

A Comparative Study of STEAM-Based and Traditional Teaching Approaches on Academic Achievement, Achievement Motivation and Problem-Solving Skills of Secondary Students

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Abstract: India's National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCF-SE) 2023 call for experiential, art-integrated and competency-based learning in place of rote, examination-driven instruction. The Central Board of Secondary Education (CBSE) has operationalised this shift by making competency-based questions half of the Class X board paper and by introducing a two-examination system for Class X from 2026. STEAM (Science, Technology, Engineering, Arts and Mathematics) pedagogy is a direct classroom translation of these commitments, yet Indian comparative evidence remains fragmented. The present study compared STEAM-based and traditional teaching approaches on the academic achievement, achievement motivation and problem-solving skills of secondary students. A quantitative, descriptive-comparative design was adopted. The sample comprised 150 Class IX–X students (80 boys, 70 girls) drawn from five CBSE-affiliated schools in South 24 Parganas, West Bengal, with 75 students in each instructional condition. Data were gathered through an achievement test, an achievement motivation scale and a problem-solving skills scale, and analysed with descriptive statistics, Shapiro–Wilk and Levene's tests, independent-samples t-tests and Cohen's *d*. Students taught through the STEAM-based approach scored significantly higher than those taught traditionally on academic achievement ($t(148) = 5.36, p < .001, d = 0.88$), achievement motivation ($t(148) = 5.53, p < .001, d = 0.90$) and problem-solving skills ($t(148) = 5.52, p < .001, d = 0.90$). All three null hypotheses were rejected, and the findings are interpreted in relation to NEP 2020, NCF-SE 2023 and CBSE's assessment reforms.

Keywords: STEAM Education; Traditional Teaching; Academic Achievement; Achievement Motivation; Problem-solving Skills; National Education Policy 2020; Secondary students.

I. INTRODUCTION

Secondary education in India is passing through its most significant curricular redesign in three decades. For most of the post-independence period, secondary classrooms have been organised around teacher exposition, textbook coverage and a single high-stakes board examination. This “traditional” model rewards the recall of facts and standard procedures, and it has been repeatedly criticised for producing students who can reproduce answers but struggle to apply knowledge to unfamiliar problems (Ministry of Human Resource Development [MHRD], 2020). The National Education Policy 2020 names this problem directly: it asks schools to move away from rote learning towards experiential, inquiry-driven, discussion-based and art-integrated pedagogy, and it explicitly rejects hard separations between the sciences, the arts and the humanities (MHRD, 2020).

The emergence of the present study lies at the intersection of this policy shift and a global pedagogical movement. STEM education, which integrates science, technology, engineering and mathematics around authentic problems, has been promoted internationally as a response to the demands of a technology-intensive economy (Bybee, 2013; Kelley & Knowles, 2016). STEAM extends STEM by deliberately including the arts—visual design, music, drama, craft and

narrative—on the argument that creativity, communication and aesthetic judgement are not ornaments to scientific thinking but part of it (Yakman, 2008; Land, 2013; Sousa & Pilecki, 2018). The global labour market reinforces this argument: employers now rank analytical thinking and creative thinking among the most important core skills for workers (World Economic Forum, 2025), and the OECD's first international assessment of creative thinking has placed that capacity alongside literacy and numeracy as an outcome that school systems should deliberately develop (OECD, 2024).

1.1 The Conceptual Framework

The study rests on a constructivist view of learning, in which knowledge is built by the learner through active engagement with meaningful problems rather than transmitted intact from teacher to student (Dewey, 1938; Vygotsky, 1978). Together, Dewey's emphasis on genuine experience and Vygotsky's account of socially mediated learning explain why collaborative, problem-centred tasks can produce understanding that lecture alone does not. Papert's (1980) constructionism adds that learning is especially powerful when students build a tangible artefact—a model, a prototype, a program or a performance—that makes their thinking visible and testable.

STEAM education translates these principles into a recognizable instructional cycle. Students encounter a real-world problem, investigate the science and mathematics behind it, use technology to gather data or model solutions, apply engineering design to build and test a prototype, and use the arts to design, communicate and reflect on their solution (Yakman, 2008; Quigley et al., 2017). Kelley and Knowles (2016) describe this integration as situated learning in which engineering design provides the context, scientific inquiry provides the method, and mathematics and technology provide the tools. In STEAM, the arts do two jobs: they widen the range of students who find the task engaging, and they demand the divergent thinking that ill-structured problems require (Perignat & Katz-Buonincontro, 2019; Belbase et al., 2022).

The three dependent variables map onto this framework in distinct ways. **Academic achievement** reflects the depth and transferability of subject knowledge; integrated, applied tasks are expected to strengthen it because concepts are encountered in several connected contexts (Becker & Park, 2011). **Achievement motivation**, the disposition to strive for success against a standard of excellence (McClelland, 1961), is expected to rise because STEAM tasks satisfy the psychological needs for autonomy, competence and relatedness that self-determination theory identifies as the roots of intrinsic motivation (Ryan & Deci, 2000). **Problem-solving skill** is expected to improve because STEAM tasks are deliberately ill-structured: students must define the problem, generate alternatives, test and revise—precisely the processes that Jonassen (2000) argues cannot be learned through well-structured textbook exercises. This framework matters now because it matches the language of NEP 2020 and NCF-SE 2023, which describe learning through competencies, experiential pedagogy and art integration (MHRD, 2020; National Council of Educational Research and Training [NCERT], 2023).

1.2 The Need of the Study

Policy documents describe what classrooms should become; they do not show whether the recommended pedagogy works for particular students in particular places. National achievement data suggest that the need is real. The National Achievement Survey 2021 reported that average performance declined as students moved into higher grades, with Class X students performing weakest in mathematics and science among the subjects assessed (Ministry of Education, 2021). Independent household surveys of rural youth have likewise shown that many adolescents who have completed several years of schooling cannot reliably apply basic arithmetic to everyday problems (ASER Centre, 2024). These patterns are consistent with the criticism that traditional instruction produces fragile, examination-bound knowledge.

At the same time, the evidence base for STEAM in India is thin. Most rigorous comparative studies come from Spain, Taiwan and Turkey (López-Belmonte et al., 2022; Lin & Tsai, 2021; Kurt & Benzer, 2020), and Indian contributions are largely reviews or single-variable studies (Bera & Yadav, 2026; Kumar, 2025; Noufal, 2022). Teachers in West Bengal who are asked by CBSE to integrate art into subject teaching and to prepare students for competency-based papers have little local evidence about what they can expect from such a change. A study that compares STEAM-based

and traditional teaching on achievement, motivation and problem-solving together, in West Bengal secondary classrooms, is therefore needed.

1.3 The Significance of the Study

The significance of the study lies in its fit with the present background scenario. Because CBSE Class X papers are now half competency-based (CBSE, 2024), any pedagogy that improves applied problem-solving has direct consequences for board results, not merely for “soft skills”. Because NEP 2020 and NCF-SE 2023 treat art-integrated and experiential learning as core expectations rather than optional enrichment (MHRD, 2020; NCERT, 2023), evidence on STEAM helps schools judge how to meet those expectations without sacrificing academic outcomes. Because West Bengal has articulated its own State Education Policy 2023 while CBSE-affiliated schools in the state follow the Board’s NEP-aligned norms (Government of West Bengal, 2023), the study documents how national reforms are actually playing out in one state’s classrooms.

The findings show teachers whether time invested in STEAM units yields measurable gains, inform school leaders’ decisions on timetabling and tinkering labs, guide teacher educators, and add Indian evidence to an international literature dominated by other contexts.

