

Research Article

Cite this article: Truong, T. D., & Tran, Q. G. (2025). Factors Influencing STEAM Teaching at Private Schools in Vietnam: A Case Study of Ho Chi Minh City. *Educational Process: International Journal*, 17, e2025340. <https://doi.org/10.22521/edupij.2025.17.340>

Received May 18, 2025

Accepted July 5, 2025

Published Online July 19, 2025

Keywords: STEAM education, private secondary schools, Ho Chi Minh City-Vietnam, implementation factors, professional development

Author for correspondence:

✉ Quoc Giang Tran
✉ giang.tq894@dtu.edu.vn
✉ Dong Thap University, Dong Thap Province, Vietnam



OPEN ACCESS

© The Author(s), 2025. This is an Open Access article, distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted re-use, distribution, and reproduction, provided the original article is properly cited.

Factors Influencing STEAM Teaching at Private Schools in Vietnam: A Case Study of Ho Chi Minh City

Tan Dat Truong, Quoc Giang Tran

Abstract

Background/purpose. STEAM integrates Arts into STEM to foster creativity, critical thinking, and problem-solving. Private schools in Ho Chi Minh City, Vietnam, have pioneered STEAM; however, the drivers of effective implementation and their impacts on engagement, product quality, and evaluation remain underexplored. This study examines the key inputs that shape STEAM delivery and their impact on program outcomes.

Materials/Methods. Using a sequential explanatory mixed-methods design (QUAN → QUAL), we surveyed 480 participants, including 330 teachers, 40 administrators, 50 students, and 60 parents, in ten private schools with a 35-item Likert scale questionnaire (1 = “Strongly Disagree” to 5 = “Strongly Agree”). The questionnaire addressed six factors: five inputs (teacher competence & attitude, infrastructure & tools, curriculum & methods, organizational support & policy, learner & parent engagement) and one outcome (“STEAM implementation level”), with Cronbach’s $\alpha \geq 0.79$. Analyses included Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM). Follow-up semi-structured interviews with 20 purposively selected participants added contextual insight.

Results. All input domains significantly predicted STEAM implementation ($p < 0.01$). Administrators rated resources, policies, and teacher readiness more positively than teachers and students, exposing gaps in arts integration, collaboration, and digital tool use. Students and parents reported lower engagement and satisfaction. Qualitative themes highlighted the need for sustained professional development, flexible infrastructure, adaptive curricula, transparent policies, and structured parent involvement.

Conclusion. While private schools in Ho Chi Minh City have robust STEAM foundations, bridging stakeholder confidence and perception divides is essential. A holistic framework aligning targeted teacher support, dynamic infrastructure, flexible curricula, clear policies, and proactive parent engagement will enhance STEAM’s effectiveness, sustainability, and scalability in Vietnam.

1. Introduction

STEAM (Science, Technology, Engineering, Arts, Mathematics) education plays a crucial role in equipping 21st-century students with the necessary competencies to adapt and innovate in a dynamic socio-economic environment. The STEAM framework not only strengthens scientific and technological knowledge but also cultivates aesthetic sensibility, critical thinking, and problem-solving skills through the integration of the Arts into traditional STEM (Land, 2013; Bush & Cook, 2019; Wahyuningsih et al., 2020; Belbase et al., 2022; Burnard et al., 2021; Areljung & Günther-Hanssen, 2022).

In the United States, STEAM has been widely implemented in creative experiential programs, from developing game design projects (Bass et al., 2016) to utilizing robotics and makerspaces (Guenaga et al., 2017; Bush & Cook, 2019; Su & Yang, 2024; Su et al., 2024). In Europe, STEAM is regarded as a "comprehensive path to developing interdisciplinary thinking" and the "foundation of innovative education" (Colucci-Gray et al., 2019; Uştu et al., 2022).

In Asia, South Korea has applied STEAM to enhance interdisciplinarity and encourage teachers to develop their capacity for designing integrated lesson plans (Kim & Bolger, 2017; Kang, 2019). In South Africa and Jamaica, STEAM projects based on traditional games and digital technology have demonstrated the ability to promote student excitement and interaction (Espigares-Gómez et al., 2020; Fernández-Oliveras et al., 2021). Multiple studies indicate that STEAM not only improves academic outcomes but also fosters social skills such as teamwork, self-assessment, and project management (Bush et al., 2020; Perignat & Katz-Buonincontro, 2019).

In Vietnam, the integration of STEM into the general education curriculum has been implemented by the Ministry of Education and Training through Circular 32/2018/TT-BGDĐT and Official Letter 3089/BGDĐT-GDTrH in 2020, aiming to encourage schools to organize STEM activities and innovate teaching and assessment methods (MoET, 2018, 2020). However, most domestic research still focuses on traditional STEM, with little mention of the "Arts" element and a lack of comprehensive STEAM models (Chu, 2016; Pham et al., 2025; Ho, 2019). Research on STEM in preschool shows that teachers require additional support in interdisciplinary knowledge and integrated teaching methods (Dinh, 2021; Tran & Le, 2024; Ho & Pham, 2022; Ho, 2022). At the secondary level, surveys in Ho Chi Minh City revealed that limited infrastructure, traditional assessment methods, and exam pressure are significant barriers to STEM/STEAM activities (Bui et al., 2021, 2023).

In contrast, the private school sector in Ho Chi Minh City is pioneering the experimentation with advanced STEAM models. These schools often have better financial resources, foster flexible STEM/STEAM spaces, and collaborate with businesses and foreign universities. Many private schools have built dedicated STEAM labs, equipped with 3D printers, robotics kits, and 3D simulation software. From a management perspective, school leaders have also issued policies to encourage teacher innovation (Bui et al., 2021, 2023; Dinh, 2021; Duong et al., 2024; Tran & Le, 2024; Ho & Pham, 2022; Hoang, 2023; Nguyen et al., 2025).

However, current reports are predominantly descriptive, focusing on single activities or specific factors, and lack a systematic study that conducts a comprehensive analysis by simultaneously examining input and outcome factors. Specifically, existing research in Vietnam lacks an analytical framework to assess the interactive relationship between five key input factor groups (teacher competence, infrastructure, curriculum, policies, and parental involvement) and the level of STEAM implementation (frequency, product quality, student interaction, and evaluation effectiveness) (Aguilera & Ortiz-Revilla, 2021; Anderson, 2021; Perignat & Katz-Buonincontro, 2019). This deficiency creates a significant gap in understanding how to optimize interdisciplinary integration (especially the

role of the "Arts") and how to bridge the gap between policy enactment and practical classroom implementation.

Stemming from this research gap and practical need, this study is conducted in Ho Chi Minh City the most dynamic private education hub in Vietnam to address the following central research questions:

- RQ1: Which factors (including teacher competence & attitude, infrastructure & tools, curriculum & methods, organizational support & policy, learner characteristics & parent engagement) truly influence the implementation of STEAM education in private schools in HCMC?
- RQ2: What is the actual level of STEAM implementation (measured by frequency, product quality, interaction, and evaluation effectiveness), and how can the relationship between these inputs and outcomes be modeled?
- RQ3: Are there differences in perception and assessment of the above factors among stakeholder groups (administrators, teachers, students, parents), and how do these differences affect policy implementation and collaboration?

By answering these questions, this study expects to contribute a comprehensive analytical framework that not only offers practical value for private schools to optimize resources and teach STEAM effectively but also provides scientific evidence for developing policies and STEAM teacher training programs nationwide.

2. Literature Review

STEAM (Science, Technology, Engineering, Arts, Mathematics) education emerged from the traditional STEM foundation and has rapidly gained international attention for its potential to foster interdisciplinary thinking, creativity, and problem-solving skills in learners (Land, 2013; Darling-Hammond et al., 2020; Santi et al., 2021; Belbase et al., 2022). The core distinction of STEAM from STEM lies in the "Arts" element, which is not merely decorative but is fundamentally imbued with design thinking methodologies, aesthetic sensibility, and the encouragement of students' analytical and multi-faceted evaluation skills (Burnard et al., 2021; Areljung & Günther-Hanssen, 2022; Colucci-Gray et al., 2019; Liao, 2016; Marín-Marín et al., 2021; Boice et al., 2024; Ryan et al., 2025).

