

Effects of STEAM Education Practices on Problem Solving Ability of Elementary School Students

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Abstract- The study aims to examine the effects of STEAM Education Practices on elementary students' problem-solving ability, and it conducted hands-on activities incorporating STEAM components for 7th-grade students. The study used a pre-test, post-test, control-group design. The research participants were students in a public school located in the Farmai, Sirsa district. The study included 80 elementary students. The researcher developed 30 science modules that cover eight units based on the NCERT syllabus. The Experimental treatment was applied for 30 days in two groups: experimental group A (STEAM hands-on activity practice and Control group B (through conventional method). The researcher obtained the data using the standardized Problem Solving Ability Test by L. N. Dubey. The data were analyzed by t-test. The results showed that hands-on, activity-based STEAM practice effectively improved problem-solving ability among elementary students.

Keywords: STEAM Education Practices, Problem Solving Ability, Elementary students.

I. INTRODUCTION

Education is essential for a nation's progress. The success of a country often relies on the quality of its education system, which changes and improves over time. Good education helps people become skilled and capable. In today's world, people need to solve problems, generate new ideas, share their thoughts, and adapt to the changes around them. These skills do not appear on their own; they need to be taught and encouraged from a young age.

This helps children learn to see things from different viewpoints and think critically. Improving education takes effort from governments, teachers, and parents. The National Education Policy 2020 stresses the need to nurture creativity in everyone. It says education should teach basic skills like reading and math, as well as higher-level skills such as critical thinking, problem-solving, and decision-making. Education should also help students grow socially, ethically, and emotionally. The aim is to build an education system in India that supports national growth and creates a fair, knowledge-based society through quality learning.

Recently, educators have realised the importance of integrating subjects to help students navigate the

challenges of the 21st century. The STEAM education model was created to break down barriers between subjects and offer a more comprehensive approach to learning that supports critical thinking, creativity, and teamwork. Economic competition and downturns (Sochacka, Guyotte, & Walther, 2016) led to the introduction of STEM education in the U.S. in the 1990s by the National Science Foundation, grouping Science, Technology, Engineering, and Math together (English, 2016; Sanders, 2009).

The main goal was to prepare students for the global economy (Huser et al., 2020; Yakman & Hyonyong, 2012). However, fewer students later chose STEM careers (Lio, 2016), causing a shortage of skilled workers and leaving many jobs unfilled (Bidwell, 2014). In response, President Obama launched the 'Educate to Innovate' initiative in 2009 to improve STEM education, but it did not address the main problem: a lack of creativity and innovation.

The Adobe Create Report 2012 found that this creativity gap exists not only in schools but also in workplaces, where one in four people feel they are not reaching their creative potential (as cited in Maltas, 2015). This led to calls for adding Arts and Humanities

to STEM, creating the STEAM movement (Lio, 2016; Maeda, 2013). This approach gives students a more creative and natural way to see the world, making it a focus for teachers and researchers (Sousa & Pilecki, 2013). Liao (2016) also noted a drop in students choosing STEM careers in the U.S. and worldwide, which encouraged the shift to STEAM, where the "A" stands for Arts and Humanities (p. 44).

The STEAM model, which brings together Science, Technology, Engineering, Arts, and Mathematics, aims to develop students' creativity and problem-solving skills. In traditional education, subjects are often taught separately, limiting students' ability to connect and apply their knowledge.

STEAM education, on the other hand, encourages students to integrate knowledge and skills from diverse fields through an interdisciplinary approach, providing a richer, more practical learning experience. This integration not only deepens students' understanding but also boosts their creative and critical thinking skills. In a STEAM program, students are encouraged to explore, ask questions, experiment, and create, all of which support self-directed learning and active inquiry.

For example, by combining art and science, students can learn scientific ideas through the visual and performing arts, making learning more enjoyable and helping them understand concepts more deeply. Also, by linking technology and engineering, students can use their math and science knowledge in real-world engineering projects, learning and applying new knowledge as they solve real problems.

II. THEORETICAL FOUNDATIONS OF STEAM EDUCATION

STEAM education is a teaching approach that combines science, technology, engineering, art, and math to help students become creative and well-rounded. This approach is based on educational and psychological theories like constructivist learning, multiple intelligences, and creativity.