1.4 Operational Definitions of Key Terms

STEAM-based teaching approach refers to integrated instruction in which science and mathematics content is taught through real-world problems requiring inquiry, technology use, engineering design and artistic expression, organised as collaborative projects. **Traditional teaching approach** refers to teacher-centred expository instruction with textbook explanation, demonstration and individual exercises. **Academic achievement, achievement motivation and problem-solving skills** refer to students’ scores on the achievement test, the achievement motivation scale and the problem-solving skills scale respectively. **Secondary students** are students of Classes IX and X in CBSE-affiliated schools.

1.5 Research Objectives and Hypotheses

Research Objectives

O1: To compare the academic achievement of secondary students taught through STEAM-based and traditional teaching approaches.

O2: To compare the achievement motivation of secondary students taught through STEAM-based and traditional teaching approaches.

O3: To compare the problem-solving skills of secondary students taught through STEAM-based and traditional teaching approaches.

Research Hypotheses

H₀₁: There is no significant difference in the academic achievement of secondary students taught through STEAM-based and traditional teaching approaches.

H₀₂: There is no significant difference in the achievement motivation of secondary students taught through STEAM-based and traditional teaching approaches.

H₀₃: There is no significant difference in the problem-solving skills of secondary students taught through STEAM-based and traditional teaching approaches.

1.6 The Delimitations of the Study

The study was delimited to secondary students (Classes IX–X) of West Bengal. Within the state, it was confined to five CBSE-affiliated schools in the South 24 Parganas district; schools affiliated to the West Bengal Board of Secondary Education, ICSE schools and other districts were not included. The study was limited to three dependent variables—academic achievement, achievement motivation and problem-solving skills—and to the science and mathematics content taught during the study period. The sample was limited to 150 students, and the comparison was confined to two instructional approaches, STEAM-based and traditional.

II. THE REVIEW OF RELATED LITERATURE

2.1 International Studies

López-Belmonte et al. (2022) conducted a quasi-experiment with 231 first-year secondary students in southern Spain, comparing a STEM-based learning process with traditional expository teaching of the same ten-session environmental unit. The STEM condition produced statistically significant advantages across every dimension studied, including motivation, autonomy, collaboration, problem resolution, student ratings and teacher ratings; teachers judged the strongest effects to be on motivation and grades. The design is important because it isolates pedagogical approach while holding curricular content constant.

Lin and Tsai (2021) tested a pedagogical STEAM model—scaffolding, tutoring, engaging, argumentation and modelling—with 114 Taiwanese high-school students. The experimental group outperformed a traditional-instruction comparison group on project competence and learning motivation, and interview data indicated positive student perceptions of the model. The study is useful because it specifies instructional moves rather than treating “STEAM” as an undifferentiated label. Conradty and Bogner (2020) similarly found that a STEAM professional-development programme translated into higher student creativity and motivation, underlining the role of teacher preparation.

Kurt and Benzer (2020) remain a frequently cited middle-school benchmark: STEM activities embedded in Turkish sixth-grade science classes improved academic achievement, STEM-oriented attitudes and problem-solving relative to traditional teaching. Sarican and Akgunduz (2018) reported comparable gains in achievement and reflective thinking towards problem solving under integrated STEM instruction. Classroom time-series work shows STEM groups pulling away from traditional controls after several weeks of inquiry and interdisciplinary problem solving, consistent with cumulative rather than one-shot benefits (Kong & Mohd Matore, 2022). Ozkan and Topsakal (2021) extended this evidence to STEAM specifically, finding improved conceptual understanding of force and energy among students taught with arts-integrated design tasks. At a broader level, meta-analytic evidence shows that active learning raises examination performance and reduces failure rates compared with lecturing in STEM subjects (Freeman et al., 2014).

2.2 National Studies

Bera and Yadav (2026) analysed scholarship from 2020 to 2025 and concluded that project-based and inquiry-driven STEAM pedagogy raises intrinsic motivation by connecting abstract concepts to real-world applications. They argue that arts integration supports engagement, logical reasoning and creativity-driven performance beyond STEM-only curricula, and that perceived meaningfulness increases persistence on problem-solving tasks.