2.1. STEAM theoretical frameworks

The theoretical frameworks for STEAM have evolved from initial models emphasizing the combination of disciplines to more complex structures focused on learner competencies. Pioneers like Yakman & Lee (2012) initially established STEAM as an evolution from STEM, highlighting the synergistic relationship between science and the arts. Gradually, these frameworks became more detailed, aiming to develop specific 21st-century competencies. For instance, Perignat & Katz-Buonincontro (2019) proposed the 6C framework (Creativity, Critical thinking, Communication, Collaboration, Contextual awareness, and Confidence), while other researchers expanded it with elements like Empowerment and Reflection (Colucci-Gray et al., 2019; Bush & Cook, 2019; Guyotte, 2020; White & Delaney, 2021; Ng et al., 2022; Johnston et al., 2022; Çalışkan & Erol, 2025). Recent models have also focused on building pedagogical capacity for teachers, particularly at the preschool level, by clearly defining the skills needed to design and evaluate integrated learning activities (Çiftçi et al., 2022; Bui et al., 2023; Nguyen et al., 2025; Pham et al., 2025). This diversification demonstrates that STEAM's theoretical frameworks are becoming increasingly flexible, allowing them to adapt to specific grade levels, fields, and educational contexts.

2.2. Teacher competence and attitude

Teachers play a decisive role in the successful implementation of STEAM. Herro & Quigley (2017) and Ortega-Torres (2022) indicate that continuous Professional Development (PD) is necessary to equip teachers with high-level, integrated pedagogical methods. Anderson (2021) compares the US and South Korea, noting that Korean teachers receive systematic training through formal programs, whereas American teachers often engage in self-study and self-initiated projects. In South Korea, Kim & Kim (2016) developed an index for evaluating STEAM teaching competency, which includes interdisciplinary knowledge, lesson design capacity, technological skills, and an innovative attitude; subsequent studies have continued to affirm the impact of training on changing perceptions and teaching practices (Kang, 2019; Kim & Bolger, 2017; Díaz-Noguera, 2019; Ortiz Revilla et al., 2021; Spyropoulou & Kameas, 2024). In Vietnam, studies also show that general education teachers lack confidence in their interdisciplinary knowledge and STEAM lesson design skills, and that professional development programs have not yet harmoniously met these requirements, especially regarding aesthetics and design thinking (Chu, 2016; Ho, 2019; Ho, 2023; Bui et al., 2023; Pham et al., 2025). In summary, previous research consistently affirms that teachers are the central actors, and their competence, nurtured through professional development, is a decisive factor in the success of STEAM. The innovative aspect of this study is its assessment of teacher competence within the context of private schools in Vietnam, specifically by contrasting teachers' self-perceptions with administrators' evaluations to reveal potential underlying gaps.

2.3. Infrastructure & supporting tools

Physical and technical resources are a prerequisite that directly impacts the quality of STEAM activities. Learning spaces like makerspaces equipped with 3D printers and laser cutters (Bass et al., 2016), along with robotics kits (Guenaga et al., 2017; Jurado et al., 2020) and new technologies like drones (Chen et al., 2018), are considered effective tools for bridging the gap between theory and practice. Even at the preschool level, the use of traditional games (Espigares-Gómez et al., 2020) or warnings about the shortage of experiment kits and simulation software (Bui et al., 2023; Nguyen et al., 2025; Pham et al., 2025; Pham & Tran, 2025) highlight the importance of resources. Consequently, studies consistently recommend mechanisms for regular investment in lab maintenance and upgrades, as well as collaboration with businesses to diversify funding (Belbase et al., 2022; Bush & Cook, 2019; Halverson & Sawyer, 2022; Ryan et al., 2025).

In essence, the general trend in the literature is to emphasize the indispensable role of modern and diverse infrastructure for STEAM activities. This study contributes a novel perspective by not only inventorying resources but also analyzing their perceived availability, flexibility, and effectiveness of use from the teachers' viewpoints, thereby directly linking investment to implementation outcomes.

2.4. Curriculum - pedagogical methods

Project-Based Learning (PBL) and Inquiry-Based Learning (IBL) are two core pedagogical methods in STEAM that help students develop skills in teamwork, problem-solving, and self-assessment (Bass et al., 2016; Bush et al., 2020; Quigley et al., 2020; Boice et al., 2024). Researchers also propose transdisciplinary frameworks where lessons are not confined to STEAM fields but extend to the social sciences and humanities (English, 2017; Kelley & Knowles, 2016). Open-endedness and critical thinking in lesson design are particularly encouraged (Burnard et al., 2021), along with the integration of local cultural elements, such as folk games, to increase engagement (Fernández-Oliveras et al., 2021; Espigares-Gómez et al., 2020). In Vietnam, models such as STEM fairs and open mathematics days have been introduced as creative STEAM experiential environments (Pham et al., 2025; Pham & Tran, 2025). International literature widely agrees that integrated, student-centered pedagogical approaches, such as PBL and IBL, are the cornerstone of STEAM. The novelty of this study lies in examining the discrepancy between the curriculum as designed on paper and the actual student

experience, thereby assessing pedagogical effectiveness from multiple perspectives within the Vietnamese educational context.

2.5. Organizational Support & School Policy

The role of school leadership and institutional policy is decisive for the sustainability of STEAM. Studies emphasize the need for schools to have a long-term vision, allocate appropriate professional time, and establish mechanisms for rewarding initiatives (Bass et al., 2016; Bush et al., 2020). Technical and financial support, as well as opportunities for teachers to share experiences, are also key factors (Herro et al., 2019; Vicente et al., 2021; Ramey & Stevens, 2023). Collaboration with businesses and external experts (mentoring) also helps connect the school with real-world practice (Quigley et al., 2020). In Vietnam, although a policy framework for STEM exists from the Ministry of Education & Training (2018, 2020), specific proposals for integrating STEAM into the curriculum, building support teams, and establishing rewards are still under discussion (Bui et al., 2021, 2023; Pham et al., 2025; Pham & Tran, 2025). Collectively, studies indicate that systematic support from leadership is the foundation for STEAM's success. This research delves deeper by analyzing how policies are perceived and actualized at the teacher level, thereby illuminating the potential gap between administrative directives and practical classroom implementation.

2.6. Learner characteristics & parent engagement

Students and parents are actors who create a vibrant STEAM environment. Research confirms that STEAM increases students' learning motivation and self-assessment skills (Bush et al., 2020; Perignat & Katz-Buonincontro, 2019), while also developing communication and creative skills from the preschool level (Espigares-Gómez et al., 2020; Fernández-Oliveras et al., 2021). In the context of digital transformation, the role of parents is increasingly emphasized, particularly the need to be equipped with digital literacy (AI literacy) to support their children (Su et al., 2024; Yim, 2024a, 2024b; Yim & Su, 2024). In Vietnam, recommendations also emphasize organizing workshops to guide parents on how to support their children's STEAM learning at home (Bui et al., 2023; Pham & Tran, 2025; Nguyen et al., 2025; Pham et al., 2025). Recent research trends increasingly underscore the indispensable role of learners and parents in the STEAM ecosystem. The innovation of this study lies in incorporating student and parent voices into a quantitative analytical model, treating their engagement and satisfaction as critical input factors rather than merely passive outcomes.

2.7. STEAM implementation level and outcomes

Assessing the level of STEAM implementation is often based on indicators such as the frequency of activities, quality of artifacts, student interaction levels, and the effectiveness of assessment methods (Bush et al., 2020; Colucci-Gray et al., 2019; Potvin et al., 2023). Quantitative methods, such as SEM, EFA, and CFA, are widely applied to determine the relationship between input factors and learning outcomes (Kim & Kim, 2016; Marín-Marín et al., 2021). Concurrently, systematic review methods, such as PRISMA (Moher et al., 2015), and qualitative studies analyzing product quality are also used to provide in-depth evidence of effectiveness (Shively et al., 2021; Menacho et al., 2021; Lage-Gómez & Ros, 2021, 2023).

The literature review shows that STEAM education is a strategic direction, but its implementation is influenced by a complex interplay of many factors. Although these factors have been studied individually in various contexts, there is a lack of synchronous studies that simultaneously analyze the impact of all five input factor groups on the outcomes, especially in Vietnamese private schools. This is the scientific gap that this research aims to address, with the goal of developing a comprehensive analytical framework to support effective policymaking and educational practices in STEAM.

3. Methodology

3.1. Research Design

The study employs a mixed-methods approach with a sequential explanatory design (QUAN → QUAL), following the guidelines of Creswell & Plano Clark (2011) and Teddlie & Tashakkori (2008). The process consists of two consecutive phases: a quantitative phase followed by a qualitative phase. In the quantitative phase, we used a survey to collect data to identify general trends and relationships. The results of the quantitative analysis then informed the qualitative phase, for which semi-structured interviews were designed to explore, explain, and clarify the findings from the survey.

This combination not only provides objective "numbers" but also uncovers the "stories" behind the data. More importantly, this design enables data triangulation, where findings from the quantitative source (the survey) are cross-referenced and validated against findings from the qualitative source (the interviews). This triangulation process significantly enhances the reliability, validity, and comprehensiveness of the research conclusions.

