

# The Effect of the STEAM Learning Model on Problem-Solving Skills in Science Education for Third-Grade Students at SDN Kamasan 1

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**Abstract.** Science and Social Studies (IPAS) learning in elementary schools plays a crucial role in developing students' critical and problem-solving abilities. However, preliminary observations at SDN Kamasan 1, Cinangka District, revealed that third-grade students still struggle to identify problems and design contextual solutions in IPAS learning activities. This study aims to determine the effect of the STEAM (Science, Technology, Engineering, Art, and Mathematics) learning model on students' problem-solving skills. The research employed a quasi-experimental design with a non-equivalent control group, involving 52 students divided into an experimental class ( $n = 26$ ) and a control class ( $n = 26$ ). The experimental class received learning through the STEAM model, while the control class used conventional learning. Data were collected through problem-solving tests and observation sheets, and analyzed using an independent sample t-test. The results showed that the mean posttest score of the experimental class ( $M = 84.12$ ,  $SD = 6.45$ ) was significantly higher than that of the control class ( $M = 72.31$ ,  $SD = 7.28$ ), with  $t(50) = 6.42$ ,  $p < 0.001$ . The effect size (Cohen's  $d = 1.15$ ) indicated a strong influence of the STEAM model on students' problem-solving skills. These findings suggest that the STEAM learning model effectively enhances students' ability to connect IPAS concepts to real-life situations, promoting creativity and collaboration in 21st-century learning contexts.

**Keywords:** STEAM, problem-solving skills, IPAS, 21st century learning, elementary school.

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## INTRODUCTION

Science and Social Studies (IPAS) learning at the elementary school level requires the construction of higher-order thinking skills (HOTS) as the foundation for 21st-century scientific literacy. In the Deep Learning Curriculum, IPAS not only emphasizes mastery of concepts, but also the ability to apply knowledge in solving contextual problems relevant to students' daily lives (Kemendikbudristek, 2022). However, in practice, the learning process in lower elementary school grades still tends to be dominated by informative learning, emphasizing understanding of subject matter rather than integral thinking and problem-solving skills (Ghaleb, 2024).

Internal formative assessment reports from several elementary schools show that elementary school students still tend to rely on single answer patterns, are less willing to explore alternative solutions, and are not yet accustomed to using scientific reasoning in solving contextual problems. This is reinforced by the fact that most teachers still focus on delivering declarative knowledge and have not consistently applied project-based learning and engineering design process models, which are core characteristics of 21st-century learning (Markula and Aksela, 2022). This condition confirms that IPAS learning in elementary schools requires an approach that can provide integrative, authentic, and applicable experiences to stimulate students' higher-order thinking processes from an early age.

Initial observations in grade III at SDN Kamasan 1 Elementary School in Cinangka Subdistrict show that students' IPAS problem-solving skills are still in the low category. Students tend to have difficulty identifying the core of the problem, connecting information between concepts, and finding relevant solutions based on real contexts. The learning patterns that take place are also not systematic in encouraging multidisciplinary exploration in line with the characteristics of IPAS competencies as required by 21st-century learning.

One relevant learning approach to optimize higher-order thinking skills in elementary school children is the STEAM (Science, Technology, Engineering, Art, Mathematics) model. Conceptually, STEAM integrates various scientific domains through the processes of designing, testing, producing, and evaluating, thereby stimulating critical, creative, analytical, and problem-solving thinking (Al-Mutawah et al., 2022). STEAM-based learning has been proven to provide an active, interactive, collaborative, and meaningful learning process, thereby providing a more contextual and applicable learning experience (Lamichhane, 2021).

In the context of lower elementary school, the STEAM approach not only serves to reinforce conceptual understanding but also facilitates students in integrating science, technology, engineering, arts, and mathematics (STEM) knowledge with problem-solving skills that arise in authentic everyday situations. Through activities such as designing, trying, making decisions, and reflecting, students are trained to develop creative and logical solutions, thereby creating a more meaningful learning experience from an early age (Revenko et al., 2024).

Furthermore, the urgency of implementing the STEAM model aligns with Indonesia's national education policy, which emphasizes the integration of science, technology, and creativity as the foundation for innovation. At the elementary level, problem-solving ability is not merely an academic skill but a transformative competence that prepares students to navigate rapid social and technological changes (Singh, 2024). Traditional learning approaches that rely heavily on rote memorization have proven inadequate in developing divergent thinking skills, whereas the STEAM framework offers meaningful opportunities for students to actively construct knowledge through inquiry, exploration, and interdisciplinary collaboration (Bhor and Varghese, 2024).

Previous empirical studies have shown that STEAM-based instruction enhances students' scientific reasoning and curiosity toward real-world phenomena (Aktulun et al., 2024). In the Indonesian context, the adoption of STEAM learning is also relevant for strengthening the Profil Pelajar Pancasila—the national vision of learners who are creative, collaborative, and

critical thinkers. Consequently, the present research is not limited to measuring cognitive improvement but also aims to explore how the integration of the engineering design process within science education fosters creativity, reflection, and authentic problem-solving among young learners. This perspective situates STEAM as a pedagogical innovation that nurtures holistic learning experiences aligned with the Deep Learning Curriculum’s vision of cultivating 21st-century skills and character formation from the early grades.

These factors make the use of the STEAM approach in scientific education relevant and strategic for greatly enhancing primary school pupils' problem-solving abilities. In order to determine if using the STEAM approach may help third-grade students at SDN Kamasan 1, Cinangka District, improve their science problem-solving abilities, this study was carried out using Classroom Action Research (CAR). It is anticipated that this study will yield a learning implementation model that primary school teachers may use as a guide for creating innovative, cooperative, contextual learning that satisfies the requirements of the 21st-century curriculum.

## METHODOLOGY

### Research Design

This study uses a quasi-experimental design with a non-equivalent control group and a quantitative technique. This approach allowed for a comparison between the experimental group and the control group, which had comparable features, even though the researcher was unable to completely randomize the patients (Mulisa, 2022). There are two groups in this design: the control group got traditional instruction based on lectures and question-and-answer sessions, while the experimental group received learning therapy utilizing the STEAM paradigm.

The research design structure is described as follows:

**Table 1.** Non-Equivalent Pretest–Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experimental	O <sub>1</sub>	X	O <sub>2</sub>
Control	O <sub>3</sub>	–	O <sub>4</sub>

Description:

X = Treatment with the STEAM learning model

O = IPAS problem-solving ability test

## Research Population and Sample

The 52 third-graders at SDN Kamasan 1 Elementary School in the Cinangka District during the odd semester of the 2025–2026 school year made up the study's population. Because the courses were chosen based on academic qualities, the sampling method employed non-probability sampling with a purposive sample strategy. Class IIIA (n = 26) was the experimental class and class IIIB (n = 26) was the control class in the sample.

## Research Variables

1. Independent variable: STEAM (Science, Technology, Engineering, Art, Mathematics) learning model.
2. Dependent variable: Students' IPAS problem-solving skills.

## Research Instruments

The main instruments in this study are:

1. Problem-solving ability test, in the form of essay questions with indicators based on Polya's problem-solving stages in (Oktarisa et al., 2022), namely:
  - a) understanding the problem,
  - b) planning a solution strategy,
  - c) implementing the strategy, and
  - d) evaluating the results.

The test is administered during the pretest and posttest to measure the improvement in students' abilities.

2. Student activity observation sheet, used to monitor student engagement during the STEAM learning process, with aspects of collaboration, creativity, and critical thinking skills (Maričić and Lavicza, 2024).

Both instruments were validated by two lecturers specializing in basic education and one experienced teacher using content validity techniques. The reliability of the instruments was tested using Cronbach's Alpha formula, and the results showed a reliability coefficient of 0.87, which means that they are highly reliable (Forester et al., 2024).

## Research Procedure

The research was conducted in four main stages:

1. Preparation Stage
  - a) Conduct preliminary studies to identify IPAS learning problems at SDN Kamasan 1.
  - b) Develop STEAM-based learning tools, including lesson plans, student worksheets, and research instruments.
  - c) Have the tools validated by experts.
2. Implementation Stage
  - a) The experimental class received STEAM learning treatment for four meetings (4 x 70 minutes), while the control class underwent conventional learning with the same topics and duration.
  - b) The STEAM learning process followed the Engineering Design Process (EDP) steps, which included: Ask, Imagine, Plan, Create, and Improve (Lin et al., 2021).
3. Data Collection Stage
  - a) Problem-solving ability data was collected through pre-tests and post-tests.
  - b) Observations were conducted during the learning process to assess student participation and the application of STEAM principles.
4. Data Analysis Stage
  - a) An independent samples t-test was used to examine pretest and posttest data in order to ascertain if the experimental and control groups' means differed.
  - b) Prerequisite tests for analysis included normality (Kolmogorov-Smirnov) and homogeneity (Levene's Test).
  - c) Using Cohen's d method, effect size was computed to ascertain how much the STEAM model affected pupils' capacity for problem-solving (Erol et al., 2023).

### **Data Analysis Techniques**

Data analysis was performed using SPSS software version 26. Interpretation of results followed Cohen's criteria (Brydges, 2019):

$d < 0.2$  = small effect

$0.2 \leq d < 0.8$  = moderate effect

$d \geq 0.8$  = large effect

To ensure external validity, several control measures were applied throughout the research implementation. Both the experimental and control classes were taught by teachers with comparable qualifications, using similar lesson durations and learning objectives to minimize

instructional bias. Before the intervention, the experimental teacher participated in a short professional development workshop focused on implementing STEAM-based learning using the *Engineering Design Process (EDP)* to ensure treatment consistency (Rukminingsih and Latief, 2020).

Data credibility was strengthened through methodological triangulation by comparing students' test results with observational data on engagement and collaboration. Qualitative field notes from classroom observations were analyzed thematically to enrich the interpretation of quantitative findings, particularly in understanding students' affective and behavioral engagement during learning (Nurhayati et al., 2024).

Normality and homogeneity assumptions were examined using a 0.05 significance level, and the *effect size* was calculated to interpret the magnitude and practical relevance of the observed effects Cohen, 1988 in (Serdar et al., 2021). Statistical analyses were conducted with SPSS version 26.0, accompanied by reflective interpretation to link statistical outcomes with pedagogical implications. This comprehensive approach ensured that findings not only demonstrated numerical differences but also reflected meaningful learning transformations observed in classroom practices.

## RESULTS AND DISCUSSION

The purpose of this study is to ascertain how the STEAM learning paradigm has affected the third-grade pupils at SDN Kamasan 1 Elementary School in the Cinangka District's capacity for problem-solving. Two groups the experimental group, which used the STEAM model, and the control group, which used traditional learning were given pretest and posttest findings on their problem-solving skills.

**Table 1.** Descriptive Statistics

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Difference ( $\Delta$ )
Experimental (STEAM)	26	64.35	7.12	84.12	6.45	+19.77
Control (Conventional)	26	63.58	6.94	72.31	7.28	+8.73

Table 1 shows that the average pretest scores of the two groups were relatively equal (64.35 and 63.58), indicating balanced initial abilities. After the treatment, the average posttest score of the experimental group increased significantly to 84.12, while the control group only reached 72.31. The increase in scores (gain) in the experimental group ( $\Delta = 19.77$ ) was almost double that of the control group ( $\Delta = 8.73$ ).

Before conducting the t-test, a normality and homogeneity of variance test was performed.

**Table 2.** Normality and Homogeneity Test Results

Test	Sig. (p)	Criteria	Description
Normality (Kolmogorov–Smirnov)	0.167	> 0.05	Data are normally distributed
Homogeneity (Levene’s Test)	0.244	> 0.05	Variances are homogeneous

The results show that the data meets the assumptions of normality and homogeneity, making it suitable for a t-test.