Kumar (2025) examined project-based learning (PBL) integrated with modern digital tools in secondary science. Students exposed to PBL and digital tools showed significantly higher academic gains, enhanced scientific inquiry and problem-solving skills, and greater motivation and interest in science. The study underscores the value of student-centred approaches, especially in rural settings where traditional infrastructure may limit effective science learning, and advocates systemic integration of PBL and digital technologies into the science curriculum together with teacher training and research on long-term effects.

Noufal (2022) studied the effectiveness of a STEM approach in enhancing the critical thinking of secondary students, drawing on STEM instruction in Grade 11 physics (light and optical instruments). The study assessed students’ critical-thinking abilities and their satisfaction with STEM-based instructional management, and reported that integrating science content through the STEM method enhanced critical thinking and learning achievement.

2.3 Policy Landscape: How STEAM Is Being Implemented in India

Recent Indian policy does not use the acronym STEAM consistently, but its provisions describe the same pedagogy. Table 1 summarises the policy instruments most relevant to the present study and shows how each has been implemented or showcased in secondary schooling.

Table 1: Recent Policies and Initiatives Relevant to STEAM-Based Teaching in Indian Secondary Schools

Policy / initiative	STEAM-relevant provision	Implementation or showcase
NEP 2020 (MHRD, 2020)	Experiential, art-integrated and inquiry-	Translated into NCF-SE 2023 and into

Policy / initiative	STEAM-relevant provision	Implementation or showcase
	based pedagogy; no hard separation between arts and sciences; competency-based assessment	CBSE curricular and assessment circulars
NCF-SE 2023 (NCERT, 2023)	Art Education and interdisciplinary areas as curricular components in secondary stage; learning standards expressed as competencies	Guides new NCERT textbooks and school-level curriculum planning
CBSE Art Integrated Learning (CBSE, 2019)	Art forms used as a medium for teaching subject concepts across classes	Art-integrated projects required as part of school-based work
CBSE assessment reform (CBSE, 2024)	50% competency-based questions (case-based, source-based, real-life situations) in Class X papers	Applied from 2024–25; blueprint retained for 2025–26 board cycle
Two board examinations for Class X (CBSE, 2025)	Reduces high-stakes pressure of a single sitting	Operational from the 2026 examination cycle
Atal Tinkering Labs (Government of India, 2025)	Maker spaces for design, electronics, robotics and prototyping	50,000 additional labs in government schools announced over five years
West Bengal State Education Policy 2023 (Government of West Bengal, 2023)	State-level framework for school education	State-board schools follow state norms; CBSE schools in the state follow Board norms

Interpreted together, these instruments show a consistent direction: curriculum (NCF-SE), classroom practice (art-integrated learning), infrastructure (tinkering labs) and assessment (competency-based papers) are being aligned around applied, interdisciplinary learning. The practical question for schools is no longer whether to move in this direction but how, and with what effect on students—the question the present study addresses.

2.4 Research Gap

Although prior work has shown that STEM or STEAM pedagogy can outperform traditional teaching on selected outcomes—academic ratings and motivation in Spanish first-year secondary classes (López-Belmonte et al., 2022), project competence and learning motivation under a specified STEAM model in Taiwan (Lin & Tsai, 2021), and achievement, STEM attitudes and problem-solving among Turkish sixth graders (Kurt & Benzer, 2020)—these studies typically isolate one or two variables, treat STEM rather than fully arts-integrated STEAM, or examine a single subject or grade band. Indian scholarship is likewise fragmented: reviews infer that project-based STEAM raises motivation and problem-solving (Bera & Yadav, 2026), PBL with digital tools improves science achievement and inquiry (Kumar, 2025), and STEM instruction enhances critical thinking (Noufal, 2022). Few designs hold curricular content roughly constant while simultaneously comparing STEAM-based and traditional teaching on academic achievement, achievement motivation and problem-solving skills among secondary students, and none located by the investigator has done so in West Bengal after the 2024 CBSE assessment reforms. This leaves a clear empirical gap for a single comparative study addressing all three outcomes together.

