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Cultivating Design Thinking in Vietnamese High School Students: A STEAM-Powered Pedagogical Experiment

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ABSTRACT

Education reforms worldwide increasingly emphasise creativity, problem-solving, and higher-order thinking, as reflected in UNESCO's Education 2030, the UN Sustainable Development Goal 4, and the OECD PISA Creative Thinking assessment. Responding to these global shifts, Vietnam has integrated STEAM into its competency-based reforms; however, empirical evidence on how STEAM develops design thinking at the upper-secondary level remains limited. This study addresses this gap through a mixed-methods intervention with 69 Grade 11 students in Ho Chi Minh City. Two STEAM lessons on Electricity and Magnetic Fields were structured around a five-stage design thinking framework. Data from classroom observations, video analysis, and pre-/post-intervention assessments indicate promising improvements in reasoning and ideation, alongside moderate gains in empathy, modelling, and process management. These findings provide preliminary evidence that STEAM can cultivate design thinking competencies in Vietnamese high schools and contribute to ASEAN and global agendas promoting creativity, innovation, and 21st-century skills.

Keywords: Design thinking competency, empathetic, High school students, liberal arts, STEAM education

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Introduction

Since its introduction in 2006 as an evolution of STEM, STEAM education (Science, Technology, Engineering, Arts, Mathematics) has gained prominence as a response to the demands of a rapidly changing world (Yakman, 2018). By incorporating the arts into STEM, STEAM advances not only technical knowledge but also creativity and innovation in teaching practice. This integration fosters students' inventiveness and originality alongside scientific accuracy. The "A" has expanded to include language arts, social studies, and other creative domains, embedding creativity within technical learning (Melles et al., 2012; Vries, 2021). Interdisciplinary approaches allow students to combine STEM knowledge with interpersonal skills to solve real-world problems, strengthening adaptability and innovative capacity in the contexts of rapid technological change (Nguyen & Ta, 2021).

Recent scholarship categorises STEAM pedagogy into multidisciplinary, interdisciplinary, and transdisciplinary forms. These modes enable students to undertake complex projects across knowledge domains (Edelen et al., 2023). Typical STEAM activities include hands-on experimentation, creative problem-solving, and empathy-driven design (Bush et al., 2020), encouraging learners to connect scientific concepts with creativity and social awareness.

Vietnam and other ASEAN countries have embraced STEAM to prepare learners with creativity, problem-solving, and design-thinking competencies required by the 21st-century workforce (Cao et al., 2020). Despite strong PISA results placing Vietnamese students above OECD averages, graduates are often perceived as lacking critical thinking, teamwork, and creativity (World Bank, 2020). This skills gap reflects exam-oriented traditions that restrict opportunities for applied learning. To address these challenges, Vietnam's Ministry of Education and Training has introduced a competency-based curriculum to cultivate higher-order skills. Yet, little empirical evidence exists on how STEAM fosters design thinking at the upper-secondary level (Le et al., 2025). For both Vietnam and the ASEAN to transition toward innovation-driven economies, cultivating design-thinking skills is not merely educational but an economic imperative tied to workforce readiness and competitiveness.

This study addresses this gap by implementing two design thinking–anchored STEAM lessons in Grade 11 Physics and evaluating pre-/post-intervention changes across five design-thinking components. It provides practice-oriented guidance for Vietnam and comparable systems seeking scalable, classroom-level STEAM models.

This focus also aligns with global and regional priorities. The United Nations' Sustainable Development Goal 4 calls for quality education that fosters creativity and problem-solving (UNESCO, 2015). UNESCO's Education 2030 framework emphasises high-level cognitive and interpersonal skills for sustainable development (UNESCO, 2021). PISA's 2022 cycle assessed creative thinking across 64 countries, recognising diverse idea generation as central to future readiness (OECD, 2024). Within the ASEAN regional agendas prioritise teacher capacity-building, digital readiness, and competency-based curricula. By foregrounding design thinking in Physics lessons, this study operationalises these policy goals and provides preliminary evidence of student growth in creativity and problem-solving, offering a timely, classroom-based model for advancing education and workforce skills in Vietnam and the ASEAN.

Literature Review

STEAM education encompasses a variety of approaches, but scholars consistently highlight that the most effective programmes are those which foster creativity, student interaction, and problem-based inquiry (Anderson, 2012; Nguyen et al., 2024). Originating in the United States, STEAM was strongly promoted by John Maeda, former president of the Rhode Island School of Design, who emphasised the integration of “arts-liberal” with STEM disciplines to enrich educational innovation (Nguyen & Pham, 2020). The inclusion of the arts in STEM not only broadens students’ learning experiences but also strengthens their ability to engage in design thinking—a process combining analytical reasoning with empathy and creativity (Buchanan, 1992; Razzoukm & Shute, 2012).

Design thinking has been increasingly recognised as a powerful pedagogical tool to complement STEAM. It is characterised as an iterative, human-centred process that develops learners’ ability to empathise, ideate, prototype, and test solutions to authentic problems. Research suggests that design thinking cultivates advanced problem-solving and collaboration skills by linking cognitive and emotional intelligence (Henriksen, 2017; Rusmann & Ejsing-Duun, 2022). Recent frameworks map design thinking competencies across K–12, offering assessment models that can inform empirical classroom research (Rusmann & Ejsing-Duun, 2022). Evidence across different educational levels further demonstrates that STEAM and design thinking integration enhances higher-order thinking and practical engagement: primary (Kangas et al., 2013; Nguyen et al., 2024), secondary (Fortus et al., 2004; Mentzer et al., 2015), and tertiary (Carroll, 2014; Wrigley & Straker, 2017). These findings indicate the relevance of STEAM–design thinking integration to the development of 21st-century competencies.

At the regional level, ASEAN countries have increasingly adopted STEAM to align education with economic innovation and workforce demands (Cao, et al., 2020). Vietnam, in particular, has prioritised STEM and digital literacy in national policy (Prime Minister of Vietnam, 2022). Yet, systemic challenges remain: disconnected curricula in Indonesia hinder interdisciplinary collaboration (Arlinwibowo et al., 2023) teacher shortages constrain Cambodia’s STEM expansion (Sovansophal & Kinya, 2020), and resource constraints limit effective STEAM practices in the Philippines (Tupas & Matsuura, 2019). Within Vietnam, teacher-centred pedagogy and limited teacher training create barriers to implementing competency-based curricula that foster creativity and design thinking (World Bank, 2020). This points to the need for empirical models that demonstrate how STEAM can concretely support students’ design thinking development.

Research Questions

Building on these theoretical and regional insights, the present study integrates STEAM pedagogy with design thinking to explore both processes and outcomes of student learning. The choice of this integration is justified by its alignment with international frameworks such as UNESCO’s Education 2030 agenda and OECD’s PISA emphasis on creative thinking, as well as Vietnam’s curriculum reform priorities. By linking classroom practice with these broader agendas, the study aims to address the pressing need for evidence-based approaches in the Vietnamese and ASEAN context.

The study is guided by two interrelated research questions:

1. What opportunities does STEAM education provide for developing design thinking competencies in high school students?
2. What effects does STEAM education have on students' design thinking abilities, in terms of both learning processes and measurable outcomes?

These questions reflect a dual focus: first, on understanding the mechanisms by which STEAM fosters design thinking, and second, on evaluating the extent of student competency growth following pedagogical intervention.

Participants

The study employed a qualitative–quantitative approach. In-depth interviews were conducted with 17 experts: ten university lecturers (eight PhDs, two PhD candidates) in education, STEM, and STEAM at four pedagogical universities, and seven high school teachers with more than five years of STEAM experience. Ten young people with at least one year of STEAM-related learning or extracurricular participation were also interviewed to capture their perspectives. In Ho Chi Minh City, 69 students participated in classroom-based experiments across two high school classes, with close observation and quantitative evaluation focused on subgroups of eight students in each class.

Several limitations must be acknowledged. All participating schools were metropolitan, which may not reflect Vietnam's socio-economic diversity. Stronger infrastructure and teacher expertise in urban schools could have inflated engagement and outcomes, while the absence of a control group restricts causal inference and generalizability. Nevertheless, the design aligns with pre-experimental approaches commonly used to test feasibility and pedagogical impact (Creswell & Creswell, 2022; (Fortus et al., 2004). Validity was enhanced through triangulation of interviews, observations, and pre-/post-assessments (Denzin, 2012). Future studies should include rural and semi-urban schools and employ quasi-experimental or randomised controlled designs to strengthen generalizability and methodological rigour (Rusmann & Ejsing-Duun, 2022). Despite these limitations, the study provides exploratory evidence on cultivating design thinking through STEAM in Vietnamese secondary schools within an ASEAN context.

Methodology

Research Design

The investigation encompassed three distinct stages: a comprehensive exploration of the theoretical underpinnings of STEAM lessons, the development of an evaluative instrument to gauge students' aptitude for design thinking within the realm of STEAM education through the use of the Delphi method, and an empirical study conducted within the pedagogical framework.

Research on the Theoretical Basis of the STEAM Lesson

STEAM lessons offer an environment where students can practice overcoming obstacles. Teachers select practical themes based on the curriculum and student competencies. Students may engage with these subjects from a multidisciplinary or transdisciplinary viewpoint, adopting a practical or empathetic approach. Although many occupations may facilitate the resolution of practical challenges, sympathetic problem-solving necessitates social knowledge (Bush et al., 2020). Both methods provide students with relevant information and mathematical and scientific instruments for practical learning and knowledge advancement. Empathy generates innovative concepts across several disciplines. Instead of adhering to a teacher-defined curriculum, students choose and use compassionate problem-solving approaches (Bush et al., 2022).

Employing Henriksen's (2017) design thinking framework for STEAM education and pedagogical concepts emphasising educators' empathy in problem-solving, we devised a comprehensive STEAM teaching approach in many Vietnamese high schools (Nguyen & Ta, 2021; Ta et al., 2023).

Stage 1: Empathise

Design thinking necessitates empathy (Brown & Wyatt, 2010). Educators create immersive environments for students to engage with the subject matter. Students acquire knowledge of the topic through observation, dialogue, comprehensive user experiences and rationales, which inform their problem-solving abilities.

Stage 2: Define

Students study and examine the issue empathetically. During the "Knowledge Researching" phase, students utilize their knowledge of curricular subjects and user insights to establish criteria for problem-solving. These criteria inspire students to comprehend new concepts to create and articulate their goods, encapsulating the "novelty" of the solution.

Stage 3: Ideate

The ideation stage promotes creativity and imagination among students, spanning from issue identification to solution development. Students engage in discussions, narrate their experiences, and visualize solutions to generate multiple solutions to the problem (Brown & Katz, 2019). This strategy fosters creativity by enhancing the "novelty" of their thoughts.

Stage 4: Prototype

Students develop prototypes as their concepts progress. Students can obtain essential feedback on concepts by evaluating prototypes with target users. This iterative approach enables a deeper understanding of product constraints in light of the target demographic's preferences, inclinations, and behaviours.

Stage 5: Test

The problem-solving product undergoes evaluation and improvement through the design thinking process. Students engage in production studies and develop efficient prototypes. Presentations, arguments, and modifications enhance goods. The methodologies and outcomes of student problem-solving should be disseminated across the community to foster empathy and understanding.

Following a study of STEAM education research and the Vietnamese school system (see Figure 1), we created a teaching framework with five stages and thirteen hands-on activities. We employed this pedagogical strategy to establish a cohesive STEAM lesson framework, focusing on the concepts of "Electric Field" and "Magnetic Field" in Physics 11. Their similarities provide equally exact STEAM education, which guides the choice of these subjects.

Research Instruments

The design thinking competencies that Razzouk and Shute (2012) describe enable people to approach problems by combining different perspectives. Students design thinking abilities encompass analytical (closed) and intuitive (open) reasoning within STEAM education. This two-pronged approach focuses on the human side of problem-solving (Ta et al., 2023) and requires knowledge, skills, and personality traits such as drive, enthusiasm, and confidence to generate innovative solutions.

This study uses a redesigned competence framework to evaluate the design thinking competency of high school students. We developed a five-component, 29-item assessment tool for design thinking in high school through a unique Delphi poll and quantitative analysis (Ta et al., 2024).

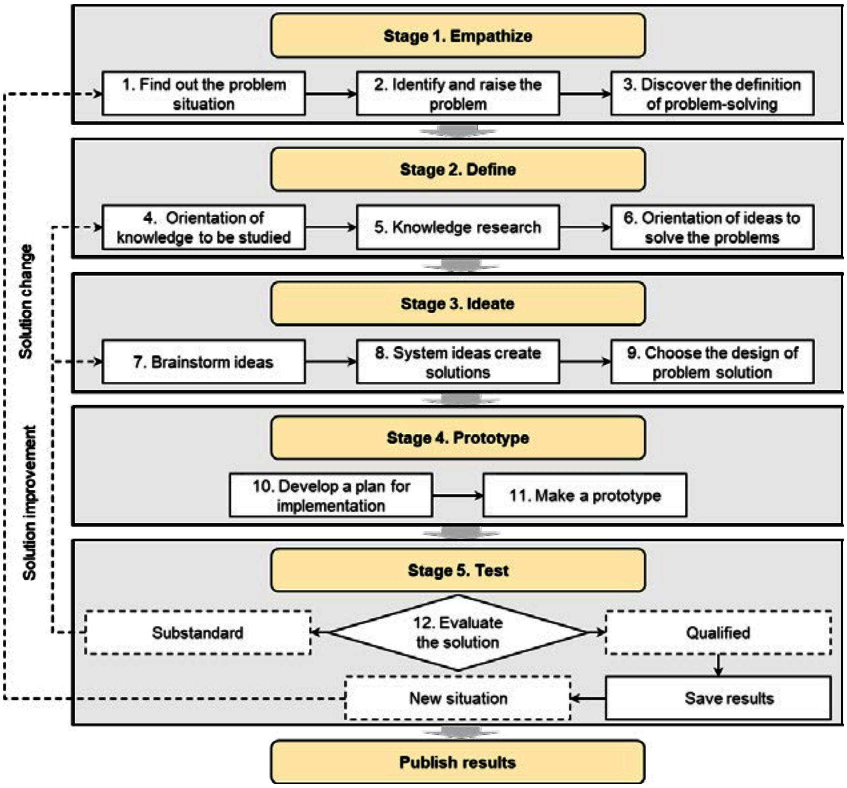
Assessment Components:

1. Empathetic Problem Setting (EM1-8): Focusing on getting and putting together accurate information, setting goals, and seeing things from the point of view of those affected by the problem (Anderson, 2012; Bequette & Bequette, 2012; Ladachart et al., 2022; Mentzer et al., 2015; Watson, 2015).

2. Reasoning (RE1-5): This includes coming up with a hypothesis,

Figure 1

The process of teaching STEAM lessons



suggesting a solution based on the data you've gathered, and then evaluating these solutions critically (Kimbell, 2007; Bequette & Bequette, 2012; Cusens & Byrd, 2013; Watson, 2015).

3. Ideation (ID1-5): Centring on generating innovative improvements and new solutions rooted in personal experience and scientific knowledge (Bain & McLaren, 2006; Baynes & Baynes, 2010; Carroll, et al., 2010; Anderson, 2012; Ladachart et al., 2022).

4. Modelling (MO1-6): Using design tools such as drawings and prototypes to visualize and test ideas (Bain & McLaren, 2006; Kimbell, 2007; Anderson, 2012; Johns & Mentzer, 2016).

5. Process Management (PM1-5): Encompassing task assignment, time management, and establishing criteria for effective problem-solving (Bain & McLaren, 2006; Carroll, et al., 2010; Anderson, 2012; Berry, 2012).

The research employs a structured evaluation method to examine students' design thinking abilities and enhance STEAM education.

Pedagogical Experience

This study uses pre-empirical methods to assess the feasibility and efficacy of design thinking-based STEAM instruction. Pretrial measurements involve testing an experimental group without a control group and encompassing pre- and post-trial scenarios. Two STEAM pieces of comparable complexity were chosen for practical use: STEAM lessons 1 and 2: Electrostatic Dust Filter (Table 1) and Electromagnetic Ship (Table 2), respectively.

Table 1

Summary of STEAM Lesson 1: Creating an Electrostatic Dust Filter

Learning Tasks	**Design and manufacture an electrostatic dust filter from recycled materials.**
STEAM Fields	
Science	● Understanding how electric forces interact between charges and electric fields is essential. ● Understanding of electrification of objects, ionisation, and the sharp-point effect.
Technology	● Construction and assembly process of the electrostatic dust filter according to the technical design. ● Operating procedure: charging dust particles and collecting them using oppositely charged metal plates.
	● Using the Internet to research methods currently used to reduce air pollution in the project area. ● Using tools such as scissors, adhesives, pliers, etc.
Engineering	● Designing the blueprint for the electrostatic dust filter. ● Reading the specifications of the power supply for the device.

Liberal Arts	●	The lesson objective has social significance and is aimed at providing solutions to tackle air pollution caused by fine dust in a specific area for a particular group.
	●	Diversity in the design models (applying creativity in design ideas) from each student group.
Mathematics	●	Calculating the dimensions of bottles and cans appropriately.
	●	Estimating the size of the dust filter.
	●	Applying the formula for electric field intensity of a point charge to deduce a solution to improve the fine dust collection efficiency of the device.

Table 2

Summary of STEAM Lesson 2: Creating an Electromagnetic Boat

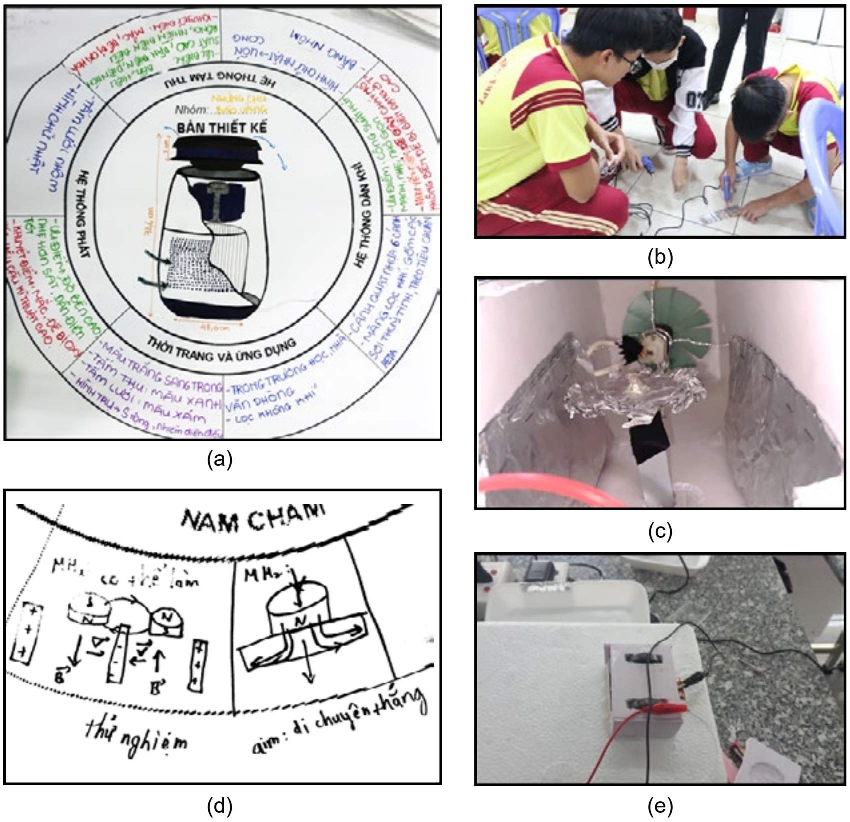
Learning Tasks	**Design and manufacture an electromagnetic boat from recycled materials.**	
STEAM Fields		
Science	●	Understanding electric current in electrolytes is essential.
	●	Understanding of magnetic force acting on a current in a magnetic field.
Technology	●	Process of constructing and assembling the electromagnetic boat according to the technical design.
	●	Operating procedure: connecting two metal plates to the battery terminals, immersing them in an electrolyte solution, and positioning the magnet to produce a thrust, pushing the boat forward.
	●	Using the Internet to research the current use of fossil fuels for ships and the air pollution caused by shipping.
	●	Using tools such as scissors, glue, pliers, etc.
Engineering	●	Design drawings of the electromagnetic boat.
	●	Reading the specifications of the power source for the equipment.
Liberal Arts	●	The lesson's objective has social significance, aiming to address issues of fossil fuel use and reduce emissions from ships.
	●	Diversity in design models (using creative design ideas) among each group of students.
Mathematics	●	Calculating the width of the hull, the area of the metal plates, and the weight of the boat.
	●	Applying the formula for the magnetic force acting on a current in a magnetic field, measuring the boat's speed to determine the magnetic induction of the magnet.

The experimental teachers applied their expertise in STEAM education and lesson delivery, adapting lesson plans to align with the school's context. To ensure an objective assessment and minimize observer bias, we formed an evaluation team comprising an education expert, two independent observers, and an experimental teacher. Before the lessons, the research team had established consensus on data collection methods, which involved defining key behavioural indicators of students' design thinking competence and employing a structured behaviour matrix with four levels of occurrence.

Two teaching assistants noted students' learning results in each experimental session, utilizing particular evidence, including classroom observations, student artefacts, and verbal interactions. After every session, we had post-lesson conversations with teachers to review teaching practices, consider instructional tactics, and validate the assessment results. The performance of students and the class as a whole was judged by comparing the results with written data, the opinions of teachers, and the students themselves (Clarke, 2012). We focused on typical and representative behavioural indicators to improve measurement validity, ensuring that we documented the students who demonstrated the highest competency levels. We conducted inter-rater reliability checks among the evaluation team to enhance consistency in observations and assessments. Additionally, data collection and evaluation adhered to established frameworks, such as criterion-based assessment, a structured assessment method, evaluative feedback, and the integration of assessment and learning activities (Botuzova et al., 2023), ensuring methodological rigour and credibility.

Figure 2

Evidence of Student Learning during the Experimental Activities



STEAM Lesson 1: (a) A student's design, (b) A student-created model, (c) A model constructed by students; STEAM Lesson 2: (d) Annotations on the arrangement of the magnet system and electrodes in the water propulsion mechanism of the boat, (e) An experiment set up by the students.

Findings and Discussion

Expressing Design Thinking Competency of Students in STEAM Lesson

In the study, we gave students two STEAM classes and observed their behaviour in each competency component. To assess students' recognition of behaviour, we divided it into four levels: (I), where most students reflect and record it; (II), where some students exhibit and record it; (III), where the behaviour does not manifest despite favourable conditions; and (IV), where it has not been allowed to express itself. Each learning problem may elicit several behaviours, and each conduct can occur in multiple tasks.

Figure 3

Recording Matrix for Students' Design Thinking Competency in STEAM Lesson 1

		The process of teaching STEAM lesson 1												Pr. Level
		Stage 1			Stage 2			Stage 3			Stage 4		Stage 5	
Activity		1	2	3	4	5	6	7	8	9	10	11	12	
Behavioural index of students' design thinking competency	EM1	IV			IV									IV
	EM2					IV								IV
	EM3	I					III							I
	EM4		II											II
	EM5	I												I
	EM6			I										I
	EM7	IV				I								I
	EM8			II										II
	RE1								III					III
	RE2				III									III
	RE3						II							II
	RE4				IV	IV	II		II				IV	II
	RE5												II	II
	ID1											IV		IV
	ID2							III	IV	II				II
	ID3							II						II
	ID4											II		II
	ID5									II			II	II
	MO1									IV				IV
	MO2											I		I
	MO3									I				I
	MO4											IV	I	I
	MO5									II				II
	MO6								IV	II				II
	PM1	IV			II			IV			IV			II
	PM2		IV			IV			IV			IV		IV
	PM3							II			IV			II
	PM4										IV			IV
	PM5									II			IV	II

Figure 4

Recording Matrix for Students' Design Thinking Competency in STEAM Lesson 2

The process of teaching STEAM lesson 2														Pr. Level
		Stage 1			Stage 2			Stage 3			Stage 4		Stage 5	
Activity		1	2	3	4	5	6	7	8	9	10	11	12	
Behavioural index of students' design thinking competency	EM1	II			II									II
	EM2					II								II
	EM3						I							I
	EM4		II											II
	EM5	II												II
	EM6			I										I
	EM7	III				II								II
	EM8			II										II
	RE1								III					III
	RE2				II									II
	RE3						II							II
	RE4				II	II	II		II				IV	II
	RE5												II	II
	ID1											II		II
	ID2							II	IV	II				II
	ID3							II						II
	ID4											II		II
	ID5									II			IV	IV
	MO1									IV				IV
	MO2											I		I
	MO3									I				I
	MO4											IV	IV	IV
	MO5									II				II
	MO6								IV	I				I
	PM1	I			IV			I			I			I
	PM2		IV			IV			IV			II		II
	PM3							II			III			II
	PM4										IV			IV
	PM5									II			IV	II

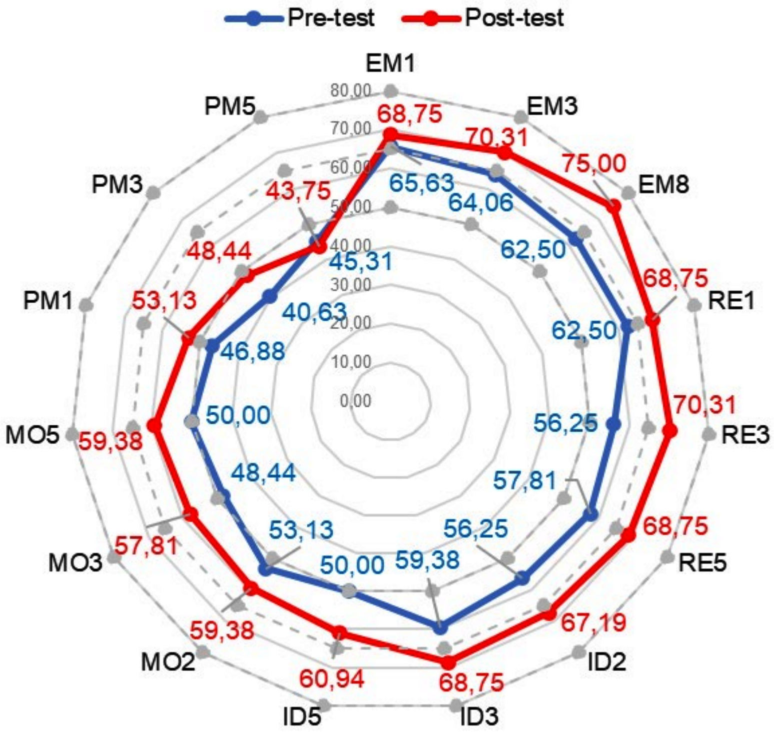
Thus, we pick the dominant and easiest-to-record behaviour in the learning exercise (the "bold box") to measure behavioural expression. Behaviour recognition at the elementary level is the most significant level acquired throughout instruction. Figures 3 and 4 illustrate the outcomes of the two STEAM lessons.