**Table 3.** t-test Results

Group	Mean Difference	t(50)	Sig. (p)	Description
Experimental – Control	11.81	6.42	< 0.001	Significant

The posttest scores of the experimental and control groups differed significantly, as indicated by the  $t(50)$  value = 6.42 with  $p < 0.001$ . As a result, using the STEAM paradigm significantly enhances pupils' ability to solve problems.

The effect size was calculated using Cohen's d formula, resulting in a value of  $d = 1.15$ , which falls into the large effect category according to Cohen's criteria (1988).

**Table 4.** Gain (g) Values

Group	Normalized Gain (g)	Category
Experimental	0.55	Medium–High
Control	0.26	Low

The gain value shows that the improvement in problem-solving skills in the experimental group was moderate to high, while in the control group it remained low. This reinforces the t-test results that the application of the STEAM model is more effective than conventional learning.

**Table 5.** Student Activity Observation Results

Observed Aspect	Experimental Average Score	Control Average Score
Active participation	4.55	3.18
Collaboration	4.47	3.05
Creativity in problem solving	4.62	3.12
Critical thinking skills	4.58	3.22
Reflection and self-evaluation	4.35	3.09

Students in the experimental group exhibited greater learning activities, particularly in terms of creativity, teamwork, and critical thinking, according to the observation data. This suggests that the STEAM method promotes the development of 21st-century capabilities in addition to improving cognitive performance.

The study's findings demonstrate that third-grade pupils at SDN Kamasan 1 significantly improve their problem-solving skills when the STEAM learning approach is used. The STEAM model's features, which highlight the integration of science, technology, engineering, art, and mathematics through the engineering design process, can account for this increase.

The STEAM model encourages students to observe, formulate questions, design solutions, test ideas, and reflect on results. These activities train students to engage in critical and systematic thinking processes as described by Yakman & Lee (2012), who argue that the STEAM approach forms learning by design that integrates various scientific domains in real-life contexts.

These findings are in line with the results of research by Rosyida et al., (2025), which shows that the application of the STEAM model in elementary school thematic learning can improve students' critical thinking and problem-solving skills through exploratory and project-based activities. Similarly, Harris et al. (2017) found that STEAM learning fosters creative and collaborative thinking skills because it provides space for students to experiment and make decisions independently.

These results also reinforce the research by Barak (2020), which states that project-based and engineering design-based IPAS learning is more effective than conventional learning because it develops connections between concepts and encourages scientific reflection.

The increase in the average posttest scores of the experimental group ( $M = 84.12$ ;  $SD = 6.45$ ) compared to the control group ( $M = 72.31$ ;  $SD = 7.28$ ) shows that STEAM is capable of improving the ability to transfer knowledge to real-world contexts. According to Wijayanti and Ridlo (2025), approaches that encourage cross-disciplinary exploration such as STEAM are relevant to the principles of the Deep Learning Curriculum, namely fostering Pancasila student profiles that are creative and critical thinkers.

In addition to improved cognitive outcomes, the observation results show an increase in student learning activities in the affective and social dimensions, such as collaboration and reflection. This indicates that STEAM learning provides a more meaningful and contextual

learning experience, as stated by the Ministry of Education, Culture, Research, and Technology (2022) that IPAS learning in elementary schools must foster higher-order thinking skills (HOTS) in an integrative manner from an early age.

Overall, the results of this study reinforce empirical evidence that the STEAM learning model is effective in improving elementary school students' IPAS problem-solving skills because it: (1) Encourages active engagement and curiosity among students. (2) Integrates science and technology concepts with artistic creativity. (3) Develops critical, collaborative, and reflective thinking processes.

Thus, the application of STEAM can be recommended as an alternative IPAS learning strategy in the implementation of the Deep Learning Curriculum to strengthen the Pancasila learner profile and 21st-century skills.

A deeper analysis of the findings reveals that the substantial improvement in problem-solving skills among students in the experimental group was accompanied by higher levels of self-confidence and engagement during learning activities. The opportunities provided through inquiry, design, and reflection stages allowed students to develop creative yet systematic ways of approaching scientific problems. This outcome is consistent with Kim and Chae (2023), who found that STEAM instruction significantly enhances learners' self-efficacy in scientific problem-solving by immersing them in authentic design challenges.