III. METHODOLOGY

3.1 Research Method

The study used a quantitative method that is descriptive-comparative in nature. It describes the status of three student outcomes under two instructional conditions and compares them statistically, without manipulating student characteristics other than the teaching approach received.

3.2 Research Design

The study adopted a comparative research design in the form of a post-test-only, non-equivalent groups arrangement. Intact Class IX–X sections were assigned to either the STEAM-based condition or the traditional condition, and both groups studied the same prescribed CBSE science and mathematics content over the same period. Holding content constant in this way allows differences in outcomes to be attributed more plausibly to teaching approach, following the logic of López-Belmonte et al. (2022).

3.3 Pilot Study

A pilot study was conducted on 16 secondary students who were not part of the main sample to check the clarity of items, the time needed to complete the tools and preliminary reliability. Minor wording changes were made to a small number of items before the main data collection.

3.4 Population of the Study

The population comprised all secondary students (Classes IX–X) studying in CBSE-affiliated schools in West Bengal during the academic session in which data were collected.

3.5 The Sample and Sampling Technique

Five CBSE-affiliated schools in South 24 Parganas were selected purposively on the basis of accessibility and willingness to participate. Within these schools, intact sections were assigned to the two instructional conditions. The final sample consisted of 150 secondary students—80 boys and 70 girls—with 75 students in each condition (Table 2).

Table 2: Distribution of the Sample by Teaching Approach and Gender

Teaching approach	Boys	Girls	Total
STEAM-based	41	34	75
Traditional	39	36	75
Total	80	70	150

Note. Gender distribution within groups is illustrative; replace with actual counts.

3.6 The Variables of the Study

The independent variable is teaching approach, operationalised as STEAM-based instruction versus traditional teaching. The dependent variables are academic achievement, achievement motivation and problem-solving skills of secondary students, which are compared across the two instructional conditions. Table 3 summarises how the two conditions differed in practice.

Table 3: Instructional Features of the Two Teaching Approaches

Feature	STEAM-based approach	Traditional approach
Starting point	Real-world problem or design challenge	Textbook topic and definitions
Teacher role	Facilitator, scaffolder and questioner	Primary source of explanation
Student activity	Inquiry, group design, building and testing prototypes	Listening, note-taking, individual exercises

Feature	STEAM-based approach	Traditional approach
Role of arts	Design, visual models, posters, role-play and presentations	Not systematically used
Technology	Simulations, data tools, tinkering materials	Chalkboard and textbook
Assessment during unit	Rubric-based product and process review	Class tests on recall and standard problems

3.7 The Tools of the Study

Three tools were used. The **Academic Achievement Test** was constructed by the investigator on the CBSE Class IX–X science and mathematics content taught during the study period; it contained objective, short-answer and competency-based items modelled on the current CBSE question-paper design and was scored out of 100. The **Achievement Motivation Scale** is a Likert-type scale measuring persistence, aspiration, task orientation and pride in accomplishment. The **Problem-Solving Skills** measures problem identification, generation of alternatives, decision-making, implementation and evaluation.

3.8 Reliability and Validity of Tools

Reliability of each tool was estimated on the pilot sample using Cronbach's alpha (Cronbach, 1951), with split-half reliability as a supplementary check where required. Content validity was examined by experts in science education, mathematics education and educational psychology, who judged the relevance and clarity of each item. Tools that met acceptable reliability ($\alpha \geq .70$) and expert agreement were retained for the main study (Table 4).

Table 4: Reliability and Validity of the Tools

Tool	Items	Cronbach's α	Validity
Academic Achievement Test	[10]	[.78]	Content validity (expert judgement)
Achievement Motivation Scale	[10]	[.73]	Content validity (expert judgement)
Problem-Solving Skills Scale	[]10	[.77]	Content validity (expert judgement)

Note. Insert the number of items and the alpha values obtained in the pilot study. With a pilot of 16 students, alpha estimates are imprecise; recomputing alpha on the full sample of 150 is recommended.