Constructivist learning theory holds that knowledge is not passively received but actively constructed from the

learner's own experience through interaction with the environment. In STEAM education, students combine theoretical knowledge with practical application through real-world projects, an approach that emphasises active exploration and problem-solving in the learning process.

For example, in an interdisciplinary project, students may need to apply mathematical calculations, understand scientific principles, utilise technological tools, carry out engineering designs, and express and present the results of their work through art (Hawari & Noor 2020). Such integrated learning activities enable students to apply their knowledge in real-world situations, leading to a deeper understanding of subject matter and the development of real-world problem-solving skills.

The Multiple Intelligences theory, proposed by Howard Gardner, asserts that there are multiple forms of human intelligence, including linguistic, logical-mathematical, spatial, physical-kinesthetic, musical, interpersonal, introspective, and naturalistic observational intelligences. STEAM education allows students to engage across multiple domains of intelligence through interdisciplinary projects, helping them develop their full range of abilities and enabling different types of students to find their strengths and interests (White & Dealney 2021).

For example, arts integration may appeal to students with visual-spatial and physical-kinesthetic intelligences, while engineering and technology elements may appeal to students with logical-mathematical intelligences. The theory of creativity emphasises the importance of innovative thinking as the key to advancing society and technology.

In STEAM education, creativity is fostered throughout all aspects of education. Students are encouraged to adopt an open mind and find new ways to solve problems through experimentation and exploration. The interdisciplinary mode of teaching and learning provides a rich ground for the development of creativity, as students need to synthesise knowledge and skills from different disciplines to create unique solutions.

III. REVIEW OF LITERATURE OF STEAM AND PROBLEM SOLVING

Problem solving Ability is the highest form of learning in Gagne's theory of learning. Polya (1981) defined problem solving as "finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately attainable. Carpenter (1989) says that Problem solving activities are often viewed as a method to practice, applying new knowledge and skills learned earlier in a different context. Problem solving involves the ability to explore, think through an issue, and reason logically to solve routine as well as non-routine problems.

Mayer (1992) summarizes three major aspects of a definition of problem solving: a) Problem solving is cognitive, because it occurs internally within the problem solver's cognitive system. b) Problem solving is a process, because it involves manipulating or performing operations on the problem solver's knowledge and c) Problem solving is directed, because the problem solver is attempting to achieve some goal. Nguyen et al. (2025) investigated the inclusion of design thinking into STEM. 334 kids were participants in the study.

The five-stage design thinking model was used with components (empathy, problem identification, ideation, prototyping, and testing). Confirmatory factor analysis was used to validate the model. It was found that incorporating design thinking into STEM education enhanced students' problem-solving skills. Azizah et al. (2025) investigated the problem-solving profile by incorporating an ethno STEAM-based approach.

18 fifth-grade students participated in the study. A descriptive quantitative design was used, and students' problem-solving performance was examined. It was found that students recognised the problems, and teachers scaffolded their solution. Asilturk et al. (2025) conducted a study on 51 seventh-grade pupils in schools in Turkey. An experimental design was constructed, and interventions were given for seven weeks. It was found that STEAM activities raised pupils' knowledge of environmental issues.

Luo et al. (2025) examined students' multidisciplinary knowledge acquisition, learning motivation, critical thinking, creativity, and problem-solving skills in C-STEAM courses and virtual simulation-supported museum-based learning. 112 primary students, comprising 54 students in C-STEAM and 58 in VSS-MBL, were selected. It was found that VSS-MBL had a more positive effect on critical thinking and problem-solving skills. Ozkul (2025) examined the effect of STEM activities based on engineering design cycles. The sample consisted of 37 fourth-grade children. Qualitative and quantitative design (quasi-experimental) of research was used. It was found that STEM activities based on engineering design helped motivate students to solve their problems by applying engineering skills.

1. Steam Education Practices

STEAM education practices are integrated, student-centered instructional approaches that bring together Science, Technology, Engineering, Arts, and Mathematics to develop learners' conceptual understanding, creativity, critical thinking, decision-making, problem solving ability of students. Through previous studies it was found that the most common practices involved, with STEAM Education are as follows:

2. Project Based Approach

Kim et al. (2019) examined in their study and found that a project-based STEAM instructional approach was effective across all levels, from pre-primary to higher levels. The study found that collaboration between art and technology could facilitate teaching in STEAM-based lessons. Other studies (Farshad & Fortin, 2026; Chen & Yag, 2019; García-Llamas et al., 2025) found that project-based methods typically involve students in solving real-world problems, collaborating across disciplines, and creating concrete products or prototypes. These techniques encourage higher-order thinking and lead to improved academic achievement.

3. Problem Based Learning

Problem-based learning involves presenting students with authentic or ill-structured problems that require investigation and the development of possible solutions. In STEAM education, problems can be designed to require students to draw on knowledge

from science, mathematics, technology, engineering, and the arts. Multiple studies support the effectiveness of combining STEAM or STEM education with problem-based learning approaches. Vossen and colleagues (2020) found that PBL in STEM environments positively affects both students' and teachers' attitudes toward STEM subjects and increases engagement. Han, Capraro, and Capraro (2015) showed that STEM PBL benefits learners at all achievement levels, especially by helping them develop key skills and increasing their motivation. English and King (2015) pointed out that STEM project-based learning promotes 21st-century skills such as collaboration, critical thinking, and creativity. Similarly, Siew, Amir, and Chong (2015) stated that both pre-service and in-service teachers consider PBL in STEM education very effective for improving student learning outcomes.

Hacıoğlu & Gülhan (2021) and Hebebcı & Ertuğrul (2022) also found it effective in promoting critical thinking and problem-solving skills, which are core competencies in STE(A)M education.

4. Inquiry Based Learning

Inquiry-based learning involves students in the learning process by asking questions, investigating phenomena, gathering evidence, analyzing information, and communicating their conclusions. It is especially appropriate for STEAM because it lets students combine scientific inquiry with mathematical reasoning, technology, engineering design, and creative methods. (Çevikbaş and Argün 2017; Yakman and Lee 2012; Henriksen 2014; Chien and Chu 2018; Land 2013) studies supported this practice in promoting meaningful, engaging, and effective STEAM education and improving problem-solving skills.

5. Flipped Learning

Kreis et al. (2024) investigated the effectiveness of flipped classroom methods in a STEAM-based educational context to determine the benefits and challenges of a teacher education program. Their results show that student engagement improved significantly among preservice teachers. They also found that flipped and STEAM-based instruction helped prospective teachers develop significant confidence in applying math concepts and pedagogical principles while acquiring important self-regulation skills.

6. Technology Based Steam Learning

Ji (2021) investigated STEAM-based teaching using VR technology in animation courses. Participants' learning performance, as measured by final grade and overall score, also improved significantly. Román-Graván et al. (2020) investigated how educational robotics can raise women and promote gender equality in teacher education. They found that robotics kits in STEAM lessons contributed to female participants' very positive attitudes toward educational robotics before and after the experience.

Hung et al. (2024) found that implementing a STEAM-based assistive technology curriculum significantly influenced student satisfaction. (Satunggale Kurniawan & Ibnu Kanaha, 2026; Wu & Chen, 2021; Zhang et al., 2022; Hsu & Hwang, 2023) encouraged students to think more innovatively, analyze problems more deeply, and improve their ability to work as a team and communicate their ideas more effectively.

7. Arts Integration In Steam Practice

Chen and Dong (2023) found that applying STEAM educational concepts in teaching art songs significantly increased students' interest in learning and motivation. They also reported that students' interpersonal skills and teamwork improved significantly after their study. (Hunter-Doniger, 2019; Maeda, 2013; Doyle, 2017; Radziwill et al., 2015; Dejonckheere et al., 2016; Purakom & Soykeree, n.d.). Integrating the arts in STEM, along with a focus on innovative, early science education, leads to more comprehensive skill development, greater creativity, and better preparation for future challenges in education and beyond.

IV. HANDS ON ACTIVITY BASED STEAM PRACTICE

Hands-on activity based STEAM practice refers to an instructional approach in which students apply theoretical knowledge to acquire concepts directly by integrating Science, Technology, Engineering, Arts, and Mathematics through practical, collaborative hands on activities by constructing, designing, observing, and creating models, rather than relying on lectures and textbooks.

The integration of hands-on methods within STEAM education presents several opportunities. Creativity flourishes when students engage in interdisciplinary, hands-on projects. Creativity training embedded in STEAM improves not only innovative thinking but also self-confidence in problem-solving (Gu et al., 2023).