Based on the synthesis and analysis of international and domestic STEAM integration models (Land, 2013; Belbase et al., 2022; Burnard et al., 2021; Areljung & Günther-Hanssen, 2022; Colucci-Gray et al., 2019; Liao, 2016; Marín-Marín et al., 2021), the study identified five key groups of influencing factors:

1. STEAM Teacher Competence & Attitude
2. Infrastructure & Supporting Tools
3. Curriculum & Teaching Methods
4. Organizational Support & School Policy
5. Learner Characteristics & Parent Engagement

The survey instrument was developed and standardized through a rigorous process, ensuring internal consistency reliability (Cronbach's Alpha ≥ 0.70) and content validity (I-CVI ≥ 0.78 , S-CVI/Ave ≥ 0.90), as described by Haynes et al. (1995).

3.2. Context and Sample

The study was carried out in private K-12 schools across Vietnam, which are recognized for their autonomy and flexibility in adopting innovative educational approaches, including STEAM. Unlike the public sector, private schools typically benefit from rapid decision-making processes and greater financial resources to invest in laboratories, technology, and teacher professional development. Selecting private institutions as the research setting enabled data collection within a relatively homogeneous management environment, thereby reducing macro-policy confounds and focusing the analysis on school- and teacher-level variables, such as instructional competence, technical infrastructure, integrated curricula, support mechanisms, and parent-school interactions. This setup provided an ideal context in which to elucidate the operational mechanisms and specific barriers affecting STEAM implementation in Vietnam's private schooling sector.

Table 1. Characteristics of the Quantitative Survey Sample (N = 480)

Sample Group	N	%	Male	Female	Central Districts	Outskirts	Mean Age	STEAM Satisfaction (%)
Teachers (TEA)	330	68.8	140	190	200	130	34	85
Administrators (ADM)	40	8.3	15	25	25	15	42	88
Students (STU)	50	10.4	20	30	20	30	15	80
Parents (PAR)	60	12.5	35	25	35	25	42	82
Total	480	100	210	270	280	200	-	-

The quantitative phase was conducted with 480 participants drawn from ten private K-12 schools in Ho Chi Minh City, using a stratified random sampling method based on two criteria: district location (central vs. suburban) and school level (primary, lower secondary, upper secondary). Specifically, the sample included 330 STEAM teachers (68.8 %)-140 male and 190 female-equally distributed between central (165) and suburban (165) districts, with a mean age of 34 years, an average of 8.2 years teaching STEAM, and an 85 % satisfaction rate with the STEAM approach; 40 administrators (8.3 %)-15 male and 25 female; 25 in central districts and 15 in suburban districts; mean age 42 years, mean management experience 15 years, and an 88 % satisfaction rate. Additionally, there were 50 students (10.4 %)-20 male and 30 female; 20 from central districts and 30 from suburban districts; mean age 15 years; and 60 parents (12.5 %)-35 male and 25 female; 35 from central districts and 25 from suburban districts; mean age 42 years; with satisfaction rates of 80 % and 82 %, respectively. A total of 500 questionnaires were collected via Google Forms and paper surveys over four weeks; after discarding 20 invalid responses, 480 valid questionnaires remained (response rate 96 %). The diversity of roles, gender, age, and district ensures a highly representative sample for examining the factors influencing STEAM education in private schools.

Table 2. Characteristics of the Qualitative Interview Sample (N = 20)

Sample Group	N	%	Male	Female	Central District	Suburban District
Teachers (TEA)	16	80.0%	7	9	8	8
Administrators (ADM)	4	20.0%	2	2	2	2
Total	20	100.0%	9	11	10	10

The qualitative phase built upon the quantitative survey findings and involved purposive sampling of 20 participants, including 16 STEAM teachers and 4 administrators (principals or department heads). This sampling strategy ensured representation across all three school levels (primary, lower secondary, and upper secondary) and both geographic zones (central districts and suburbs), as well as inclusion of schools with both advanced and emerging STEAM implementations. The average age of participants was 35, and all had completed intensive STEAM training, contributing rich perspectives and high-quality data to the study.

3.3. Data Collection Instruments

Quantitative Data Collection

Quantitative data were collected via a researcher-designed questionnaire comprising two parts. Part 1 captured demographic information and contextual variables to describe the sample and control for background factors. Part 2 consisted of 35 items measured on a five-point Likert scale (1 = “Strongly disagree” to 5 = “Strongly agree”), organized into six constructs: five input domains (teacher competence & attitude; infrastructure & tools; curriculum & pedagogical methods; organizational support & policy; learner characteristics & parent engagement) and one outcome domain (“STEAM implementation intensity”). Questionnaire items were derived from an extensive STEM/STEAM literature review and refined through expert feedback to ensure clarity, cultural relevance, and alignment with the Vietnamese context.

Table 3. Internal Consistency Reliability (Cronbach’s Alpha) of STEAM Measurement Constructs

No.	Construct / Factor	Description	Cronbach’s Alpha
1	Teacher Competence & Attitude in STEAM	Assesses teachers’ readiness, confidence, and skills when teaching STEAM (e.g., designing integrated, interdisciplinary lessons; openness to new methods).	> 0.84
2	Infrastructure & Resources	Measures the adequacy of equipment, STEAM labs, instructional materials, and supporting documentation available for STEAM activities in schools.	> 0.88
3	Organizational & Administrative Support	Evaluates leadership commitment, incentive policies (e.g., training, reduced teaching load), and school culture that embraces and promotes STEAM.	> 0.81
4	STEAM Curriculum & Instructional Materials	Gauges the extent of STEAM integration in the core curriculum, flexibility for interdisciplinary projects, and quality of lesson plans and guides.	> 0.85
5	Learner Characteristics & Parent Engagement	Assesses students’ interest and attitudes toward STEAM, and the level of parental support and involvement in school STEAM initiatives.	> 0.79
6	STEAM Implementation Intensity (Outcome)	Measures the frequency and effectiveness of STEAM activities (interdisciplinary projects, workshops, experiments), product quality, and student engagement.	> 0.82

Note on Reliability and Pilot Testing: To ensure the internal consistency of each scale, we calculated Cronbach’s Alpha for all six constructs. This coefficient reflects the average inter-item correlation within a scale, with higher values indicating greater internal consistency. Following Haynes et al. (1995) and El-Sabaa et al. (2017), we adopted a minimum threshold of $\alpha \geq 0.70$, an accepted benchmark in social-behavioral research, thereby confirming that each set of items reliably measures a single underlying concept without redundancy. Prior to the main survey, we drafted 35 Likert-type statements spanning the five input domains and the STEAM implementation outcome. A pilot test with 30 non-sample STEAM teachers assessed item clarity and preliminary reliability. Based on participant feedback, we refined wording and expanded the survey instructions to define “STEAM” uniformly. Pilot data were then used to recompute Cronbach’s Alpha for each scale (all $\alpha \geq 0.70$) and to conduct an exploratory factor analysis (principal-axis factoring with Promax rotation), verifying

that all items loaded ≥ 0.40 on their target factors. These results confirmed the survey's clarity and reliability, authorizing its deployment in the full study.

Qualitative Interview Protocol

Building on the quantitative findings, we designed a semi-structured interview guide comprising three open-ended question clusters, vetted by two STEAM education experts: (1) personal awareness and experiences with STEAM implementation (e.g., "When did you first begin using STEAM, and how was that experience?"); (2) enablers and barriers encountered (e.g., "In what ways did school leadership, technical support, or the wider community facilitate or hinder your STEAM efforts?"); and (3) recommendations for improving STEAM effectiveness (e.g., "What conditions or resources are essential for STEAM to achieve its full potential?"). Interviewers flexibly adjusted question order and added probes to explore emerging themes in depth. Each 45-60 minute, audio (and video, when virtual) recorded interview was conducted after obtaining informed consent, ensuring rich and accurate qualitative data.

3.4. Data Collection and Analysis Procedures

The process was conducted in two sequential phases, with an emphasis on integrating and triangulating the results to ensure accuracy and validity.

Phase 1: Quantitative data collection and analysis (January-February 2024)

In the quantitative phase, electronic and paper-based surveys were distributed at 10 private schools in HCMC, yielding 480 valid responses (a 96% response rate). The data was cleaned and processed using SPSS 26 and AMOS 24. The analysis steps included: (1) Descriptive statistics (frequency, mean); (2) Cronbach's Alpha reliability testing (all scales achieved $\alpha \geq 0.79$); (3) Exploratory Factor Analysis (EFA) to identify the factor structure; (4) Confirmatory Factor Analysis (CFA) to confirm the measurement model ($CFI \geq 0.90$, $RMSEA \leq 0.08$); and (5) Structural Equation Modeling (SEM) estimation to test the hypotheses regarding the relationships between factors.