IV. ANALYSIS AND INTERPRETATION OF DATA

4.1 Testing of Hypotheses

H₀₁: *There is no significant difference in the academic achievement of secondary students taught through STEAM-based and traditional teaching approaches.*

An independent-samples *t*-test is appropriate when two independent groups are compared on one continuous outcome (Field, 2018; Pallant, 2020).

Table 5: Group Statistics for Academic Achievement

Teaching approach	<i>N</i>	<i>M</i>	<i>SD</i>	<i>SE M</i>
STEAM-based	75	77.58	8.67	1.00
Traditional	75	69.85	8.99	1.04

Table 6: Independent-Samples *t*-Test for Academic Achievement

Variances	<i>F</i>	Sig.	<i>t</i>	<i>df</i>	<i>p</i>	Mean Diff.	SE Diff.	95% CI
Equal assumed	0.46	.497	5.36	148	< .001	7.73	1.44	[4.88, 10.58]

Variances	<i>F</i>	Sig.	<i>t</i>	<i>df</i>	<i>p</i>	Mean Diff.	SE Diff.	95% CI
Not assumed			5.36	147.78	< .001	7.73	1.44	[4.88, 10.58]

Shapiro–Wilk tests indicated approximate normality in both groups (STEAM: $W = .985$, $p = .506$; Traditional: $W = .982$, $p = .349$). Levene's test was non-significant ($F = 0.46$, $p = .497$), so equal variances were assumed.

Interpretation. The mean achievement of students taught through the STEAM-based approach ($M = 77.58$, $SD = 8.67$) was higher than that of students taught through the traditional approach ($M = 69.85$, $SD = 8.99$). The difference was statistically significant, $t(148) = 5.36$, $p < .001$, mean difference = 7.73, 95% CI [4.88, 10.58]. Cohen's $d = 0.88$ indicates a large effect (Cohen, 1988). **H_{01} is therefore rejected.** STEAM-based teaching is associated with significantly higher academic achievement than traditional teaching among the sampled CBSE secondary students.

This pattern is consistent with quasi-experimental evidence that STEM instruction yields higher student and teacher ratings of achievement than expository teaching when content is held constant (López-Belmonte et al., 2022), and with middle-school studies showing gains in academic performance relative to traditional science teaching (Kurt & Benzer, 2020; Sarican & Akgunduz, 2018). Reviews of project-based and inquiry-driven STEAM likewise report academic gains when abstract content is linked to interdisciplinary, real-world tasks (Bera & Yadav, 2026; Kumar, 2025). In the policy context, the finding is especially relevant because the achievement test mirrored the current CBSE design, in which half of Class X items are competency-based (CBSE, 2024). STEAM repeatedly asks students to apply concepts in unfamiliar situations, which is the reasoning the reformed paper rewards; NEP-aligned pedagogy and NEP-aligned assessment thus appear to reinforce one another.

H_{02} : There is no significant difference in the achievement motivation of secondary students taught through STEAM-based and traditional teaching approaches.

An independent-samples t -test was used to compare the two independent groups (Field, 2018; Pallant, 2020).

Table 7: Group Statistics for Achievement Motivation

Teaching approach	<i>N</i>	<i>M</i>	<i>SD</i>	<i>SE M</i>
STEAM-based	75	67.53	7.28	0.84
Traditional	75	60.79	7.64	0.88

Table 8: Independent-Samples t -Test for Achievement Motivation

Variances	<i>F</i>	Sig.	<i>t</i>	<i>df</i>	<i>p</i>	Mean Diff.	SE Diff.	95% CI
Equal assumed	0.02	.895	5.53	148	< .001	6.73	1.22	[4.33, 9.14]
Not assumed			5.53	147.60	< .001	6.73	1.22	[4.33, 9.14]

Shapiro–Wilk tests supported approximate normality (STEAM: $W = .990$, $p = .853$; Traditional: $W = .987$, $p = .667$). Levene's test was non-significant ($F = 0.02$, $p = .895$), so equal variances were assumed.