Teaching STEAM Lessons Helps Students Develop Design Thinking Competency

To assess behavioural growth in design thinking competency, the mean scores for each behavioural expression of a set of 16 chosen students are calculated. To collect enough data from all

Figure 5

Average Student Behavioral Scores across Two STEAM Lessons



students in this group, the researchers chose three behavioural manifestations for each design thinking ability scale component. The behavioural attributes are “poor”, “weak”, “moderate”, “fair”, and “good”, with scores ranging from 0 to 4. The proficiency assessment converts these results into percentages. Two pre- and post-tests, synchronised with the two STEAM class hours, measure a student’s behavioural aptitude through the grade point average.

Figure 5 shows the 15 behavioural markers recorded and measured for all the group pupils. These indications are EM1, EM2, EM8, RE1, RE3, RE5, ID2, ID3, ID5, MO2, MO3, MO5, PM1, PM3, and PM5. The spider web graph of the sample mean score indicates an increase on most axes, suggesting potential improvements in students’ design thinking behaviours.

The paired sample t-test results in Table 3 indicate a significant difference in students’ ability to think about the design before and after the program. All two-tailed p-values were below .05, indicating statistically significant differences between the pre- and post-test scores. The reasoning and ideation components increased the most, while process management increased the least. We may conclude that the STEAM instructional method offers preliminary evidence of improving students’ design thinking.

Table 3

Paired Sample T-test Results on Students' Design Thinking Competence

Composition	Assessments	Average value	S.D.	Difference	Sig
EM	Pre-test	64.06	14.82	7.29*	.011
	Post-test	71.36	11.77		
RE	Pre-test	58.85	10.30	10.42**	.002
	Post-test	69.27	11.67		
ID	Pre-test	55.21	15.48	10.42***	< .001
	Post-test	65.62	12.87		
MO	Pre-test	50.52	11.57	8.33**	.006
	Post-test	58.85	13.08		
PM	Pre-test	44.27	16.59	4.17*	.015
	Post-test	48.44	15.88		
DT	Pre-test	54.58	11.03	8.13***	< .001
	Post-test	62.71	10.45		

Note: ***, **, and * denote statistical significance levels of .001, .01, and .05, respectively.

Discussion

Positioned against regional priorities, our gains in ideation and reasoning suggest that design thinking–anchored STEAM instruction can contribute to ASEAN's goal of developing innovation-ready human capital. The smaller improvements in process management highlight the need for targeted teacher support, consistent with ASEAN's emphasis on professional development and assessment literacies. Overall, this study provides preliminary evidence of the pedagogical potential of STEAM for cultivating design-thinking skills in high school students.

Problem-Solving and Ideation

STEAM-oriented classes enhanced students' problem-solving and creativity, aligning with the design-thinking framework (Rusmann & Ejsing-Duun, 2022), which includes problem setting, empathy, ideation, modelling, reasoning, and process management. Gains in problem setting and ideation were most evident, as students generated and refined multiple solutions through inquiry (Cook & Bush, 2018). The rise in behavioural indicators between lessons suggested more active engagement. This finding aligns with research highlighting the value of diverse perspectives in fostering innovation (Carroll et al., 2010; Mentzer et al., 2015). Rather than passively collecting knowledge, students appeared to participate actively in creative and analytical processes.

Iterative Design and Higher-Order Abilities

Design thinking employs iterative cycles of prototyping and feedback to refine concepts (Davis, 2011; Bequette & Bequette, 2012). As the lessons progressed, students engaged more in modelling and solution modification, improving reasoning and adaptability. These outcomes are consistent with studies emphasising iterative design as a means to strengthen metacognition and evaluation skills (Kangas et al., 2013;

Scheer et al., 2012). STEAM thus provides a pathway for students to apply abstract concepts more concretely and develop transferable higher-order abilities.

Teacher Guidance and Classroom Management

Variation in behavioural expression reflected the role of teacher scaffolding. Gains in empathy and process management were linked to clearer guidance, structured projects, and improved classroom management (Nguyen, Nguyen, & Ta, 2024). In contrast, limited experience with STEAM in the first session hindered engagement. When more explicit explanations and hands-on activities were introduced in the second session, students became more independent and motivated. These findings echo research on the importance of scaffolding in STEAM (Goleman, 1999; Wells, 2013; Yu et al., 2024).

However, expressiveness declined in tasks requiring empathy and modelling when the problem context shifted to abstract issues (Ta et al., 2024). Without direct end-user involvement, students found it harder to relate to tasks. This highlights the need for contextual relevance to sustain motivation (Carroll et al., 2010). A lack of visible real-world application can reduce student confidence and participation in inquiry-based learning (Edelen et al., 2023). Future STEAM initiatives should ensure scenarios connect meaningfully with students' lived experiences and, where feasible, include direct end-user engagement.

Limitations and ASEAN Relevance

These findings must be interpreted cautiously, as the small, urban-biased sample and lack of a control group may inflate effect sizes and limit generalisability. The results should therefore be considered exploratory and context-specific.

Despite these constraints, the results speak to broader ASEAN contexts. The Philippines has embedded agri-fisheries into STEAM curricula (Sarmiento et al., 2020), while Thailand, Indonesia, and Singapore have prioritised interdisciplinary, high-tech STEAM initiatives (Cao et al., 2020). Malaysia has adapted STEAM to ensure accessibility in post-pandemic recovery (Ng, 2024). Regional frameworks increasingly emphasise teacher collaboration, reflective practice, and real-world applications, underscoring the shared challenges of scaling STEAM equitably.

The observed gains in ideation, reasoning, and problem-solving point to the promise of design thinking–anchored STEAM as a vehicle for advancing both regional and global education agendas. By fostering creativity, collaboration, and higher-order thinking, these lessons support UN Sustainable Development Goal 4 and align with PISA's Creative Thinking domain, which benchmarks creativity and problem-solving as essential competencies for sustainable futures (OECD, 2022; UNESCO, 2015). They also resonate with UNESCO's Education 2030 framework and ASEAN's education cooperation priorities, which emphasize teacher capacity, competency-based curricula, and digital readiness. Importantly, for both Vietnam and ASEAN, strengthening design-thinking competencies is not only an educational aspiration but also an economic imperative, directly tied to workforce readiness and competitiveness in the transition to innovation-driven economies.

Implications

The findings suggest that STEAM lessons enhance students' design-thinking and problem-solving skills. Because measurable gains were most evident in problem-setting and ideation, teachers should design tasks closely aligned with students' lived experiences to strengthen engagement and self-efficacy (Cook & Bush, 2018; Rusmann & Ejsing-Duun, 2022). Given that improvements in process management were smaller, professional development should prioritise STEAM-specific scaffolding and classroom management strategies to better support iterative learning (Nguyen, Nguyen, & Ta, 2024). Finally, variations in behavioural expression underscore the importance of contextual relevance, as meaningful links to students' realities are crucial for sustaining motivation and ownership (Carroll et al., 2010).

Conclusion

This study provides preliminary evidence that STEAM education fosters design-thinking competencies among Vietnamese high school students, equipping them with creativity, reasoning, and collaboration skills needed for a rapidly evolving learning environment. By bridging the gap between theory-oriented instruction and competency-based reform goals, design thinking–anchored STEAM lessons demonstrate strong potential for classroom-level innovation.

The findings reflect broader regional realities, where uneven implementation, teacher shortages, and disparities in school resources remain ongoing challenges. They also align with current efforts across educational systems to advance competency-based curricula, strengthen teacher capacity, and promote collaborative development of innovative instructional models.

Based on these insights, three recommendations are proposed. First, as teacher facilitation played a key role in student outcomes, cross-border professional collaboration and access to shared STEAM teaching resources could be strengthened. Second, since STEAM lessons effectively supported reasoning and ideation, integrating design-thinking competencies into curriculum and assessment frameworks would enable more coherent implementation. Third, to enhance generalisability, future studies should include more diverse school settings and apply comparative or quasi-experimental designs across different regions.

Despite limitations related to its urban sample and lack of a control group, this study contributes exploratory evidence on cultivating design thinking in Vietnamese secondary schools and offers practical insights for education systems seeking to advance innovation-oriented learning agendas.

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4. **Ethical Approval:** At the time of data collection, the research institution did not require a formal ethics approval code for classroom-based educational studies. However, all procedures were conducted in accordance with human research

ethics. Prior to the intervention, the researcher obtained informed consent from participating students and school administrators, ensured voluntary participation, maintained confidentiality, and clearly communicated the right to withdraw at any stage of the process. These measures were implemented to guarantee ethical compliance even in the absence of a mandatory institutional review code.

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Bionote

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