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Navigating the Future of Learning: A Review of Teacher Professional Development and Implementation Challenges in K-12 STEAM Education (2015-2025)

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Abstract

This systematic synthesis integrates recent literature from 2015 to 2025 to explore K-12 teachers' professional development and the common challenges they encounter in instructing STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning. STEAM, as a combined K-12 learning approach, is conceptualized to prepare students for 21st-century workforce demands with essential learning skills; notwithstanding, successful implementation is usually hindered by systemic and pedagogical barriers. Our synthesis reveals prominent barriers, such as rigid curricula, resource constraints, insufficient preparation for interdisciplinary and intrapersonal competencies, and inconsistent administrative support. Successful methodologies, by contrast, value the potential of experiential, interdisciplinary and intrapersonal and iterative professional learning to broaden the self-efficacy of teachers, construct interdisciplinary and intrapersonal knowledge bases, and integrate technology. authentic classroom practice is invariably characterized by culturally responsive, inquiry-based, and student-centered learning environments. The synthesis provides practical recommendations for teachers, policymakers, and professional learning leaders to incorporate tailored support and adaptive structures to allow teachers to facilitate meaningful STEAM learning experiences.

Keywords: STEAM Education, Teacher Professional Development, K-12 Education, