

Integrating STEAM into Elementary Classrooms: A Case Study of Elementary Teachers

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ABSTRACT

This study examines how elementary teachers new to Science, Technology, Engineering, Arts, and Mathematics (STEAM) perceive its relevance, implement it, and experience related challenges in classroom practice. Addressing the increasing demand for interdisciplinary, student-centered learning, the study employed a qualitative design using open-ended questionnaires administered to 12 purposively selected teachers in a private elementary school in North Jakarta. Data were analyzed through inductive thematic analysis to explore teachers' perceptions, strategies, challenges, and professional learning needs. Findings indicate that teachers view STEAM as a holistic, future-oriented pedagogical approach aligned with child development and twenty-first-century competencies. However, implementation remains at an early stage, characterized by cautious, planning-focused experimentation. Teachers reported enhanced student engagement, improved collaboration, and the emergence of inquiry-based practices during integrated activities, despite challenges such as limited instructional confidence, lack of formal training, time constraints, and classroom management demands. The study provides empirical insight into how novice educators navigate STEAM integration without structured preparation and underscores the importance of sustained, practice-based professional learning. It concludes that effective and sustainable STEAM implementation requires alignment among classroom practice, professional development, and educational policy, supported by ongoing mentoring and collaborative learning structures to strengthen teachers' confidence and professional identity.

Keywords

Elementary Teachers
Professional Learning
Qualitative Study
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Teacher Perceptions

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**Introduction**

In the evolving landscape of 21st-century education, there is increasing consensus that traditional methods centered on memorization are inadequate for preparing learners to thrive in a complex, interconnected world. Teachers are called to advocate for instructional approaches that foster creativity, collaboration, critical thinking, and real-world problem-solving from the earliest stages of schooling [1]. One such pedagogical framework that has gained prominence is STEAM (Science, Technology, Engineering, Arts, and Mathematics), which integrates multiple domains to support student engagement and higher-order thinking [2],[3]. STEAM aligns with contemporary reforms that emphasize active, student-centered learning, moving beyond isolated subject instruction toward interdisciplinary and contextualized experiences. Research has shown that STEAM initiatives can nurture students' critical thinking, creativity, and collaboration skills, while integrating arts and design to make learning more meaningful and connected to lived contexts [4],[5]. Moreover, STEAM learning has been associated with improvements in student numeracy and literacy when implemented through digital and project-based activities [6].

Despite these documented benefits and increasing research interest, the successful implementation of STEAM in classroom practice remains uneven [7]. International syntheses highlight persistent barriers in teacher preparation, including limited interdisciplinary training, resource constraints, and inconsistencies in curricular support [8]. While many studies focus on student outcomes or curriculum design, there is a notable gap in understanding teachers' lived experiences when encountering STEAM without formal preparation [9]. Specifically, research has yet to comprehensively explore how elementary teachers who are new to STEAM perceive its relevance, what strategies they attempt in practice, how they navigate challenges, and what forms of support they deem most effective [10],[11]. This gap is particularly critical in under-resourced learning environments where access to professional development opportunities may be limited, and teachers rely on intuition or trial-and-error to adapt to STEAM pedagogies.

Addressing this gap, the present study examines the experiences of elementary and early childhood teachers who have no prior formal STEAM training but are open to integrating

this approach into their classrooms. By investigating their perceptions of STEAM's relevance and applicability, the strategies they use, the challenges and opportunities they encounter, and the professional learning supports they consider valuable, this research aims to generate practical insights to inform professional development, curriculum support, and policy decisions. The study contributes to the field by foregrounding teacher voices at an early stage of STEAM adoption and providing empirically grounded recommendations for scalable, context-sensitive STEAM integration in elementary education. Limitations include the self-reported nature of the data and its focus on perceptions rather than measured instructional outcomes; nonetheless, the findings offer valuable direction for strengthening teacher readiness and confidence in STEAM practice [12].

A. Research Questions

1. How do elementary teachers who are new to STEAM perceive its relevance and applicability in their classrooms?
2. What strategies do these teachers use (or attempt) to integrate STEAM into their daily teaching practices?
3. What challenges and opportunities do they encounter while implementing STEAM without formal prior training?
4. What forms of support or professional learning do they consider effective for improving their STEAM-based instruction?

