.2	0.172	0.418
STEAM	Post-test	83.6	5.1	0.136	0.495
Scientific	Pre-test	59.2	4.5	0.186	0.418
Scientific	Post-test	76.4	5.3	0.149	0.495

An independent-samples t-test was conducted on the post-test results to determine whether there was a significant difference between students taught using the STEAM approach and those taught using the scientific approach. The analysis using SPSS version 25.0 yielded $t = 3.10$ ($df = 48$) with a significance value of 0.003 ($p < 0.05$). This indicates that the null hypothesis (H_0), which states that there is no difference in mean learning outcomes between the two groups, is rejected, while the alternative hypothesis (H_1) is accepted. Thus, there is a statistically significant difference between the two groups. Figure 1 illustrates the acceptance and rejection regions of H_0 in the independent sample t-test.

**Figure 1.** Acceptance and Rejection Regions of H_0 in the Independent Sample t-Test

The curve above illustrates the distribution of t-values at a 5% significance level ($\alpha = 0.05$) using a two-tailed test. The red regions represent the rejection areas of H_0 , while the green region indicates the acceptance area. The calculated t-value of 3.10 lies outside the critical boundaries (± 2.01 at $df = 48$), reinforcing the conclusion that the difference in learning outcomes between the two groups is statistically significant.

These findings indicate that, although both groups started from an equivalent level, the STEAM approach produced stronger post-test performance than the scientific approach. This pattern is consistent with earlier studies in primary education: STEAM learning has been shown to produce higher mastery of science content among fourth-grade students (Nasrah et al., 2021) and better higher-order thinking and science learning outcomes among fifth-grade students than conventional learning (Juliharti et al., 2024), while local culture-based STEAM has been reported to deepen students' understanding of social studies concepts, including cultural diversity (Salamah & Susapti, 2025).

The STEAM learning approach, which integrates Science, Technology, Engineering, Arts, and Mathematics, offers significant advantages in improving educational quality. Through interdisciplinary integration, students are encouraged to think critically, solve problems creatively, and collaborate effectively (Zakaria & Md Osman, 2024). This approach also promotes active student engagement in the learning process (Juliharti et al., 2024) and enhances creativity (Atikah & Biru, 2024). By incorporating artistic elements, STEAM not only emphasizes logic and analysis but also fosters expression and innovation (Nguyen, 2025), and the use of the arts can raise learners' interest and confidence (Okwara & Pretorius, 2023). Consequently, it better prepares students to face complex challenges in modern life and the workforce.

In contrast, the scientific approach emphasizes systematic scientific thinking processes, including observing, questioning, collecting data, reasoning, and communicating (Siswati, 2023). This approach aims to develop logical, critical, and analytical thinking skills, enabling students to actively construct knowledge through direct experience rather than passively receiving information (Altenberga & Rubene, 2022). In practice, students are trained to formulate questions, seek answers through observation or experimentation, and draw evidence-based conclusions.

However, the scientific approach has several limitations compared to STEAM. First, it tends to focus primarily on cognitive and linear thinking processes, offering less opportunity for creative expression and innovation, which are key strengths of STEAM (Iffiani et al., 2024). Second, it is generally discipline-specific, whereas STEAM adopts an integrative, interdisciplinary perspective that better reflects real-world complexity (Asrizal et al., 2023). Third, STEAM encourages cross-disciplinary collaboration and integrates technology and the arts to connect abstract concepts with practical applications (Zakaria & Md Osman, 2024), while the scientific approach, in classroom practice, may rely on rigid, teacher-centered routines that leave less room for idea exploration (Muhammad et al., 2023). Thus, although the scientific approach is effective for developing systematic thinking, STEAM is more comprehensive in promoting 21st-century skills.

N-Gain Score Analysis and Effectiveness

The average N-gain score for the STEAM group was 0.65, which falls in the upper range of the moderate category ($0.30 \leq g \leq 0.70$), while the scientific group achieved 0.42, also in the moderate category. The difference in gain scores was further analyzed using an independent sample t-test, which yielded a significance value of 0.014 ($p < 0.05$). This result confirms that the STEAM approach is statistically more effective in improving students' learning outcomes compared to the scientific approach. The summary of the independent sample t-test results is presented in Table 3, and the comparison of N-gain scores is illustrated in Figure 2.

Table 3. Summary of Independent Sample t-Test Results

Data	STEAM Mean	Scientific Mean	p	Conclusion
Pre-test	58.4	59.2	0.521	No significant difference
Post-test	83.6	76.4	0.003	Significant difference
N-gain	0.65	0.42	0.014	Significant difference

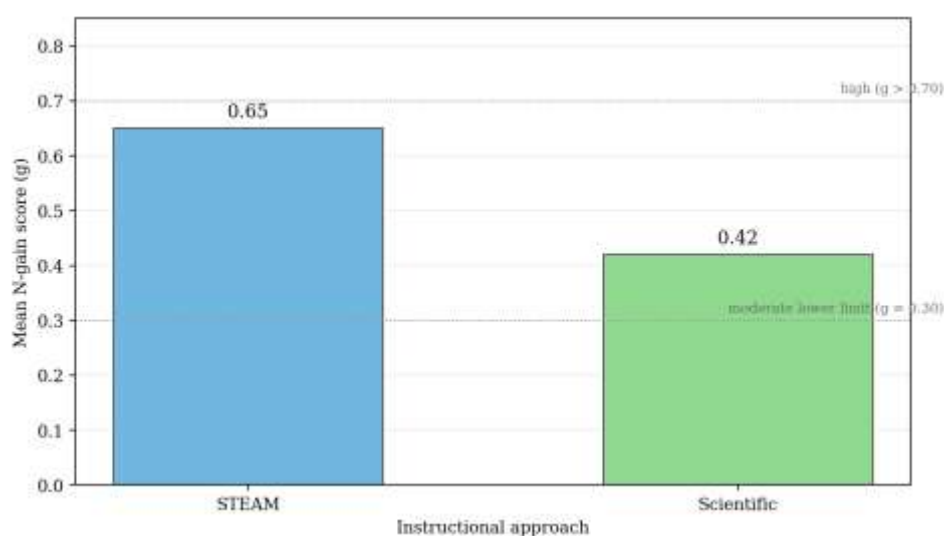


Figure 2. Comparison of N-Gain Scores between STEAM and Scientific Groups

These findings indicate that the STEAM approach demonstrates a significant advantage over the scientific approach in improving students' learning outcomes. The STEAM N-gain of 0.65 is comparable to the average N-gain of 0.65 reported for STEAM-based learning on cultural diversity material in fourth grade (Suandari & Afrijal, 2026), although that study did not include a comparison group. The multidisciplinary framework of STEAM fosters critical thinking (Mansyur et al., 2024), creativity (Gracia et al., 2024), and collaboration (Zakaria & Md Osman, 2024) among students, which better prepares them to address real-world challenges.

Moreover, STEAM education promotes 21st-century skills such as teamwork, communication, and adaptability (Pahmi et al., 2022). Through this approach, students learn to collaborate effectively, fostering a sense of community and shared responsibility in their learning process. Taken together with recent reviews of STEAM in primary school learning (Muntazah et al., 2025), these results support the use of contextual, project-based STEAM activities, such as a mini cultural exhibition, in Social Studies lessons on cultural diversity.

Conclusion

This study aimed to compare the effectiveness of STEAM and scientific approaches in improving elementary school students' learning outcomes in Social Studies, particularly on the topic of Indonesia's cultural diversity. The findings revealed that both approaches improved students' learning outcomes; however, the STEAM approach was significantly more effective than the scientific approach. Students taught using the STEAM approach achieved a mean post-test score of 83.6 and an N-gain score of 0.65, indicating learning improvement in the upper range of the moderate category, whereas those taught using the scientific approach achieved a mean post-test score of 76.4 and an N-gain score of 0.42, both classified as moderate. The t-test results confirmed a statistically significant difference between the two groups ($p = 0.003 < 0.05$). These findings indicate that the STEAM approach is more effective in improving students' learning outcomes, particularly in contextual and multidisciplinary Social Studies learning. This advantage may be attributed to the integration of science, technology, engineering, arts, and mathematics,

which can provide students with more creative, meaningful, and relevant learning experiences connected to real-life contexts. Therefore, this study provides empirical evidence that may inform teachers and curriculum developers in selecting and designing STEAM-based Social Studies instruction to improve elementary school students' learning outcomes.

Acknowledgment

The authors sincerely thank Universitas Pakuan for providing facilities and a supportive academic environment throughout the research process. The authors also extend appreciation to the participating elementary school for its willingness to serve as a research partner, as well as to all students and teachers who were involved in the data collection process.

Author Contributions

Conceptualization: SST; Methodology: SST, SN; Formal analysis: SN, BR; Investigation: SST, SN, BR; Writing – original draft: SST, SN, BR; Writing – review & editing: SST, SN, BR; Supervision: SST, SN, BR.

Funding

This research received no external funding.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of Artificial Intelligence

The authors used Grammarly to assist with language editing, grammar correction, and improvements in clarity and readability. All AI-assisted suggestions were reviewed and verified by the authors, who take full responsibility for the accuracy, integrity, and final content of the manuscript.

References

- Altenberga, J., & Rubene, Z. (2022). How to learn science literacy? Overview of most topical and researched learning approaches. In *Human, technologies and quality of education*, 2022 (pp. 487–498). University of Latvia Press. <https://doi.org/10.22364/htqe.2022.35>
- Anggraini, F. D. P., Aprianti, Setyawati, V. A. V., & Hartanto, A. A. (2022). Pembelajaran statistika menggunakan software SPSS untuk uji validitas dan reliabilitas. *Jurnal Basicedu*, 6(4), 6491–6504. <https://doi.org/10.31004/basicedu.v6i4.3206>
- Asrizal, A., Dhanil, M., & Usmeldi, U. (2023). The effect of STEAM on science learning on student learning achievement: A meta-analysis. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1650–1657. <https://doi.org/10.29303/jppipa.v9i4.3108>

- Atikah, C., & Biru, L. T. (2024). STEAM-based learning to enhance early childhood creativity. *International Journal of STEM Education for Sustainability*, 4(1), 164–175. <https://doi.org/10.53889/ijses.v4i1.303>
- Călin, M. (2022). The role of STEAM projects in the interactive and captivating involvement of students in the learning process. In *Materialele conferinței științifice naționale cu participare internațională «Probleme ale științelor socioumanistice și ale modernizării învățământului»* (pp. 62–67). “Ion Creangă” State Pedagogical University. <https://doi.org/10.46728/c.v2.25-03-2022.p62-67>
- Fadhilah, M. N., Fawaid, A., Yulianti, I., & Rahmah, N. (2025). Development of a Madurese local wisdom-based learning model using a STEAM integrative approach to improve creativity and innovation of Indonesian elementary school students. *Al-Bidayah: Jurnal Pendidikan Dasar Islam*, 17(2), 190–205. <https://doi.org/10.14421/al-bidayah.v17i2.44294>
- Gracia, E., Nurohman, S., & Wilujeng, I. (2024). Analysis the implementation of STEAM approach on creative thinking ability in science learning. *Jurnal Penelitian Pendidikan IPA*, 10(11), 757–763. <https://doi.org/10.29303/jppipa.v10i11.7782>
- Gupta, K. (2023). Validity and reliability of students’ assessment: Case for recognition as a unified concept of valid reliability. *International Journal of Applied & Basic Medical Research*, 13(3), 129–132. https://doi.org/10.4103/ijabmr.ijabmr_382_23
- Iffiani, Z., Chaerunnisa, Surudin, Y., Rosdianto, Ngabidin, & Kartika, I. (2024). Pengembangan kurikulum berbasis STEAM (Science, Technology, Engineering, Arts, and Mathematics) untuk meningkatkan kreativitas dan kemampuan berfikir kritis. *Reslaj: Religion Education Social Laa Roiba Journal*, 6(4). <https://doi.org/10.47467/reslaj.v6i4.1217>
- Juliharti, L., Hidayati, A., Helsa, Y., & Asrizal, A. (2024). Investigating the impact of STEAM learning on higher order thinking and science achievement. *Ta’dib*, 27(1), 151. <https://doi.org/10.31958/jt.v27i1.12270>
- Mansyur, M. I., Sumarno, S., & Dwijayanti, I. (2024). Analisis model pembelajaran STEAM dalam meningkatkan kemampuan berpikir kritis siswa sekolah dasar. *Pedagogika: Jurnal Ilmu-Ilmu Kependidikan*, 4(1), 23–27. <https://doi.org/10.57251/ped.v4i1.1394>
- Muhammad, R. R., Lawson, D., Aslam, F., & Crawford, M. (2022). The scientific approach of the Indonesian 2013 curriculum: A comparison with other active learning strategies in mathematics. *Journal of Research in Science, Mathematics and Technology Education*, 5(2), 155–171. <https://doi.org/10.31756/jrsmte.523>
- Muhammad, R. R., Lawson, D., Aslam, F., & Crawford, M. (2023). Indonesian curriculum 2013 ten years on: Impact on mathematics teaching. *Journal of Research in Science, Mathematics and Technology Education*, 6(SI), 109–136. <https://doi.org/10.31756/jrsmte.616SI>
- Muntazah, A., Elizar, Apriza, B., & Suprpto, I. (2025). The effectiveness of STEAM learning model implementation in primary school students’ IPAS learning: A systematic literature review. *Journal for Lesson and Learning Studies*, 8(1), 75–85. <https://doi.org/10.23887/jlls.v8i1.89722>
- Nasrah, N., Amir, R. H., & Purwanti, R. Y. (2021). Efektivitas model pembelajaran STEAM (Science, Technology, Engineering, Art, and Mathematics) pada siswa kelas IV SD. *JKPD (Jurnal Kajian Pendidikan Dasar)*, 6(1), 1–13. <https://doi.org/10.26618/jkpd.v6i1.4166>