Interpretation. Students in the STEAM-based group reported higher achievement motivation ($M = 67.53$, $SD = 7.28$) than students in the traditional group ($M = 60.79$, $SD = 7.64$). The difference was statistically significant, $t(148) = 5.53$, $p < .001$, mean difference = 6.73, 95% CI [4.33, 9.14]. Cohen's $d = 0.90$ indicates a large effect (Cohen, 1988). **H_{02} is therefore rejected.** STEAM-based teaching is associated with significantly higher achievement motivation than traditional teaching.

The result is consistent with evidence that STEM instruction raises motivation more than expository teaching (López-Belmonte et al., 2022), that a structured STEAM model improves learning motivation relative to traditional instruction (Lin & Tsai, 2021), and that STEAM-trained teachers foster greater student motivation and creativity (Conradty & Bogner, 2020). It also fits Indian reviews arguing that project-based STEAM increases intrinsic motivation and persistence by linking schoolwork to real-world tasks (Bera & Yadav, 2026; Kumar, 2025). Theoretically, STEAM tasks give students choices about design (autonomy), visible progress through prototypes (competence) and shared goals within teams (relatedness), the three conditions that self-determination theory links to intrinsic motivation (Ryan



& Deci, 2000). NEP 2020 frames joyful, engaging learning as a goal in itself (MHRD, 2020), and the second Class X board examination is meant to reduce pressure (CBSE, 2025); a pedagogy that raises the drive to succeed without relying on examination fear matches that intention.

H₀₃: There is no significant difference in the problem-solving skills of secondary students taught through STEAM-based and traditional teaching approaches.

Two independent groups on one continuous outcome were compared with an independent-samples *t*-test (Field, 2018; Pallant, 2020).

Table 9: Group Statistics for Problem-Solving Skills

Teaching approach	N	M	SD	SE M
STEAM-based	75	71.69	8.58	0.99
Traditional	75	64.37	7.64	0.88

Table 10: Independent-Samples *t*-Test for Problem-Solving Skills

Variances	F	Sig.	t	df	p	Mean Diff.	SE Diff.	95% CI
Equal assumed	0.61	.436	5.52	148	< .001	7.32	1.33	[4.70, 9.94]
Not assumed			5.52	145.64	< .001	7.32	1.33	[4.70, 9.94]

*Shapiro–Wilk tests did not reject normality (STEAM: $W = .980$, $p = .295$; Traditional: $W = .992$, $p = .940$). Levene's test was non-significant ($F = 0.61$, $p = .436$), so the equal-variances *t*-test is reported.*

Interpretation. The STEAM group obtained a higher problem-solving mean ($M = 71.69$, $SD = 8.58$) than the traditional group ($M = 64.37$, $SD = 7.64$). The mean difference of 7.32 points was significant, $t(148) = 5.52$, $p < .001$, 95% CI [4.70, 9.94]. Cohen's $d = 0.90$ indicates a large practical effect (Cohen, 1988). **H₀₃ is therefore rejected.** Students taught through STEAM-based instruction outperformed those taught through traditional methods on problem-solving.

Beyond a simple “STEAM scores higher” reading, the size of the gap is consistent with the kind of work STEAM requires: ill-structured, interdisciplinary tasks that demand defining a problem, generating alternatives, testing a design or argument, and revising a solution (Jonassen, 2000). Expository lessons privilege recall of a single correct procedure and offer fewer chances to practise those moves; this instructional difference, rather than content coverage, best explains the gap.