Literature Review

Elementary education in the 21st century increasingly calls for instructional approaches that move beyond rote memorization toward learning experiences that are active, engaging, and centered on the learner. Such approaches emphasize the development of critical thinking, collaboration, creativity, and problem-solving skills from an early age [13]–[15]. Within this context, the STEAM framework has been widely recognized as a pedagogical means to support these aims. STEAM integrates Science, Technology, Engineering, Arts, and Mathematics to foster students' creative and critical problem-solving across disciplines [16]. This conceptualization aligns closely with the purpose of the present study, which seeks to understand how elementary teachers who are new to STEAM perceive its relevance, the strategies they attempt to employ, and the types of support they require for effective implementation.

Teachers' perceptions play a central role in determining the success of STEAM implementation in classroom settings. Dignam, Pennington, and Daifallah [17] emphasize that the strength of STEAM lies in its interdisciplinary and transformative nature. They argue that when learning environments intentionally connect interdisciplinary and transdisciplinary perspectives, they create innovative opportunities for both teaching and learning [2]. This

perspective underscores the importance of helping teachers recognize STEAM not as an additional subject, but as an integrative framework that bridges science, the arts, and humanities in meaningful ways.

Moreover, Dignam et al. [18] highlight that STEAM learning encourages the formation of collaborative, community-based environments akin to modern “Communities of Practice.” Such environments promote creativity, reflection, and empathy, qualities essential to contemporary education. For teachers who are new to STEAM, understanding its relevance involves recognizing how it reshapes traditional teaching roles, shifting teachers from transmitters of knowledge to facilitators who guide inquiry and exploration.

Recent research also offers practical insights into how STEAM can be implemented without reliance on costly or advanced resources. Jantakoon, Jantakun, and Jantakun [19] for example, propose a STEAM Learning Ecosystem that incorporates gamification to enhance learner engagement. Their model integrates a STEAM learning environment, a gamification process, and the development of innovation skills, demonstrating how playful, goal-oriented activities can stimulate imagination, experimentation, and reflective thinking, particularly among elementary learners. Gamification has been shown to increase motivation and engagement in STEAM-oriented learning contexts, suggesting that teachers can adopt accessible strategies such as classroom challenges, collaborative projects, and hands-on design tasks to support creativity and student agency [19]. These findings are directly relevant to the present study’s focus on the strategies that novice STEAM teachers attempt in practice [20].

Despite its potential, the implementation of STEAM presents notable challenges, especially for teachers with limited or no formal training. Ortega-Torres [21] reports significant gaps between teachers’ prior knowledge and their perceptions of STEAM, revealing generally low levels of initial confidence in integrating multiple disciplines. This lack of preparedness is further compounded by the absence of clear STEAM references in national curricula, requiring teachers to take individual initiative rather than rely on standardized guidelines. Such conditions place additional pressure on elementary teachers who are still developing their professional identities.

At the same time, literature points to meaningful opportunities for supporting teachers during the early stages of STEAM adoption [22]. Dignam et al. [17] suggest that digital Communities of Practice can serve as collaborative spaces where teachers share resources, reflect on practice, and support one another. These communities leverage technology to foster collaboration, reflection, and social-emotional learning, offering valuable support for teachers who are beginning to integrate STEAM into their classrooms [9].

The effectiveness of STEAM education ultimately depends on the extent to which teachers are prepared and supported in their professional growth. Well-designed STEAM programs enable learners to develop confidence and identity across multiple disciplines through integrated, inquiry-based, and play-oriented experiences grounded in real-world contexts [23],[24]. For such outcomes to be realized, teachers must experience the value of interdisciplinary learning. In parallel, Ortega-Torres [21], drawing on Bandura's concept of self-efficacy, emphasizes that teachers' beliefs in their own capabilities strongly influence their willingness to adopt innovative pedagogical approaches. Professional learning communities, mentoring, and reflective practice are therefore essential in strengthening teacher self-efficacy and sustaining meaningful STEAM implementation [12], [21].

Against this backdrop, the present study explores how elementary teachers who are new to STEAM understand its relevance, navigate early implementation strategies, and respond to the challenges they encounter. By examining their experiences alongside the forms of professional support they perceive as most effective, this research aims to contribute practical and contextually grounded insights that can inform teacher development and support the long-term integration of STEAM as a meaningful and sustainable approach in elementary education [10], [25].

Table 1. Literature Review Synthesis: Key Themes in STEAM Education

Research Question	Literature Theme	Key Concepts (with Supporting Authors)	Analysis
RQ1. How do elementary teachers new to STEAM perceive its relevance and applicability?	Why STEAM	STEAM promotes interdisciplinary learning and creativity (Wijayanti et al.); integration across disciplines enhances critical and transdisciplinary thinking (Dignam et al.); STEAM fosters creativity, collaboration, and higher-order thinking (Spyropoulou et al.); early learners benefit from collaborative and skill-based learning (Erol & Erol)	Guides exploration of teachers' beliefs, perceived value, and understanding of STEAM
RQ2. What strategies do teachers use to integrate STEAM into practice?	Teacher perception and readiness	Teachers often show positive attitudes but limited prior knowledge (Ortega-Torres); confidence develops through exposure and structured learning experiences (Berman)	Supports analysis of initial teacher perceptions and readiness levels
	How STEAM	Inquiry-based STEAM and integrated curriculum design (Lupi3n-Cobos et al.); STEAM learning ecosystems emphasizing investigation, creation, and reflection (Jantakoon et al.); project-based and technology-supported STEAM enhances reasoning and engagement (Siregar et al.)	Inform analysis of instructional strategies, classroom practices, and unit planning approaches
	STEAM Learning Design	Learning environments and structured classroom approaches influence implementation (Berman); interdisciplinary project design promotes authentic learning (Dignam et al.)	Supports coding of classroom strategies and teaching adaptations
RQ3. What challenges and opportunities do	Implementation Challenges	Teachers struggle with interdisciplinarity, assessment, and technology integration (Kulevi3ien3 et al.); implementation requires curriculum guidance and	Provides an analytical lens for identifying barriers and enabling factors.

Research Question	Literature Theme	Key Concepts (with Supporting Authors)	Analysis
teachers encounter?		institutional support (Spyropoulou et al.); teacher competence and infrastructure affect implementation success (Truong & Tran)	
	Contextual Influences	Organizational culture, leadership, and resources shape STEAM adoption (Truong & Tran)	Supports contextual interpretation of findings within the school environment
RQ4. What professional support do teachers consider effective?	Professional Development and Teacher Learning	Structured STEAM training improves teacher readiness (Ortega-Torres); professional development strengthens implementation capacity but requires systemic support (Spyropoulou et al.); inquiry-based PD enhances teacher design skills (Lupi3n-Cobos et al.)	Guides analysis of effective professional learning supports and recommendations
	Teacher Growth and Capacity Building	Collaborative reflection, practice-based learning, and ongoing support enhance implementation confidence (Berman; Erol & Erol)	Links findings to implications for future PD design

Material and Methods

A. Research Design

This study employed a qualitative descriptive design [26]–[28] to investigate elementary teachers' perceptions, implementation strategies, and support needs related to STEAM learning. The research was conducted in a private school located in North Jakarta, Indonesia, serving early childhood and elementary students. The school operates within a structured academic environment emphasizing holistic student development. This contextual information supports the interpretation of implementation processes and transferability to similar private school settings. The participants included are 12 early childhood and elementary classroom teachers who are actively involved in instructional planning and implementation, with varied levels of teaching experience. Inclusion criteria emphasized active classroom engagement and willingness to participate in STEAM-focused professional development and unit planning.

B. Participant's Experience

The data shows the distribution of teaching experience among participants. The majority of teachers (67%) have between 2 and 5 years of experience, indicating that most respondents are in the early to mid stages of their teaching careers. A smaller proportion (25%) have less than 2 years of experience, suggesting the presence of relatively new entrants to the profession. Meanwhile, only 8% of teachers have 6–8 years of experience, representing a limited number of more experienced practitioners.