Hands-on experiences allow students to learn science by actively exploring and examining different phenomena. When learners conduct experiments, they can observe changes, ask questions, gather information, and develop explanations based on their findings. For example, growing plants in different light conditions, making a simple electrical circuit, or observing the results of physical and chemical changes can help students understand how and why things happen. (Beers, 2011). Any equipment used by children when playing is technology, from simple to modern forms, including simple machines that children come across in their daily lives (Henriksen, 2017).

For example, students can use clay, to design a thermometer. These hands-on experiences encourage students to explore, make changes, identify errors, and solve problems. Students learn engineering concepts effectively when they design and build something. Activities such as building a bridge with popsicle sticks and creating a simple water filtration system that can develop creativity, problem-solving ability, critical thinking, and perseverance.

It also helps students understand that successful solutions often require repeated testing and modification (Sanders, 2009). Including art in STEAM activities can encourage imagination, creativity, visual communication, and personal expression while strengthening conceptual understanding (Wynn & Harris, 2012).

calculating ,measuring the amount of quantity to be taken in carrying out science experiments helps learners to see and experience mathematical relationships rather than simply memorizing procedures. As a result, hands-on mathematical experiences can support conceptual understanding, spatial reasoning, problem-solving, and mathematical skills (Carbonneau, Marley, & Selig, 2013).

Objectives of Study-

- To compare the problem solving ability of student's taught through STEAM Education Practices and through traditional method before the experimental treatment at elementary level.
- To compare the problem solving ability of student's taught through STEAM Education Practices and through traditional method after the experimental treatment at elementary level.
- To compare the mean gain scores of problem solving ability of experimental group and control group.

1. Hypothesis Of Study

- There will be no significant difference between the student's problem solving ability taught through STEAM Education Practices and through traditional method before the experimental treatment at elementary level.
- There will be no significant difference between the student's problem solving ability taught through STEAM Education Practices and through traditional method after the experimental treatment at elementary level.
- There will be no significant difference between the mean gain scores of problem solving of experimental group and control group.

V. METHODOLOGY AND DESIGN OF STUDY

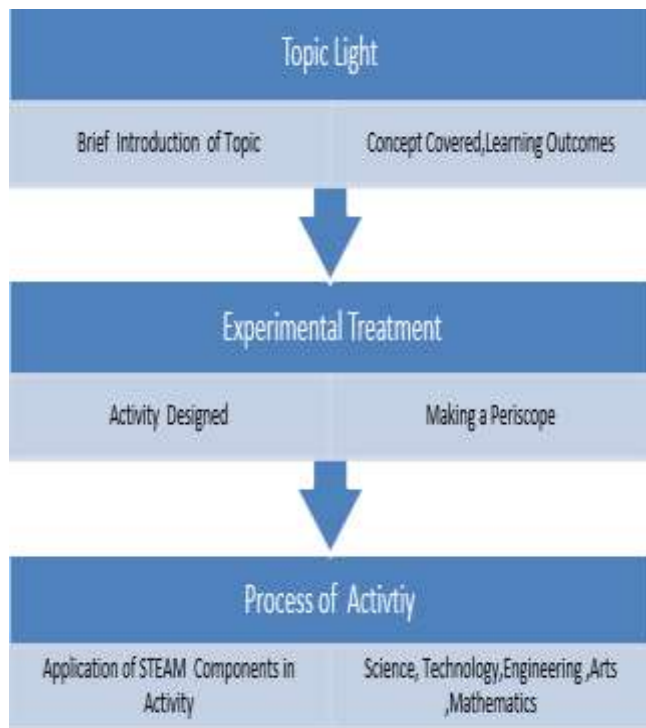
The study used a pre-test, post-test control group design. The selected sample was randomly split into two groups. Group A was taught using STEAM Education Practices, and Group B was taught using traditional teaching methods. First, all selected students in the experimental and control groups were pre-tested on problem-solving ability. Secondly, the experimental treatment was given for 30 days .

The experimental treatment consisted of teaching Group A through STEAM Education Practices and Group B through the traditional teaching method. In the third stage, students were post-tested on Problem-solving ability of elementary students.

1. Pre-Test Post-Test Control Group Design

Phases	Control Group	Experimental Group
Pre-test	To know the existing level of problem solving skills.	To know the existing level of problem solving skills.
Treatment	To teach through traditional method of teaching for 30 days.	To teach through STEAM education practices for 30 days.
Post-test	After teaching through traditional method of teaching knowing the existing level of problem solving skills.	After treatment, knowing the existing level of problem solving skills.

2. Development Of Modules Based On Hands-On Activity- Steam Practice



Hands-on, activity-based STEAM practice is adopted as a STEAM practice for the subject Science for Class 7 students. Nine units of the science subject are selected.

The content was developed according to the NCERT syllabus.

The researcher prepared 30 modules based on hands-on activities aligned with STEAM, covering topics such as Nutrition in Plants, Transportation in Plants and Animals, Motion and Time, Heat, Physical Changes and Chemical Changes, Acids and Bases, Electric Current, and Wastewater Story. The modules were prepared involving activity designed, learning concepts and outcomes involving STEAM components. An example of the framing of the module is illustrated below.

- First, the researcher selected the topic Light from the 7th-class NCERT. Next, the researcher prepared a brief introduction to the topic. Next, the researcher framed learning objectives and outcomes, including the concept of reflection and mirror angles; how changing the direction of light helps us see objects; and demonstrating and designing a periscope through hands-on learning. After that, the researcher selected an activity named "Making a Periscope". Before the start of the activity, the researcher tested the previous knowledge of students by asking some basic questions related to the concept of light, like "What is the natural source of light?" which promotes curiosity among students. Students were then divided into groups to carry out the activity.
- The researcher instructed students to gather learning materials such as chart paper, pencil, notebook, tapestry scissors, glue, transparent sheet, and a plane mirror. The researcher showed a video on making a periscope using the smartboard and, with scaffolding, asked students to make their own periscope. The students' hands-on activity involved all the STEAM components.
- Science:** Students understood reflection and how light travels through mirrors, and connected it to the visibility of things around them.
- Technology:** Using pencils, cardboard boxes, and smart board during periscope construction helped students develop technological skills and connect technology principles to creating different types of mirrors.

- **Engineering:** Designing, assembling, and fixing the mirrors correctly helped students learn and apply engineering skills, helping them structure various objects in practical life.
- **Arts:** Decorating the periscope with stickers, colors, and paint developed students' artistic skills.
- **Mathematics:** Students also improved their measurement accuracy and spatial reasoning skills during periscope construction.

VI. DATA ANALYSIS

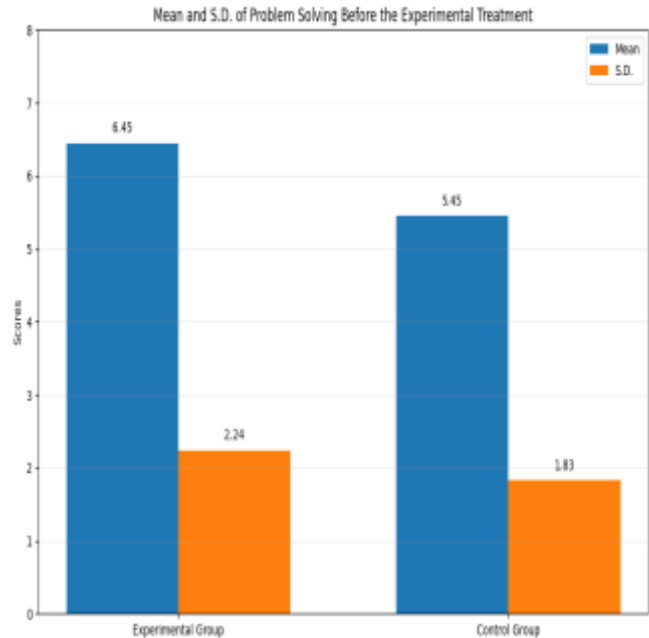
Hypothesis No. 1: There is no significant difference between the student's problem solving ability taught through STEAM Education Practices and through traditional method before the experimental treatment at elementary level.

Table 1.1: Student's problem solving ability of experimental and control group before the experimental treatment

Groups	N	Mean	S.D.	t-value	Level of Significance
Experimental Group	40	6.45	2.24	2.188	Significant at 0.05 level
Control Group	40	5.45	1.83	2.188	Significant at 0.05 level

For Objective 1, which has to do with understanding if there is any comparison of the problem-solving ability of students before the experimental treatment at the elementary level, the results suggested a statistically significant difference between both groups (experimental and control groups).

For the problem-solving, the reported t value is 2.188, df is 78, and p is 0.032. As the p-value is less than 0.05, Hypothesis 1 was rejected. This outcome implies that the two groups were not quite on the same level for problem-solving at baseline, meaning full equivalence at the starting point wasn't achieved for this variable.