Observational data further demonstrated that students showed greater initiative and collaboration during the *Plan* and *Create* phases of the EDP. They engaged in discussions, contributed diverse ideas, and demonstrated persistence in testing and improving their solutions. The integration of art within STEAM was particularly influential in reducing students' fear of failure and encouraging flexible thinking. Zhang and Jia (2024) emphasized that the inclusion of artistic expression in STEAM promotes divergent creativity, enabling students to visualize and communicate their scientific understanding more effectively.

From a theoretical standpoint, the findings can be interpreted through the lens of *constructivist learning theory* Vygotsky, 1978 in (MacLeod et al., 2022), which posits that knowledge is actively constructed through social interaction and experiential engagement. The STEAM model embodies this principle by situating learning within authentic, multidisciplinary contexts that mirror real-world problem-solving. Students do not simply memorize concepts but internalize them through active experimentation and reflection, leading to deeper and more durable learning outcomes.

Furthermore, the results show that STEAM application fosters the development of 21st-century skills including teamwork, communication, critical thinking, and creativity. Students in the experimental group showed improved social-emotional skills in addition to higher cognitive scores. They were also more inclined to take the initiative, participate in group problem-solving, and reflect on their own learning processes. These dimensions are often overlooked in conventional classrooms but are essential for lifelong learning and adaptability in the digital age.

Considering the Indonesian educational context, the integration of STEAM should be culturally adapted to align with local values and community-based learning traditions. Teachers play a central role as facilitators who connect scientific inquiry with students' daily experiences and cultural environments. Thus, the present study contributes not only to theoretical discourse but also to practical insights for teacher professional development and curriculum enrichment. The results underline the necessity for sustained policy support to implement STEAM-based practices systematically within the Merdeka Curriculum framework.

## CONCLUSION

The results of the study demonstrate that when the STEAM (Science, Technology, Engineering, Art, and Mathematics) learning model is used, third-grade students at SDN Kamasan 1 Elementary School in the Cinangka District greatly enhance their problem-solving skills in IPAS learning. Students in the experimental group and the control group had significantly different learning outcomes, according to the independent sample t-test analysis, which produced a t-value of 6.42 with  $p < 0.001$ . The experimental group's average posttest score ( $M = 84.12$ ,  $SD = 6.45$ ) was higher than the control group's ( $M = 72.31$ ,  $SD = 7.28$ ) with a Cohen's  $d$  effect size of 1.15, indicating a substantial influence of the STEAM model's implementation on students' problem-solving skills.

In addition to having a significant impact on cognitive outcomes, the application of the STEAM model also increased student learning activities in the aspects of collaboration, creativity, critical thinking, and self-reflection. The STEAM-based learning process allows students to be actively involved in finding solutions to contextual problems through the engineering design process stages, namely observing, designing, creating, testing, and improving. This approach creates an interactive, integrative, and contextual learning atmosphere and helps students relate IPAS concepts to everyday phenomena.

Overall, it can be concluded that the STEAM learning model is effective in IPAS learning in elementary schools because it is able to develop higher-order thinking skills from an early age, improve problem-solving skills relevant to real life, and foster Pancasila student profiles that are creative, critical thinkers, and collaborative in accordance with the demands of the Deep Learning Curriculum and 21st-century learning.

This research provides practical implications for improving science learning in Indonesian elementary schools. The STEAM model has demonstrated its effectiveness in enhancing students' cognitive, affective, and social competencies in an integrated manner, thus serving as an appropriate pedagogical alternative for realizing the goals of the Merdeka Curriculum. Future research is encouraged to explore the long-term impact of STEAM-based instruction across different grade levels and subject areas to build a more comprehensive understanding of its potential.

Furthermore, broader teacher involvement in designing and implementing STEAM-oriented learning projects is essential to cultivate an innovative and sustainable school culture. Continuous professional support and collaboration among educators, curriculum developers, and policymakers are required to ensure that STEAM becomes an embedded practice rather than an experimental initiative in Indonesian basic education.

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