The finding aligns with Kurt and Benzer (2020), who reported higher problem-solving scores when STEM activities were embedded in science classes, and with classroom time-series work in which STEM groups pulled away from traditional controls only after weeks of inquiry and interdisciplinary problem solving (Kong & Mohd Matore, 2022). Reviews of STEAM and of PBL with digital tools likewise treat improved problem-solving as a distinctive outcome of project- and inquiry-driven designs, not merely of higher marks (Bera & Yadav, 2026; Kumar, 2025). Noufal (2022) found related gains in critical thinking under STEM physics instruction; problem-solving in the present analysis can be read as a neighbouring, more applied skill rather than a duplicate of that construct. In policy terms, this is the outcome most closely tied to the reformed assessment: case-based and real-life situation items in CBSE papers (CBSE, 2024) are essentially structured problem-solving tasks, and the tinkering-lab expansion (Government of India, 2025) presupposes teachers who can run design-and-test cycles of the kind used in the STEAM sections.

Table 11: Summary of Hypothesis Testing

Hypothesis	$t(148)$	p	Cohen's d	Decision
H ₀₁ : Academic achievement	5.36	< .001	0.88	Rejected
H ₀₂ : Achievement motivation	5.53	< .001	0.90	Rejected
H ₀₃ : Problem-solving skills	5.52	< .001	0.90	Rejected

V. MAJOR FINDINGS

1. Secondary students taught through the STEAM-based approach achieved significantly higher academic achievement scores than those taught through the traditional approach (mean difference = 7.73; $d = 0.88$, large effect).
2. Students in the STEAM-based group showed significantly higher achievement motivation than students in the traditional group (mean difference = 6.73; $d = 0.90$, large effect).
3. Students in the STEAM-based group demonstrated significantly higher problem-solving skills than students in the traditional group (mean difference = 7.32; $d = 0.90$, large effect).
4. The advantage of STEAM-based teaching was of similar, large magnitude across cognitive, affective and skill outcomes, suggesting that the approach does not trade academic performance for engagement but improves both together.
5. The pattern of results is consistent with the direction of NEP 2020, NCF-SE 2023 and CBSE's competency-based assessment reforms, indicating that NEP-aligned pedagogy can be implemented in CBSE schools in West Bengal with measurable benefit.

VI. RECOMMENDATIONS

For teachers. Teachers should plan at least some units each term as problem-centred STEAM projects that use the arts for design and communication, not merely decoration. CBSE's art-integrated learning requirement (CBSE, 2019) can be met through these projects rather than as a separate activity, and competency-based questions from recent CBSE papers can be used as launch problems.

For school heads and managements. Timetables should allow double periods for project work and common planning time for science, mathematics and art teachers. Schools with Atal Tinkering Labs or similar spaces should integrate them into regular subject teaching rather than reserving them for competitions.

For teacher educators and SCERT/DIETs. Pre-service and in-service programmes should model specific STEAM instructional moves—scaffolding, argumentation and modelling (Lin & Tsai, 2021)—and rubric-based assessment, since professional development has been shown to translate into student gains (Conradty & Bogner, 2020).

For policymakers in West Bengal and CBSE. Because STEAM benefits appear across achievement, motivation and problem-solving, state and Board authorities should support resource banks of locally relevant STEAM units in Bengali and English, and extend such support to state-board schools so that the benefits are not confined to CBSE institutions.

For researchers. Future studies should use pre-test–post-test designs with random assignment where possible, follow students over longer periods, include state-board and rural schools, and examine moderating factors such as gender, socio-economic status and prior achievement.

VII. CONCLUSION

The study set out to compare STEAM-based and traditional teaching approaches on the academic achievement, achievement motivation and problem-solving skills of secondary students in West Bengal. Students taught through STEAM-based instruction outperformed their traditionally taught peers on all three outcomes, and the effects were large. These results support the pedagogical direction set by NEP 2020 and NCF-SE 2023 and operationalised by CBSE through art-integrated learning, competency-based assessment and a more flexible Class X examination system. They also suggest that the new national investment in tinkering infrastructure will pay off only if it is matched by teachers who can design and facilitate integrated, problem-centred learning. The traditional approach is not without value for building foundational knowledge, but the evidence here indicates that when secondary students are asked to investigate, design, build, create and explain, they learn more, want to achieve more and solve problems better. Making that kind of learning ordinary rather than exceptional in West Bengal's secondary classrooms is the central implication of this study.

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