Hypothesis No. 2: There is no significant difference between the student's problem solving ability taught through STEAM Education Practices and through traditional method after the experimental treatment at elementary level.

Table 2: Student's problem solving ability of experimental and control group after the experimental treatment

Groups	N	Mean	S.D.	t-value	Level of Significance
Experimental Group	40	6.705	1.75	-0.278	Not significant at 0.05 level
Control Group	40	6.58	1.75	-0.278	Not significant at 0.05 level

The results showed that there was no statistically significant difference between the experimental and control groups in Problem Solving ($t = -0.278$, $df = 78$, $p = 0.782$). So, basically this suggests that both instructional approaches led to comparable post-test problem-solving performance. Because the p-value comes out higher than 0.05, the null hypothesis (H_{08}) is accepted.

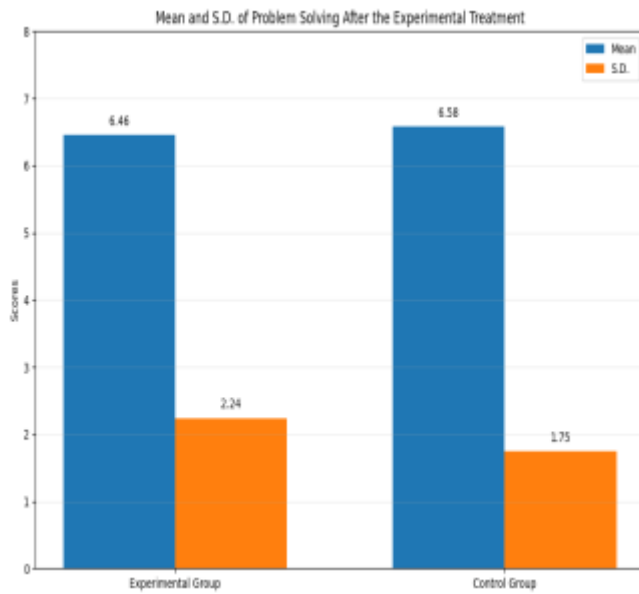


Figure 2 :Student's problem solving ability of experimental and control group after the experimental treatment

Hypothesis No.3 :There is no significant difference between the mean gain scores of problem solving of experimental group and control group.

Table 3: Showing that Mean, S.D and t-ratio of mean gain scores of the experimental group and control groups (problem solving)

Groups	N	Mean of Gain Scores	S.D.	t-value	Level of Significance
Experimental Group	40	0.05	0.56	-6.863	Significant at 0.05 level
Control Group	40	1.13	0.79	-6.863	Significant at 0.05 level

The hypothesis said "There will be no significant difference between the mean gain scores of problem solving of the experimental group and control group", but that doesn't seem to hold up. When the independent samples t-test was run, the experimental group ended up with a mean gain score of 0.05 , (S.D.

= 0.56). Meanwhile, the control group showed a mean gain score of 1.13 (S.D. = 0.79). The obtained t-value was -6.863 with 78 degrees of freedom, and the matching p-value came out as < 0.001. So, because this p-value is smaller than the significance level of 0.05 , the gap between the mean gain scores across the two groups is statistically significant. As a result, the null hypothesis is rejected. In other words, there is a real difference in the gain scores for problem-solving skill between the experimental and control groups.

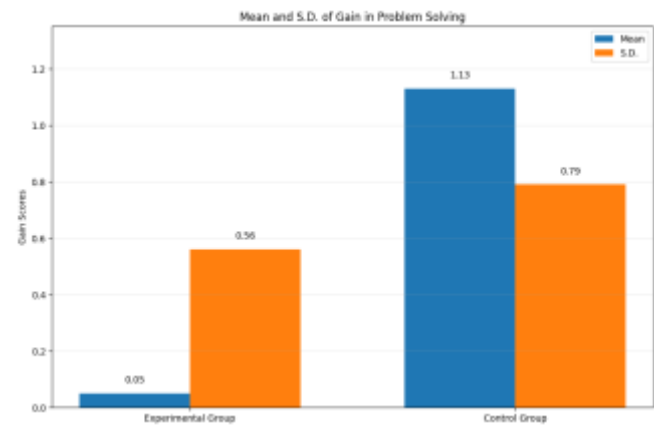


Figure 3 : Mean of gain scores of the experimental group and control groups (problem solving ability)

VII. DISCUSSION AND FINDINGS

For Objective 1, which has to do with understanding if there is any comparison of the problem-solving ability of students before the experimental treatment at the elementary level, the results suggested a statistically significant difference between both groups (experimental and control groups). For the problem-solving, the reported t value is 2.188, df is 78, and p is 0.032. As the p-value is less than 0.05, Hypothesis 1 was rejected. This outcome implies that the two groups were not quite on the same level for problem-solving at baseline, meaning full equivalence at the starting point wasn't achieved for this variable.