C. The Professional Development Session

The professional development session was conducted over one full day (07:30–15:00) and functioned as the primary intervention before in-depth data collection. The training consisted

of structured presentations, collaborative discussions, and hands-on workshops. The session began by introducing the rationale for STEAM in early and elementary education, addressing its relevance, interdisciplinary nature, and alignment with contemporary learning goals. Subsequent sessions focused on practical classroom implementation, including inquiry-based strategies, interdisciplinary lesson integration, student-centered activities, and assessment approaches for STEAM learning. Participants engaged in guided workshops to design STEAM-integrated unit plans and examine examples of STEAM in action. The professional development exposure directly informed subsequent interviews and reflections, which explored teachers' perceptions, intended implementation strategies, and perceived challenges following the training.

D. Data Collection

Data was collected through a pre-session survey, semi-structured interviews, and written reflections to capture participants' experiences and perceptions from multiple perspectives. The survey, consisting of seven core items, examined key domains including prior STEAM knowledge, attitudes toward STEAM, self-efficacy in implementation, instructional readiness and practices, and perceived challenges and support needs. Semi-structured interviews followed a predefined protocol with open-ended questions aligned with the research objectives, enabling in-depth exploration of teachers' understanding of STEAM, the rationale for adoption, classroom implementation strategies, perceived benefits and challenges, and experiences in developing STEAM-integrated unit plans. Interviews were conducted individually, lasted approximately 10–15 minutes each, and took place over 10 days using Microsoft Forms and facilitated group discussions. All interviews were conducted with participant consent, recorded, manually transcribed, and reviewed for accuracy. The use of multiple data sources supported methodological triangulation to enhance the credibility of the findings, while the structured school context and its focus on early-grade education provide a relevant background for interpreting implementation and assessing transferability to similar educational settings.

The professional development session was conducted over one full day and consisted of structured presentations, collaborative discussions, and hands-on activities designed to deepen teachers' understanding of STEAM integration. The program began by exploring the rationale for STEAM in early and elementary education, addressing key questions related to its relevance, educational value, and alignment with contemporary learning goals. This was followed by a practical exploration of how STEAM can be implemented within classroom contexts, including strategies for interdisciplinary learning, inquiry-based activities, and student-centered approaches. Participants engaged in guided workshops to design STEAM learning experiences, examine examples of STEAM in action, and discuss appropriate

assessment practices to support integrated learning outcomes. The session concluded with collaborative development of unit plans that intentionally incorporated STEAM principles, allowing teachers to translate conceptual understanding into practical instructional design.

E. Data Analysis

Data analysis employed an inductive thematic analysis conducted by researchers. Interview and survey data were transcribed verbatim and systematically reviewed to identify meaningful patterns and recurring ideas [29]. Initial codes were generated directly from the data and subsequently refined through iterative comparison and reflection. These codes were then organized into higher-order categories, and themes aligned with the research questions. This researcher-led analytic process allowed for careful interpretation of participants' experiences while maintaining analytical rigor and transparency [28]–[30].

F. Ethical Considerations

Formal permission to conduct the study was obtained from the school principal and the overseeing foundation before data collection. As the study involved minimal risk and focused on professional development activities within the school context, institutional ethical review was not required. All participants provided informed consent before participation. To protect confidentiality, participants were anonymized using pseudonyms, and identifiable role-specific information was removed from transcripts and reports. All data were securely stored and accessed solely for research purposes. The use of multiple data sources supported methodological triangulation to enhance the credibility of the findings, while the structured school context and its focus on early-grade education provide a relevant background for interpreting implementation and assessing transferability to similar educational settings.

Results and Discussions

To provide a clearer and more nuanced understanding of the findings, a preliminary survey was administered to capture teachers' prior knowledge, experiences, and exposure to STEAM [31]. This contextual data serves as an important foundation for interpreting the results, while also illuminating how the study was shaped to generate insights and inform strategies aimed at strengthening teachers' understanding and implementation of STEAM.

The findings show that most participants were early-career teachers, many of whom were still in the process of entering or preparing for early childhood education (ECE) and lower elementary contexts. This formative career stage strongly shaped how STEAM was perceived. Rather than being experienced as an external mandate, STEAM was received as a foundational way of thinking about teaching that could influence their emerging professional identity. Teachers demonstrated high openness and a strong desire to learn, reflecting pedagogical beliefs that were still developing and adaptable. At the same time, limited classroom

experience heightened feelings of uncertainty, particularly around instructional choices and classroom management, making STEAM both an opportunity for growth and a source of professional vulnerability [8], [25].

Table 2. Qualitative Analysis of Expectations toward STEAM

Analytical Dimension	Informants' experience of STEAM	Categories	Themes	Research Interpretation
Teaching Experience Profile	<2 years; 2–5 years; 6–8 years; Transition to Early Childhood Education (ECE)	Career stage: Professional identity formation	Early-Stage Professional Identity with High Learning Orientation	Most participants are early-career teachers (≤ 5 years), indicating a formative phase where pedagogical beliefs are still malleable. This positions STEAM not as a reform to resist, but as a framework to shape emerging teaching identity—particularly relevant for long-term instructional transformation.
Prior Exposure to STEAM	Never trained; No prior STEAM; No formal exposure	Absence of formal preparation	STEAM as a Novel Pedagogical Encounter	The complete absence of prior STEAM training establishes a clean baseline: perceptions are not shaped by institutional mandates but by first encounters. This strengthens internal validity by linking teachers' views directly to the training experience rather than prior bias or expertise.
Related Professional Learning (Non-STEAM)	Classroom management; Curriculum; Montessori; Science activities; Inclusion; Numeracy & literacy; ECE coursework	Adjacent pedagogical knowledge	Partial Pedagogical Capital without Integration Framework	Teachers possess fragmented but relevant pedagogical knowledge. However, this knowledge exists in silos. STEAM is perceived as a unifying framework capable of integrating prior learning (e.g., Montessori, science play, inclusion) into coherent classroom practice.
Expectations of STEAM Training	Want applicable material; Learn deeply; Understand clearly; Apply in class; Prepare for ECE teaching; Sharpen creativity.	Learning goals: Practical orientation	Expectation of Practical Transfer, Not Theory Accumulation	Teachers' expectations consistently emphasize applicability, clarity, and classroom transfer. This reflects a practitioner's epistemology: knowledge is valued insofar as it can be enacted. Abstract or theoretical delivery is implicitly viewed as insufficient.
Anticipated Pedagogical Outcomes	Creative teaching; Classroom implementation; Grade 1–2 adaptation; ECE readiness; Teaching confidence	Desired outcomes	STEAM as a Confidence-Building Pedagogy	Beyond student outcomes, STEAM is expected to strengthen teachers' own confidence, especially for those anticipating placement in ECE. STEAM is thus framed as both an instructional approach and a professional assurance mechanism.

All participants indicated that they had not previously received formal STEAM training, although many had been exposed to related areas such as Montessori approaches, literacy and numeracy, classroom management, or inclusive education. STEAM was therefore perceived as new yet meaningful, offering a unifying framework that connected previously fragmented pedagogical knowledge. Teachers viewed STEAM as highly relevant because of its holistic, child-centered, and future-oriented emphasis, particularly for ECE and early elementary

learners [5], [1]. However, while its principles were seen as developmentally appropriate and aligned with children's natural curiosity, teachers also expressed concern about practical demands, including time for preparation, managing open-ended learning in diverse classrooms, and shifting from teacher-led to facilitative roles. As a result, implementation remained exploratory and planning-focused rather than fully enacted [13]. Importantly, these challenges reflected professional responsibility rather than resistance. Teachers expressed a clear preference for sustained, practice-embedded, and relational professional learning, such as mentoring, concrete examples, and collaborative planning, indicating that STEAM was understood not only as an instructional approach, but also as a confidence-forming process that supports long-term professional growth [32].

Table 3. Thematic Analysis of Elementary Teachers' STEAM Reflection

Research Question	Key Codes	Categories	Core Themes	Analytical Interpretation
RQ1. Perceptions of relevance and applicability of STEAM	Understanding STEAM; Hope to apply; Contextual learning; Interdisciplinary; Student-centered; Holistic development; 4Cs; Early childhood suitability	Perceived pedagogical value; Developmental appropriateness; Instructional relevance	STEAM as a Holistic and Future-Oriented Pedagogical Framework	Novice teachers perceive STEAM as highly relevant, especially for developing holistic competencies (cognitive, creative, and social). Relevance is framed less as content mastery and more as alignment with 21st-century skills and child development. However, applicability is conditional—teachers believe STEAM is valuable in principle, but it is still emerging in practical clarity.
RQ2. Strategies used or attempted to integrate STEAM	Trying to design STEAM lessons; Using simple examples; Contextual activities; Lesson planning (RPP); Interdisciplinary ideas; Student exploration	Emerging instructional strategies; Planning-oriented practices	Exploratory and Planning-Focused Implementation	Teachers primarily engage STEAM at the level of lesson design intention rather than sustained enactment. Strategies remain cautious and preparatory: adapting existing lesson plans, trialing small-scale activities, and using contextual examples. This reflects an early adoption phase characterized by experimentation rather than confident routine practice.
RQ3. Challenges and opportunities without formal training	Lack of confidence; Time-consuming planning; Newness of approach; Classroom management; Diversity and inclusion; Financial constraints; Facilitator role shift	Professional readiness gaps; Structural and contextual constraints; Identity transition	Tension Between Vision and Capacity	Teachers experience a clear gap between their positive beliefs about STEAM and their readiness to implement it. Challenges cluster around three tensions: (1) pedagogical identity shift from instructor to facilitator, (2) managing diverse and inclusive classrooms within open-ended learning, and (3) systemic constraints such as time, workload, and resources. Nonetheless, the perceived "newness" also creates openness to growth, signalling

Research Question	Key Codes	Categories	Core Themes	Analytical Interpretation
RQ4. Desired support and professional learning	Need more resources; Learn from journals / videos; Mentoring; Collaboration; Model lesson plans; Clear procedures; Ongoing study	Preferred professional learning modes; Support structures	Practice-Oriented and Relational Professional Learning	opportunity for professional formation. Teachers favor professional learning that is concrete, sustained, and relational. Rather than one-off workshops, they value exemplars, mentoring, collaborative planning, and access to practical resources. This indicates a preference for formation-based professional learning—learning that shapes both competence and confidence over time.

The findings address the four research questions by revealing a coherent pattern in how elementary teachers who are new to STEAM perceive, attempt, and struggle to implement the approach. In response to RQ1, teachers consistently viewed STEAM as a meaningful and relevant pedagogical framework, particularly for early childhood and lower primary contexts [33]. STEAM was understood as holistic, interdisciplinary, and student-centered, with strong alignment to the development of the 4Cs and broader life skills. Rather than emphasizing content mastery, teachers framed relevance in terms of supporting children's overall growth and preparation for future learning. However, while STEAM was valued conceptually, its applicability was often described as conditional, indicating that practical clarity was still developing.

Regarding RQ2, teachers' integration strategies reflected an early and exploratory stage of adoption. Most efforts were concentrated on planning rather than full implementation, such as designing lesson plans, adapting simple examples from training, and experimenting with small-scale, contextual activities. These strategies suggest that teachers are engaging with STEAM cautiously, using it as an emerging instructional idea rather than a routine classroom practice [32]. This planning-oriented approach highlights intentionality but also signals limited confidence in sustained enactment.

In relation to RQ3, a clear tension emerged between teachers' positive vision of STEAM and their perceived capacity to implement it without formal training. Challenges centered on time-intensive lesson preparation, managing diverse and inclusive classrooms, shifting professional identity from instructor to facilitator, and navigating systemic constraints such as workload and limited resources [8], [34]. Importantly, these challenges were not expressed as resistance. Instead, they reflected professional responsibility and careful consideration of classroom realities. At the same time, the novelty of STEAM created openness to learning, positioning these challenges as opportunities for professional growth rather than barriers.

Finally, RQ4 revealed strong preferences for practice-oriented and relational professional learning. Teachers expressed a desire for concrete support such as model lesson

plans, clear procedures, mentoring, collaborative planning, and access to journals or instructional videos. One-off or purely theoretical training was viewed as insufficient. Instead, teachers favored sustained learning experiences that mirror STEAM principles themselves, collaborative, inquiry-based, and grounded in practice. Effectively, these findings suggest that effective STEAM integration requires not only instructional resources but also long-term professional formation that builds both competence and confidence [35].

To enhance transparency and demonstrate how the themes were grounded in participants' responses, representative anonymized quotations are presented in Table 4. The table illustrates how key codes and categories informed the development of core themes aligned with the research questions. In addition to providing direct participant voice, qualitative indicators of prevalence (e.g., most, several, a few) are included to clarify the relative consistency of patterns across informants. This evidentiary presentation ensures that the analytic interpretations are directly supported by the data rather than solely by the researcher's synthesis.

Table 4. Representative Evidence Supporting Thematic Findings

Research Question	Core Theme	Representative Participant Quote (Anonymized)	Pattern Prevalence	How Does Evidence Support Interpretation
RQ1. Perceptions of relevance and applicability of STEAM	STEAM as a Holistic and Future-Oriented Pedagogical Framework	"STEAM helps students think creatively and connect subjects, not just learn separately." (T3, 2 years' experience)	Most participants	Quotes emphasize interdisciplinarity and creativity, supporting the interpretation that STEAM is viewed as holistic rather than content-based.
		"I see STEAM as important for developing 4Cs, especially critical thinking and collaboration." (T7, 4 years' experience)	Several participants	Explicit reference to 21st-century skills supports the analytical claim that relevance is framed developmentally.
RQ2. Strategies used or attempted to integrate STEAM	Exploratory and Planning-Focused Implementation	"I tried to design a simple activity connecting science and art in my lesson plan." (T2, 3 years' experience)	Several participants	Indicates experimentation at the planning level rather than full implementation
		"We are still adapting our RPP to include STEAM ideas." (T9, 6 years' experience)	A few participants	Shows early-stage integration characterized by cautious adaptation.
RQ3. Challenges and opportunities without formal training	Tension Between Vision and Capacity	"I understand the concept, but I am not confident implementing it in class." (T5, <2 years' experience)	Most participants	Directly evidences the confidence gap identified in thematic analysis.
		"Planning STEAM activities takes more time, especially with limited resources." (T8, 5 years' experience)	Several participants	Supports interpretation of structural and time constraints.

Research Question	Core Theme	Representative Participant Quote (Anonymized)	Pattern Prevalence	How Does Evidence Support Interpretation
RQ4. Desired support and professional learning	Practice-Oriented and Relational Professional Learning	"I need model lesson plans to see how STEAM really works." (T1, 2 years' experience)	Most participants	Reinforces preference for practical exemplars over theory.
		"It would help if we had mentoring or collaboration sessions." (T10, 8 years' experience)	Several participants	Supports a theme emphasizing relational and sustained professional learning.

Conclusion

This study extends the current STEAM literature by conceptualizing early-stage teacher identity formation as a critical entry point for STEAM implementation. Rather than encountering resistance to reform, novice teachers in this study engaged STEAM as a formative framework capable of shaping their emerging professional identities. The findings introduce the idea of STEAM as a confidence-forming pedagogy, where pedagogical coherence and teacher self-efficacy develop simultaneously through structured experimentation, collaborative reflection, and contextual adaptation.

Beyond confirming the importance of professional development, the study identifies specific support design principles. Teachers expressed a clear preference for practice-oriented, staged professional learning rather than one-off workshops. Effective support structures include (1) model lesson exemplars, (2) collaborative planning routines, (3) mentoring or peer-guided reflection cycles, and (4) gradual integration beginning with "minimum viable" STEAM lesson adaptations before full interdisciplinary redesign.

For policymakers and school leaders, the implication is clear: sustainable STEAM integration requires developmental mentoring systems rather than isolated training events. A staged mentoring model—beginning with exposure, followed by guided co-planning, supported classroom trials, and reflective consolidation—may better support early-career teachers in building both competence and confidence. Aligning institutional expectations, resource allocation, and collaborative time structures is essential to transforming STEAM from aspirational policy into enacted classroom practice.

Limitation and Suggestions

An unexpected finding was teachers' strong openness and willingness to adopt STEAM despite low initial self-efficacy, suggesting that motivation can precede formal competence. While the study is limited by its small sample size and context-specific setting, it contributes to practical insights into early-stage STEAM adoption. Future research is encouraged to examine how early and sustained exposure to STEAM shapes teachers' long-term pedagogical identity, self-efficacy, and instructional decision-making across diverse educational contexts.

Conflict of Interest

The authors declare no conflict of interest.

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