- Nguyen, A. Q. (2025). Pedagogical approaches in STEAM education. In *Transformative approaches to STEAM integration in modern education* (pp. 53–78). IGI Global. <https://doi.org/10.4018/979-8-3693-7408-5.ch003>
- Ofori Bekoe, S. (2023). Construction and analysis of items for assessing learning outcomes: Concise models for ensuring validity. *International Research in Education*, 11(2), 29. <https://doi.org/10.5296/ire.v11i2.21160>
- Okwara, V. U., & Pretorius, J. P. H. (2023). The STEAM vs STEM educational approach: The significance of the application of the arts in science teaching for learners' attitudes change. *Journal of Culture and Values in Education*, 6(2), 18–33. <https://doi.org/10.46303/jcve.2023.6>
- Pahmi, S., Juandi, D., & Sugiarni, R. (2022). The effect of STEAM in mathematics learning on 21st century skills: A systematic literature reviews. *PRISMA*, 11(1), 93. <https://doi.org/10.35194/jp.v11i1.2039>
- Salamah, I., & Susapti, P. (2025). STEAM berbasis budaya lokal dalam pembelajaran ilmu sosial: Inovasi kreatif untuk siswa MI. *Al Ibtida: Jurnal Penelitian dan Pengembangan Pendidikan Dasar*, 13(2), 49–66. <https://ejournal.kopertais4.or.id/mataraman/index.php/alibtida/article/view/6469>
- Salas-Pilco, S. Z. (2024). K-12 STEAM education in Latin America: A systematic review. In *2024 IEEE World Engineering Education Conference (EDUNINE)* (pp. 1–6). IEEE. <https://doi.org/10.1109/EDUNINE60625.2024.10500534>
- Siswati. (2023). Penerapan pembelajaran saintifik sebagai alternatif meningkatkan hasil belajar dan ketrampilan siswa. *Discovery: Jurnal Ilmu Pengetahuan*, 8(1), 40–45. <https://doi.org/10.33752/discovery.v8i1.3922>
- Suandari, A., & Afrijal. (2026). The effectiveness of STEAM-based learning on elementary school students' cultural and civic literacy skills. *JIPSINDO*, 13(2), 42–58. <https://doi.org/10.21831/jipsindo.v13i2.100976>
- Temiz, Z., & Çevik, M. (2024). STEAM education with young learners: Five different design processes. *Early Years*, 44(3–4), 918–933. <https://doi.org/10.1080/09575146.2023.2274293>
- Wanojaleni, K. (2021). Konsep dan implementasi pembelajaran scientific Kurikulum 2013. *QALAM: Jurnal Pendidikan Islam*, 2(2). <https://doi.org/10.57210/qlm.v2i2.89>
- Zakaria, S., & Md Osman, S. Z. (2024). STEAM innovation: Curriculum alignment, experimental learning, and transdisciplinary approaches. *International Journal of Modern Education*, 6(22), 319–335. <https://doi.org/10.35631/IJMOE.622024>