Phase 2: Qualitative data collection and analysis (March 2024)

Based on the salient findings from the quantitative phase (e.g., the perception gap between administrators and teachers), 20 semi-structured interviews were conducted. The interviews (45-60 minutes) were audio-recorded, transcribed, and imported into NVivo 12 software for management and analysis. We applied the six-step Thematic Analysis method by Braun & Clarke (2006).

The initial open coding process generated approximately 120 codes. For example, statements like "we lack time for joint lesson planning" or "the teaching schedule is too dense" were assigned the code "Barriers to collaboration time." To ensure objectivity, two researchers independently conducted cross-coding on 25% of the data, achieving an inter-coder agreement rate of 88% (calculated using Miles & Huberman's formula), which indicates high consistency. The codes were then grouped, refined, and developed into 5 main themes corresponding to the research factors. To enhance credibility, a member checking process was also conducted with 5 interview participants to reconfirm the research team's interpretations.

Data integration and triangulation

This was the most critical step of the methodology. The qualitative results were used to provide a deeper explanation for the relationships identified by the SEM model. For example, the SEM model revealed that "School Support" had a significant influence on "Teacher Competence," and interview excerpts confirmed that this support extended beyond financial assistance to encompass trust and empowerment. The integration of these two data sources is the core of the triangulation method, helping to confirm and interpret the findings in-depth, thereby developing more comprehensive and reliable recommendations for STEAM education.

3.5. Ethical Considerations

This study adhered to rigorous ethical standards, as the protocol received institutional review board approval, and all participants provided informed consent, retaining the right to withdraw at any time. Quantitative surveys were anonymous; interviews used pseudonyms (e.g., “TEA1,” “ADM1”). Audio files and transcripts were stored securely under encryption and will be destroyed upon completion of the study. To avoid conflicts of interest, no external funding from vested parties was accepted, and participants received no financial incentives. Instead, our findings have been shared with participating schools to inform and improve their STEAM practices.

4. Results

Table 4. Teacher Competence & Attitudes in STEAM

Component	Administrators		Teachers		Sig. (p)
	Mean (M)	SD	Mean (M)	SD	
Teachers possess deep subject-matter knowledge across STEAM disciplines	4.38	0.48	3.92	0.66	0.013
Teachers feel confident designing interdisciplinary STEAM lessons	4.24	0.52	3.75	0.72	0.007
Teachers are willing to engage in STEAM training and professional development	4.41	0.46	3.88	0.64	0.009
Teachers proactively collaborate with colleagues on STEAM projects	4.18	0.58	3.65	0.78	0.004
Teachers encourage student creativity and critical thinking	4.32	0.50	3.82	0.68	0.011
Teachers flexibly integrate the “Arts” component into STEAM	4.12	0.60	3.54	0.82	0.002
Teachers demonstrate a positive, patient attitude when implementing STEAM methods	4.46	0.44	4.02	0.58	0.015
Overall mean	4.30	0.50	3.83	0.69	0.001

Table 4 reveals a significant gap between administrators’ ratings and teachers’ self-evaluations of STEAM competence (4.30 vs. 3.83; $p = 0.001$), with leaders generally holding more optimistic views about faculty capabilities. Administrators rated teachers’ STEAM expertise at 4.38 (SD 0.48) versus 3.92 (SD 0.66; $p = 0.013$) in self-ratings, and interdisciplinary lesson-design skills at 4.24 (SD 0.52) versus 3.75 (SD 0.72; $p = 0.007$), highlighting teachers’ limited confidence in their theoretical and design practice. Willingness to pursue STEAM training differed (4.41 vs. 3.88; $p = 0.009$), underscoring the desire for further preparation. Collaboration on STEAM projects was rated 4.18 by administrators versus 3.65 by teachers ($p = 0.004$), indicating a need to strengthen the team-teaching culture. Encouraging student creativity and critical thinking scored 4.32 versus 3.82 ($p = 0.011$), and the flexible integration of “Arts” was the lowest of all (4.12 versus 3.54; $p = 0.002$), confirming the demand for deeper artistic training. Even positive attitudes toward STEAM adoption differed (4.46 vs. 4.02; $p = 0.015$), indicating that motivated teachers still lack full confidence. These findings suggest that schools should offer targeted, practice-based professional development, emphasizing arts

integration, interdisciplinary design, and collaborative methodologies, paired with ongoing feedback, to build teacher self-efficacy and enhance STEAM instruction.

Table 5. Infrastructure & Support Tools

Component	Administrators		Teachers		Sig. (p)
	Mean (M)	SD	Mean (M)	SD	
The school provides a dedicated, flexible STEAM lab space	4.50	0.45	4.00	0.70	0.005
Computers with sufficient configuration for simulations and data processing are available	4.40	0.50	3.85	0.75	0.008
The school is equipped with 3D printers, robotics kits, and other STEM tools	4.30	0.55	3.90	0.65	0.020
Licensed specialized software (CAD, programming IDEs, simulations) is provided	4.20	0.60	3.75	0.80	0.012
Internet and LAN/Wi-Fi networks are stable with high bandwidth	4.45	0.48	4.10	0.68	0.015
A variety of measurement devices (sensors, microscopes, lab equipment) is available	4.35	0.52	3.95	0.70	0.010
A regular budget is allocated for maintenance, upgrades, and procurement of STEAM equipment	4.40	0.50	4.00	0.60	0.018
Overall mean	4.40	0.51	3.92	0.71	0.002

Table 5 reveals a notable perception gap ($p < 0.01$) regarding STEAM infrastructure between administrators and teachers. Overall, school administrators rate the infrastructure very highly (overall mean $M=4.40$), while teachers, as the direct users, have a more pragmatic view ($M=3.92$). This difference lies not in the existence of equipment, but in its practical availability and effectiveness. For example, while administrators rate the dedicated labs very highly ($M=4.50$), teachers perceive these spaces as less flexible ($M=4.00$). Similarly, specialized software like CAD or programming tools is rated at 4.20 by administrators, but only 3.75 by teachers, indicating a real need for more licenses and user training. Even the budget for maintenance and procurement, which administrators consider adequate ($M=4.40$), is expected by teachers to be more flexible ($M=4.00$). In summary, although private schools have invested heavily, the key to optimizing effectiveness is to bridge this perception gap. The focus should be on enhancing the multifunctionality of spaces, improving equipment performance, and creating flexible support processes to best serve innovative teaching and learning.

Table 6. Curriculum & Instructional Methods

Component	Administrators		Teachers		Students		Sig. (p)
	Mean (M)	SD	Mean (M)	SD	Mean (M)	SD	
The core curriculum clearly integrates STEAM objectives	4.55	0.40	4.05	0.60	3.70	0.70	0.001
Teachers use Project-Based Learning for STEAM activities	4.50	0.45	4.00	0.65	3.60	0.75	0.002
STEAM lessons are linked to local, real-world issues	4.48	0.42	3.95	0.68	3.55	0.78	0.003
The curriculum is flexible and adjusted to students' abilities	4.40	0.50	3.90	0.70	3.50	0.80	0.002
Digital tools (3D simulation, LMS, online quizzes) are applied	4.60	0.38	4.10	0.60	3.80	0.72	0.005
A variety of assessment formats (rubrics, portfolios, video reports) are used	4.45	0.48	3.85	0.75	3.45	0.85	0.004
Timely, specific feedback is provided during project implementation	4.50	0.44	4.00	0.65	3.70	0.80	0.006
Overall mean	4.49	0.44	4.05	0.67	3.61	0.77	0.001

Table 6 reveals a distinct perception gap ($p < 0.001$) among the three groups regarding the STEAM curriculum and instructional methods. Administrators hold the most optimistic view (overall mean $M=4.49$), followed by teachers ($M=4.05$), and finally, students with the most modest assessment ($M=3.61$). This gap tells a story of "design versus reality." On the design side, administrators believe the curriculum has well-integrated STEAM objectives. However, in terms of actual experience, students feel that lessons are not deeply connected to real-world issues (only $M=3.55$) and that the curriculum is not flexible enough to accommodate their diverse abilities. In practice, the most alarming finding is in assessment. Students gave the lowest score in the entire table (only $M=3.45$) for the diversity of assessment formats (rubrics, portfolios), indicating that this process is perceived as rigid and ineffective in the learners' eyes. The application of Project-Based Learning and the provision of timely feedback follow a similar trend. In summary, while the STEAM curriculum framework has a good foundation, the key to enhancing its effectiveness lies in implementation. The focus needs to be on training teachers how to implement engaging projects and, most importantly, on reforming the assessment process to make it more transparent and varied for students.

Table 7. School Policies for STEAM Education

Component	Administrators		Teachers		Sig. (p)
	Mean (M)	SD	Mean (M)	SD	
The school leadership defines a clear, long-term vision and strategy for STEAM	4.60	0.42	4.00	0.68	0.002
The school regularly organizes STEAM training sessions and workshops for teachers	4.45	0.50	3.70	0.75	0.005
Allocated professional development time for teachers to plan and collaborate on STEAM	4.30	0.55	3.60	0.80	0.008
A transparent reward and recognition system for STEAM initiatives and achievements	4.50	0.48	3.85	0.70	0.003
A streamlined budgeting process for STEAM projects and equipment procurement	4.40	0.52	3.75	0.78	0.006
Administrative and technical support is available when teachers implement STEAM activities	4.35	0.58	3.65	0.82	0.007
Policies encourage experimentation, acceptance of risk, and learning from failure	4.55	0.40	3.90	0.65	0.001
Overall mean	4.47	0.49	3.79	0.73	0.001

Table 7 reveals a significant "policy-practice gap" ($p < 0.001$) between administrators and teachers. Overall, while school administrators rate STEAM support policies very highly (overall mean score $M=4.47$), teachers perceive this support at a much lower level ($M=3.79$). This disparity is evident across several aspects. For instance, while leadership expresses high confidence in the long-term STEAM strategic vision ($M=4.60$) and regular training sessions ($M=4.45$), teachers rate these factors significantly lower (at $M=4.00$ and $M=3.70$, respectively). Similarly, teachers perceive that the time allocated for collaboration ($M=3.60$) and technical support during implementation ($M=3.65$) are limited, even though administrators rate these items very positively. This indicates that policies, while well-designed on paper, may not be effectively communicated and operationalized in practice. To bridge this gap, schools need to focus on policy actualization, ensuring teachers genuinely feel supported through transparent processes and accessible resources.

Table 8. Learner Characteristics & Parental Involvement

Component	Administrators		Teachers		Students		Parents		Sig. (p)
	Mean (M)	SD	Mean (M)	SD	Mean (M)	SD	Mean (M)	SD	
Students show interest and motivation to participate in STEAM activities	4.45	0.50	4.00	0.70	3.80	0.75	3.90	0.65	0.002
Students confidently solve problems and work collaboratively in STEAM	4.40	0.55	3.95	0.68	3.75	0.80	3.85	0.70	0.004
Students proactively use digital tools and resources for STEAM learning	4.30	0.60	3.85	0.75	3.60	0.85	3.80	0.72	0.006
Students are able to self-assess and adjust their project development	4.35	0.52	3.90	0.70	3.70	0.80	3.88	0.68	0.003
Parents understand and support STEAM activities at school	4.20	0.65	3.75	0.78	3.50	0.90	3.95	0.60	0.005
Parents participate in and provide material or emotional support for STEAM projects	4.25	0.60	3.80	0.80	3.55	0.85	3.90	0.62	0.004
Parent community is informed and invited to STEAM exhibitions and workshops	4.15	0.70	3.70	0.85	3.45	0.95	3.85	0.75	0.007
Overall mean	4.31	0.59	3.85	0.76	3.64	0.83	3.87	0.70	0.001

Table 8 reveals a significant perception gap ($p < 0.001$) among the groups regarding STEAM learning. School administrators have a very optimistic view (overall mean score $M=4.31$), whereas students are the group with the most modest assessment ($M=3.64$). Specifically, while administrators rate student motivation very highly ($M=4.45$), the students themselves self-report at a significantly lower level ($M=3.80$). This disparity is also evident in practical skills, such as using digital tools or the ability to self-assess, indicating that students need more empowerment and guidance to build their confidence. Similarly, there is a disconnect with parents. Although parents believe they are very understanding and supportive ($M=3.95$), students gave the lowest score in the entire table (only $M=3.45$) when asked about the parent community being informed and invited to events. This suggests that the desire for support from families exists, but it needs to be channeled more effectively. Therefore, the study concludes that bridging these gaps is of utmost importance. There is a need to enhance digital skills training, develop structured self-assessment processes for students, and organize more school-family engagement activities to optimize STEAM outcomes.

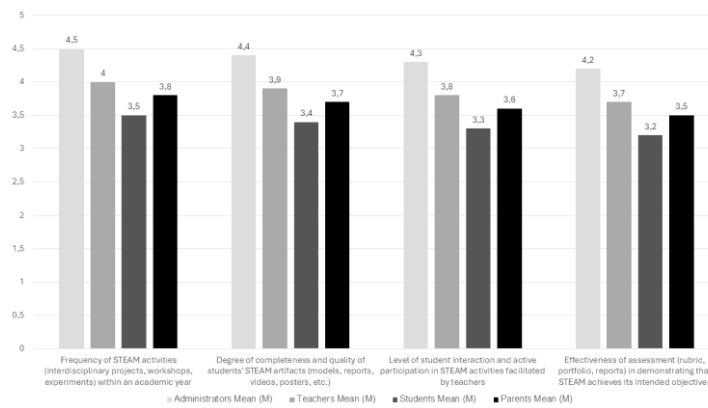


Figure 1. Outcomes - Level of STEAM Implementation

Figure 1 shows significant differences ($p < 0.001$) among administrators, teachers, students, and parents in rating STEAM implementation (overall means: 4.35, 3.85, 3.35, 3.65). Administrators rate annual STEAM activity frequency highest (4.50 vs. teachers 4.00, parents 3.80, students 3.50; $p = 0.002$), suggesting that despite regular projects, student and family engagement lags. Artifact quality (models, reports, videos, posters) is rated 4.40 by administrators versus 3.90 by teachers, 3.70 by parents, and 3.40 by students ($p = 0.003$), indicating a need for clearer quality standards and guidance. Active participation also varies (4.30 vs. 3.80 vs. 3.60 vs. 3.30; $p = 0.004$), underscoring the importance of diverse group-work methods and digital tools to boost engagement. Finally, assessment effectiveness (as measured by rubrics, portfolios, and reports) scores 4.20 among administrators, 3.70 among teachers ($p = 0.005$), 3.50 among parents, and 3.20 among students, indicating a need for transparent feedback processes and shared evaluation criteria. In sum, while STEAM activities are well organized, perceptual gaps across stakeholders highlight the necessity for detailed implementation guidelines, targeted hands-on training, and openly communicated assessment standards to strengthen collaboration and maximize educational impact.

5. Discussion

This study provides a multi-dimensional perspective on the factors affecting STEAM education in the private schools of Ho Chi Minh City. This discussion will deeply analyze the key findings, placing them in dialogue with international and domestic literature while clarifying the critical implications for educational policy and professional development.

First, regarding the perception gap and teacher competence, the most striking finding is the significant disparity between the optimistic assessments of administrators and the modest self-confidence of teachers. This strongly resonates with the international research of Herro and Quigley (2017), which indicates that STEAM teachers often lack confidence in their interdisciplinary knowledge and integrated design skills. However, our study adds a crucial dimension: this gap persists even in the context of well-funded private schools, demonstrating that financial resources do not automatically translate into professional confidence. This finding also deepens the concerns raised in the Vietnamese context by Duong et al. (2024) and Ho (2022) regarding teachers' apprehension about integrating the "Arts" element. Instead of offering short-term training courses, policymakers and school leaders should develop sustainable and in-depth professional development (PD) programs. These programs must focus on practice, providing opportunities for teachers to co-design projects (peer coaching), be mentored by experts, and receive feedback in a safe environment for experimentation and failure. Policy should prioritize the allocation of professional time for interdisciplinary collaboration, rather than solely focusing on equipment investment.

Second, concerning infrastructure and supporting tools, despite being well-equipped, our findings reveal a "usability gap" teachers perceive these resources as less flexible and more difficult

to access than administrators do. This not only affirms the importance of creative spaces like makerspaces (Belbase et al., 2022; Guenaga et al., 2017) but also points to a more nuanced issue: possessing technology is not synonymous with using it effectively. While many studies in the public school context highlight resource shortages (Dinh, 2021; Bui et al., 2023; Tran & Le, 2024; Nguyen et al., 2025; Pham et al., 2025; Pham & Tran, 2025), our research shows that in the private sector, the challenge shifts to operation and optimization. School investment policy needs to shift from "procurement" to "ecosystem building." This includes establishing clear operational procedures for labs, providing timely technical support, and, most importantly, involving teachers in the procurement decision-making process to ensure new tools meet pedagogical needs. PD programs need to integrate in-depth user training for available equipment within practical projects.

Third, regarding curriculum and teaching methods, the study shows a discrepancy between the curriculum designed with advanced methods (PBL, IBL) and the actual student experience. This finding confirms the importance of student-centered pedagogical approaches (Anderson, 2021; Colucci-Gray et al., 2019) but simultaneously highlights the challenge of implementing them consistently. Even in well-resourced environments, transforming a curriculum on paper into a profound learning experience for students remains a major hurdle, reflecting issues of pedagogical capacity rather than just a lack of resources. A school-level or system-wide policy is needed to build a repository of high-quality, customizable sample STEAM lesson plans and projects. PD programs must focus on practical skills: how to manage a complex project, how to pose inquiry-based questions, and how to assess creative products, rather than just stopping at the theory of PBL or IBL.

Fourth, on organizational policy and school culture, the results show that although policies encouraging innovation have been enacted, they have not truly permeated to the teacher level. This "policy-practice gap" resonates with the findings of Herro et al. (2019) and Bush et al. (2020) that a supportive culture, which accepts risk and has a transparent reward mechanism, is paramount. Our study has quantified the perceptual differences regarding the effectiveness of these policies, showing that policy communication and actualization are weak points. School leadership must not only enact policies but also focus on communicating and operationalizing them. There need to be clear and accessible procedures for teachers to apply for project funding and schedule collaborative time, along with a recognition and reward mechanism (both material and moral) that is known and trusted by the entire teaching staff.

Fifth, concerning the roles of learners and parents, the findings show that students lack confidence in their self-assessment skills, while parents, despite being supportive, do not yet have a deep understanding of STEAM to effectively partner in the process. This expands the discussion from equipping parents with digital literacy (Ryan et al., 2025) to the need to transform them into "pedagogical partners." The students' lack of confidence in self-assessment is also a wake-up call that STEAM education needs to place more emphasis on metacognitive skills. Schools need to implement a dual strategy: (1) integrate instruction on self-assessment and peer-assessment skills into STEAM projects for students, using clear rubrics; (2) organize hands-on workshops for parents instead of informational meetings, helping them understand the nature of project-based learning and how to support their children at home.

Finally, regarding implementation effectiveness and evaluation, the significant difference in assessment among the groups reveals a lack of a "common language" for success in STEAM. This affirms the urgent need for more standardized and multifaceted assessment tools, as proposed by Boice et al. (2024) and Çalışkan and Erol (2025). Our study shows that this deficiency creates differing perceptions of success, which can lead to dissatisfaction and a lack of coordination. A school-wide policy on a STEAM assessment framework is needed, one that is co-developed and understood by all stakeholders. This framework should include both process assessment (project logs, teamwork) and

product assessment (portfolios, presentations, exhibitions), with clear criteria for both artistic creativity and scientific-technical accuracy.

6. Conclusion

This study, “Factors Influencing STEAM Teaching at Private Schools in Vietnam: A Case Study of Ho Chi Minh City,” has confirmed the multifaceted and tightly interwoven relationships among five input domains-teachers’ competence and attitudes, infrastructure and resources, curriculum and pedagogy, organizational support and policy, and learner & parent engagement-and both the implementation intensity and effectiveness of STEAM. Although school leaders rated teacher readiness and institutional investments highly, teachers and students self-reported significant gaps in integrating the Arts, collaborating in teams, using digital tools, and conducting self-assessment. Parents, despite expressing support for STEAM, require additional knowledge and skills to guide their children effectively.

Specifically, while administrators praised teachers' professional expertise and growth mindset, teachers still lack confidence in designing interdisciplinary lessons and applying Project-Based and Inquiry-Based Learning. STEAM infrastructure-labs, robotics kits, 3D printers, and simulation software-is well funded, yet teachers desire more versatile, readily accessible equipment and more flexible operational procedures. Although STEAM objectives have been embedded into the core curriculum, they have not fully permeated student experiences, as evidenced by suboptimal project frequency, artifact quality, and student engagement. Institutional policies on protected planning time, recognition of innovation, and risk-tolerant experimentation are documented, but they lack transparent implementation protocols and dedicated forums for sharing best practices. Furthermore, parental understanding and material-or emotional support vary widely, underscoring the need for regular Open Labs and STEAM Days that actively involve families.

Overall, this research paints a comprehensive picture of STEAM deployment in Vietnam’s most dynamic private-school sector and identifies critical theory-practice gaps. The findings not only corroborate international and domestic studies but also provide field-based evidence to guide professional development programs, investment policies, and home-school engagement strategies. While this conclusion does not prescribe specific interventions, the study’s implications clearly outline priority areas: strengthening teacher capacity, sustaining and upgrading STEAM infrastructure, making curricula more adaptive, ensuring policy transparency, fostering parental partnerships, and standardizing assessment frameworks. These insights offer a solid foundation for private schools in Ho Chi Minh City-and beyond-to refine and scale their STEAM initiatives, ultimately advancing 21st-century competencies for Vietnamese students.

7. Recommendations and Future Research Directions

While this study provides valuable insights, its findings are limited by its focus on private schools within a single metropolitan area. To create a more comprehensive roadmap for STEAM education in Vietnam, future research should employ broader, probability-based sampling across diverse regions and include comparative analyses with public and semi-public institutions to understand how different policy and funding models affect implementation. Methodologically, future work would benefit from longitudinal studies that track development over time, as well as deeper qualitative methods like case studies and focus groups to uncover nuanced local practices and barriers. Finally, a specific focus on disaggregating data by gender is essential to explore potential dynamics and develop tailored interventions that foster inclusive participation for all students.

Declarations

Author Contributions. All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest. The authors declare that they have no competing interests.

Ethical Approval. The information in this research is based on respect for privacy and approval by the ethics committee.

Data Availability Statement. Data is available by the orresponding author upon request.

Acknowledgements. We thank the leadership, teachers, students, and parents of the ten private schools in Ho Chi Minh City, Vietnam for their participation and candid insights during surveys and interviews, which made this research possible.

References

- Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: A systematic literature review. *Education Sciences*, 11(7), 331. <https://doi.org/10.3390/educsci11070331>
- Areljung, S., & Günther-Hanssen, A. (2022). STEAM education: An opportunity to transcend gender and disciplinary norms in early childhood? *Contemporary Issues in Early Childhood*, 23(4), 500-503. <https://doi.org/10.1177/14639491211051434>
- Anderson, N. (2021). A systematic review of STEAM education research: Comparing American and Korean studies. *Academia Letters*, 2. <https://doi.org/10.20935/AL1039>
- Bass, K. M., Hu Dahl, I., & Panahandeh, S. (2016). Designing the game: How a project-based media production program approaches STEAM career readiness for underrepresented young adults. *Journal of Science Education and Technology*, 25(6), 1009-1024. <https://doi.org/10.1007/s10956-016-9631-7>
- Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2022). At the dawn of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education: Prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology*, 53(11), 2919-2955. <https://doi.org/10.1080/0020739X.2021.1922943>
- Boice, K. L., Alemdar, M., Jackson, J. R., Kessler, T. C., Choi, J., Grossman, S., & Usselman, M. (2024). Exploring teachers' understanding and implementation of STEAM: One size does not fit all. *Frontiers in Education*, 9, Article 1401191. <https://doi.org/10.3389/feduc.2024.1401191>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp0630a>
- Burnard, P., Colucci-Gray, L., & Sinha, P. (2021). Transdisciplinarity: Letting arts and science teach together. *Curriculum Perspectives*, 41(1), 113-118. <https://doi.org/10.1007/s41297-020-00128-y>
- Bush, S. B., Cook, K. L., Edelen, D., & Cox, R. (2020). Elementary students' STEAM perceptions: Extending frames of reference through transformative learning experiences. *The Elementary School Journal*, 120(4), 692-714. <https://doi.org/10.1086/708642>
- Bush, S. B., & Cook, K. L. (2019). Structuring STEAM inquiries: Lessons learned from practice. In M. S. Khine & S. Areepattamannil (Eds.), *STEAM education* (pp. 19-35). Springer. https://doi.org/10.1007/978-3-030-04003-1_2
- Bui, T., Tran, T., Nguyen, T., Nguyen-Thi, L., Tran, V., Dang, U. P., Nguyen, M., & Hoang, A. (2023). Dataset of Vietnamese preschool teachers' readiness towards implementing STEAM activities and projects. *Data in Brief*, 46, 108821. <https://doi.org/10.1016/j.dib.2022.108821>
- Bui, V. H., Phan, N. T. P., & Nguyen, Q. T. (2021). Developing a STEM teaching competency training program for lower secondary technology teachers. *Journal of Education*, 511, 31-34. <https://tcgd.tapchigiaoduc.edu.vn/index.php/tapchi/article/view/241>