For Hypothesis 2 ,There will be no significant difference between the student's problem solving ability taught through STEAM Education Practices and through traditional method after the experimental treatment at elementary level. Table 2 above results showed that there was no statistically significant difference between

the experimental and control groups in Problem Solving ($t = -0.278$, $df = 78$, $p = 0.782$). So, basically this suggests that both instructional approaches led to comparable post-test problem-solving performance. Because the p -value comes out higher than 0.05, the null hypothesis (H_{08}) is accepted. For hypothesis 3 said "There will be no significant difference between the mean gain scores of problem solving of the experimental group and control group" , but that doesn't seem to hold up. When the independent samples t-test was run, the experimental group ended up with a mean gain score of 0.05 , (S.D. = 0.56). Meanwhile, the control group showed a mean gain score of 1.13 (S.D. = 0.79). The obtained t-value was -6.863 with 78 degrees of freedom, and the matching p -value came out as < 0.001 . So, because this p -value is smaller than the significance level of 0.05 , the gap between the mean gain scores across the two groups is statistically significant.

As a result, the null hypothesis is rejected. In other words, there is a real difference in the gain scores for problem-solving skill between the experimental and control groups. Various studies have highlighted the importance and effectiveness of STEM- and STEAM-based approaches in enhancing students' problem-solving abilities at all levels of education . Wang et al. (2025) found that technology-integrated STEM problem-based learning improved vocational students' problem-solving abilities in advanced mathematics. Similarly, Syahmani et al. (2025) examined the effect of a web-based STEAM biodiesel-developed module, which enhanced students' conceptual understanding, environmental literacy, and problem-solving skills. Ozkul (2025) also showed that STEM activities based on engineering design cycles helped primary students develop problem-solving skills through hands-on engineering experiences.

Collectively, these studies emphasize the potential of STEM/STEAM-based learning and the use of technology integration in learning to promote students' problem-solving abilities, conceptual understanding, and improved practical application of knowledge. Yulianti et al. (2025) examined in their study that implementation of a transdisciplinary STEAM approach enhanced and improved students' understanding of science topics of heat and

temperature and evaluated the students' ability to apply these scientific concepts to real-world problems. Similarly, Almujaiddid et al. (2025) found that incorporating STEM with computational thinking and experiential learning enhanced and improved students' problem-solving abilities.

Inal and Ergen (2025) reported that STEM activities based on the 5E learning model improved students' problem-solving performance and changed their attitude towards mathematics learning . Similarly, Dhitasarifa and Wusqo (2024) assessed in their study that STEAM-based digital teaching resources significantly promoted creative problem-solving skills among students . Overall, these findings suggest that STEM/STEAM-based instructional approaches promote meaningful learning and problem-solving abilities across different educational levels and contexts.

VIII. CONCLUSION

- **Fundamental Finding:** The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach to science learning integrates these five disciplines to enhance critical thinking, problem-solving, and creativity. Problem-solving is the strategic competence demonstrated by students in understanding, choosing, and applying approaches and strategies to solve problems.
- **Implication:** These problem-solving skills are needed to face various challenges in the coming era. A literature review indicates that learning with the STEAM approach can enhance problem-solving skills and holds promising potential, particularly in science subjects at the elementary school grade VII level. The STEAM approach offers advantages over traditional methods, including improved problem identification, critical thinking, creative problem-solving, conceptual understanding, information analysis, motivation and interest, and student learning outcomes.
- **Limitation:** Many findings supporting STEAM's effectiveness come from literature reviews, while direct empirical evidence of STEAM implementation in elementary school classes in India remains limited.
- **Future Research:** Quantitative and Qualitative experimental research is recommended to evaluate

STEAM's impact on specific aspects of problem-solving (understanding problems, designing strategies, implementing solutions, and evaluating results).

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