- Bui, V. H., Phan, N. T. P., & Nguyen, Q. T. (2023). Current status of STEM teaching for upper secondary students in Ho Chi Minh City. *Journal of Education*, 23(3), 31-35. <https://tcgd.tapchigiaoduc.edu.vn/index.php/tapchi/article/view/640>
- Çalışkan, İ., & Erol, M. (2025). STEAM model based criteria development in national and global science education politics. *Journal of Baltic Science Education*, 24(1), 19–36. <https://doi.org/10.33225/jbse/25.24.19>
- Chen, C.J., Huang, Y.M., Chang, C.Y., & Liu, Y.C. (2018). Exploring the learning effectiveness of STEAM education of flying and assembly of drone. In *Proceedings of the 2018 Seventh International Conference of Educational Innovation through Technology* (pp. 63-67). IEEE.
- Chu, C. T. (2016). Lessons from the STEM festival and open mathematics day in Vietnam: Implications for teacher training. *Journal of Science, Hanoi National University of Education*, 61(10), 195-201.
- Colucci-Gray, L., Burnard, P., Gray, D., & Cooke, C. (2019). A critical review of STEAM (Science, Technology, Engineering, Arts, and Mathematics). In *Oxford Research Encyclopedia of Education* (pp. 1-26). Oxford University Press. <https://doi.org/10.1093/acrefore/9780190264093.013.398>
- Çiftçi, A., Topçu, S. M., & Foulk, A. J. (2022). Pre-service early childhood teachers' views on STEM education and their STEM teaching practices. *Research in Science & Technological Education*, 40(2), 207-233. <https://doi.org/10.1080/02635143.2020.1784125>
- Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Sage Publications.
- Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97-140. <https://doi.org/10.1080/10888691.2018.1537791>
- Dinh, L. T. (2021). Difficulties in implementing STEAM education model at the Northern mountainous preschool in Vietnam. *Journal of Physics: Conference Series*, 1835(1), Article 012020. <https://doi.org/10.1088/1742-6596/1835/1/012020>
- Duong, N. H., Nam, N. H., & Trung, T. T. (2024). Factors affecting the implementation of STEAM education among primary school teachers in various countries and Vietnamese educators: comparative analysis. *Education 3-13*, 1–15. <https://doi.org/10.1080/03004279.2024.2318239>
- Díaz-Noguera, M. D. (2019). Gender attitudes of pre-service teachers to innovation in STE(A)M. In *Proceedings of INTED2019* (pp. 9926-9930). IATED. <https://doi.org/10.21125/inted.2019.2484>
- English, L. D. (2017). Advancing elementary and middle school STEM education. *International Journal of Science and Mathematics Education*, 15(S1), 5-24. <https://doi.org/10.1007/s10763-017-9802-x>
- El-Sabaa, F. M. F., Alshimaa Abdelbasit, M., & Zakria, S. K. (2017). The qualitative and quantitative methods of Kovalevsky's case. *Journal of Applied Mathematics and Physics*, 5(9). <https://doi.org/10.4236/jamp.2017.59155>
- Espigares-Gámez, M. J., Fernández-Oliveras, A., & Contreras, M. L. O. (2020). Games as STEAM learning enhancers: Application of traditional Jamaican games in early childhood and primary intercultural education. *Acta Scientiae*, 22(4), 28-50. <https://doi.org/10.17648/acta.scientiae.6019>

- Fernández-Oliveras, A., Espigares-Gámez, M. J., & Oliveras, M. L. (2021). Implementation of a playful microproject based on traditional games for working on mathematical and scientific content. *Education Sciences*, 11(10), 624. <https://doi.org/10.3390/educsci11100624>
- Guenaga, M., Mentxaka, I., Garaizar, P., Eguiluz, A., Villagrasa, S., & Navarro, I. (2017). Make world, a collaborative platform to develop computational thinking and STEAM. In P. Zaphiris & A. Ioannou (Eds.), *Learning and Collaboration Technologies: Technology in Education—4th International Conference, LCT 2017 (Lecture Notes in Computer Science, Vol. 10296, pp. 50–59)*. Springer. https://doi.org/10.1007/978-3-319-58515-4_5
- Guyotte, K. W. (2020). Toward a philosophy of STEAM in the Anthropocene. *Educational Philosophy and Theory*, 52(7), 769–779. <https://doi.org/10.1080/00131857.2019.1690989>
- Halverson, E., & Sawyer, K. (2022). Learning in and through the arts. *Journal of the Learning Sciences*, 31(1), 1–13. <https://doi.org/10.1080/10508406.2022.2029127>
- Haynes, S. N., Richard, D. C. S., & Kubany, E. S. (1995). Content validity in psychological assessment: A functional approach to concepts and methods. *Psychological Assessment*, 7(3), 238–247. <https://doi.org/10.1037/1040-3590.7.3.238>
- Herro, D., & Quigley, C. (2017). Exploring teachers' perceptions of STEAM teaching through professional development: Implications for teacher educators. *Professional Development in Education*, 43(3), 416–438. <https://doi.org/10.1080/19415257.2016.1205507>
- Herro, D., Quigley, C., & Cian, H. (2019). The challenges of STEAM instruction: Lessons from the field. *Action in Teacher Education*, 41(2), 172–190. <https://doi.org/10.1080/01626620.2018.1551159>
- Ho, C. T. (2022). The application of STEAM teaching: A case study of STEAM teachers' beliefs and practice at secondary schools in Ho Chi Minh city. *VNUHCM Journal of Social Sciences and Humanities*, 6(SI), 42–51. <https://doi.org/10.32508/stdjssh.v6iSI.796>
- Ho, N. T. T., & Pham, A. T. V. (2022). Perceptions of Vietnamese lecturers and administrators on STEAM competence and developing students' competences in STEAM education. In *Proceedings of the 7th International Conference on Distance Education and Learning (ICDEL '22)* (pp. 233–237). Association for Computing Machinery. <https://doi.org/10.1145/3543321.3543360>
- Ho, T. T. H. (2019). Introduction to basic features of STEM education models in some countries. *Journal of Education (Special Issue 10)*, 325–328.
- Hoang, T. T. (2023). STEM, STEAM and STREAM education from the world and Vietnam perspectives. *Vietnam Journal of Educational Sciences*. <https://doi.org/10.15625/2615-8957/12310311>
- Johnston, K., Kervin, L., & Wyeth, P. (2022). STEM, STEAM and makerspaces in early childhood: A scoping review. *Sustainability*, 14(20), 13533. <https://doi.org/10.3390/su142013533>
- Jurado, E., Fonseca, D., Coderch, J., & Canaleta, X. (2020). Social STEAM learning at an early age with robotic platforms: A case study in four schools in Spain. *Sensors*, 20(13), 3698. <https://doi.org/10.3390/s20133698>
- Kang, N. H. (2019). A review of the effect of integrated STEM or STEAM education in South Korea. *Asia-Pacific Science Education*, 5(1), 1–22. <https://doi.org/10.1186/s41029-019-0034-y>
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(1), 1–11. <https://doi.org/10.1186/s40594-016-0046-z>

- Kim, B. H., & Kim, J. (2016). Development and Validation of Evaluation Indicators for Teaching Competency in STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(7), 1909-1924. <https://doi.org/10.12973/eurasia.2016.1537a>
- Kim, D., & Bolger, M. (2017). Analysis of Korean elementary pre-service teachers' changing attitudes about integrated STEAM pedagogy through developing lesson plans. *International Journal of Science and Mathematics Education*, 15(4), 587-605. <https://doi.org/10.1007/s10763-015-9709-3>
- Krüger Mariano, W., & Chiappe, A. (2021). Habilidades del siglo XXI y entornos de aprendizaje STEAM: una revisión. *Revista de Educación a Distancia (RED)*, 21(68). <https://doi.org/10.6018/red.470461>
- Lage-Gómez, C., & Ros, G. (2021). Transdisciplinary integration and its implementation in primary education through two STEAM projects. *Journal for the Study of Education & Development*, 44(4), 801-837. <https://doi.org/10.1080/02103702.2021.1925473>
- Lage-Gómez, C., & Ros, G. (2023). How transdisciplinary integration, creativity and student motivation interact in three STEAM projects for gifted education? *Gifted Education International*, 39(2), 247-262. <https://doi.org/10.1177/02614294231167744>
- Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*, 20, 547-552. <https://doi.org/10.1016/j.procs.2013.09.317>
- Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education. *Art Education*, 69(6), 44-49. <https://doi.org/10.1080/00043125.2016.1224873>
- Marín-Marín, J. A., Moreno-Guerrero, A. J., Dúo-Terrón, P., & López-Belmonte, J. (2021). STEAM in education: A bibliometric analysis of performance and co-words in Web of Science. *International Journal of STEM Education*, 8, 41. <https://doi.org/10.1186/s40594-021-00296-x>
- Menacho, A., Plaza, P., Sancristóbal, E., Perez-Molina, C., Blazquez, M., & Castro, M. (2021). Halloween educational robotics. *IEEE Transactions on Education*, 64(4), 406-412. <https://doi.org/10.1109/TE.2021.3066891>
- Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, 4(1), 1-9. <https://doi.org/10.1186/2046-4053-4-1>
- Ministry of Education and Training. (2018). *National general education curriculum framework* (Circular No. 32/2018/TT-BGDĐT).
- Ministry of Education and Training. (2019). *Official dispatch on implementing STEM education in upper secondary schools* (Dispatch No. 3089/BGDĐT-GDTrH, August 14, 2020).
- Ng, A., Kewalramani, S., & Kidman, G. (2022). Integrating and navigating STEAM (InSTEAM) in early childhood education: An integrative review and InSTEAM conceptual framework. *EURASIA Journal of Mathematics, Science and Technology Education*, 18(7), e2133. <https://doi.org/10.29333/ejmste/12174>
- Nguyen, M. T., Ha, T. A., Mai, H. A., Vu, K. T. T., & Nguyen, M. Q. (2025). Factors affecting preschool teachers' implementation of STEAM activities: A quantitative study in Vietnam. *Social Sciences & Humanities Open*, 11, 101227. <https://doi.org/10.1016/j.ssaho.2024.101227>
- Ortega-Torres, E. (2022). Training of future STEAM teachers: Comparison between primary degree students and secondary master's degree students. *Journal of Technology and Science Education*, 12(2), 484-495. <https://doi.org/10.3926/jotse.1319>

- Ortiz-Revilla, J., Greca, I. M., & Meneses-Villagr , J.  . (2021). Effects of an integrated STEAM approach on the development of competence in primary education students (“Efectos de una propuesta STEAM integrada en el desarrollo competencial del alumnado de Educaci n Primaria”). *Infancia y Aprendizaje*, 44(4), 838–870. <https://doi.org/10.1080/02103702.2021.1925473>
- Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, 31, 31-43. <https://doi.org/10.1016/j.tsc.2018.10.002>
- Pham, V. X., Mai, M. Q., Phan, P. T. K., Tran, T. T. T., Dang, D. T. T., & Nguyen, N. V. S. (2025). STEAM and the innovation of art teacher education in Vietnamese pedagogical universities in the digital era. *International Journal of Computational and Experimental Science and Engineering*, 11(3), 4154–4159. <https://doi.org/10.22399/ijcesen.2712>
- Pham, T. T. H., & Tran, T. H. (2025). Literature review of STEM/STEAM teaching in Vietnam. *VNU Journal of Science: Education Research*. <https://doi.org/10.25073/2588-1159/vnuer.5250>
- Potvin, J., Chappell, K., Balestracci, K., Greene, G. W., Sweetman, S., & Amin, S. (2023). Formative evaluation of a STEAM and nutrition education summer program for low-income youth. *Evaluation and Program Planning*, 97, 102255. <https://doi.org/10.1016/j.evalprogplan.2023.102255>
- Quigley, C. F., Herro, D., King, E., & Plank, H. (2020). STEAM designed and enacted: Understanding the process of design and implementation of STEAM curriculum in an elementary school. *Journal of Science Education and Technology*, 29(4), 499-518. <https://doi.org/10.1007/s10956-020-09832-w>
- Ramey, K. E., & Stevens, R. (2023). Dilemmas experienced by teachers in adapting to the role of facilitator in the STEAM classroom. *Teaching and Teacher Education*, 133, 104271. <https://doi.org/10.1016/j.tate.2023.104271>
- Ryan, S., Walsh, E., & Liston, M. (2025). “The Parents Were Brilliant!” Engaging parents in STEM learning: Insights from preservice teachers’ field experience. *Social Sciences*, 14(4), 215. <https://doi.org/10.3390/socsci14040215>
- Santi, K., Sholeh, S. M., Rahmayanti, F., Alatas, H., Ichsan, I. Z., & Rahman, M. M. (2021). STEAM in environment and science education: Analysis and bibliometric mapping of the research literature (2013-2020). *Journal of Physics: Conference Series*, 1796(1), 012097. <https://doi.org/10.1088/1742-6596/1796/1/012097>
- Shively, K., Hitchens, C., & Hitchens, N. (2021). Teaching severe weather: Examining teacher candidates’ early field experience in a makerspace environment. *Journal of Education*, 201(3), 198-209. <https://doi.org/10.1177/0022057420908061>
- Spyropoulou, N., & Kameas, A. (2024). Augmenting the impact of STEAM education by developing a competence framework for STEAM educators for effective teaching and learning. *Education Sciences*, 14(1), 25. <https://doi.org/10.3390/educsci14010025>
- Su, J., & Yang, W. (2024). STEM in early childhood education: A bibliometric analysis. *Research in Science & Technological Education*, 42(4), 1020-1041. <https://doi.org/10.1080/02635143.2023.2201673>
- Su, J., Yim, I. H. Y., Wegerif, R., & Chu, K. W. S. (2024). STEAM in early childhood education: A scoping review. *Research in Science & Technological Education*. Advance online publication. <https://doi.org/10.1080/02635143.2023.2296445>

- Tashakkori, M. A., & Teddlie, B. C. (2008). *Mixed Methodology: Combining Qualitative and Quantitative Approaches*. Sage Publications.
- Tran, V. N., & Le, N. T. U. (2024). Factors affecting kindergarten teachers' self-efficacy in organizing scientific discovery activities using inquiry-based methods. *Journal of Educational Sciences*, 69(4A), 25–36. <https://doi.org/10.18173/2354-1075.2024-0077>
- Uştu, H., Saito, T., & Mentiş Taş, A. (2022). Integration of art into STEM education at primary schools: An action research study with primary school teachers. *Systemic Practice and Action Research*, 35(2), 253-274. <https://doi.org/10.1007/s11213-021-09570-z>
- Vicente, F. R., Zapatera Llinares, Á., & Montes Sanchez, N. (2021). Curriculum analysis and design, implementation, and validation of a STEAM project through educational robotics in primary education. *Computer Applications in Engineering Education*, 29(1), 160-174. <https://doi.org/10.1002/cae.22373>
- Wahyuningsih, S., Nurjanah, N. E., Rasmani, U. E. E., Hafidah, R., Pudyaningtyas, A. R., & Syamsuddin, M. M. (2020). STEAM learning in early childhood education: A literature review. *International Journal of Pedagogy and Teacher Education*, 4(1), 33-44. <https://doi.org/10.20961/ijpte.v4i1.39855>
- White, D., & Delaney, S. (2021). Full STEAM ahead, but who has the map? A PRISMA systematic review on the incorporation of interdisciplinary learning into schools. *LUMAT: International Journal on Math, Science and Technology Education*, 9(2), 9-32. <https://doi.org/10.31129/LUMAT.9.2.1387>
- Yakman, G., & Lee, H. J. (2012). Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. *Journal of the Korean Association for Science Education*, 32(6), 1072-1086. <https://doi.org/10.14697/jkase.2012.32.6.1072>
- Yim, I. H. Y. (2024a). A critical review of teaching and learning artificial intelligence (AI) literacy: Developing an intelligence-based AI literacy framework for primary school education. *Computers and Education: Artificial Intelligence*, 7, 100319. <https://doi.org/10.1016/j.caeai.2024.100319>
- Yim, I. H. Y. (2024b). Artificial intelligence literacy in primary education: An arts-based approach to overcoming age and gender barriers. *Computers and Education: Artificial Intelligence*, 7, 100321. <https://doi.org/10.1016/j.caeai.2024.100321>
- Yim, I. H. Y., & Su, J. (2024). Artificial intelligence (AI) learning tools in K-12 education: A scoping review. *Journal of Computers in Education*. Advance online publication. <https://doi.org/10.1007/s40692-023-00304-9>

About the Contributor(s)

Tan Dat Truong is a Lecturer at Dong Thap University, Vietnam. His research interests include resource development management, human resource management in educational institutions, education quality assurance, teacher professional development, state management in education, and innovative teaching methods.

Email: truongtandat@dthu.edu.vn

ORCID: <https://orcid.org/0009-0002-9719-9484>

Quoc Giang Tran is a PhD candidate at Dong Thap University, Vietnam. His research focuses on education reform in Vietnam within the context of globalization, school leadership and management,

staff development, and the application of digital technologies in teaching and administration, with particular emphasis on effective school consultancy models.

Email: giang.tq894@dthu.edu.vn

ORCID: <https://orcid.org/0009-0007-9489-9107>

Publisher's Note: *The opinions, statements, and data presented in all publications are solely those of the individual author(s) and contributors and do not reflect the views of Universitepark, EDUPIJ, and/or the editor(s). Universitepark, the Journal, and/or the editor(s) accept no responsibility for any harm or damage to persons or property arising from the use of ideas, methods, instructions, or products mentioned in the content.*
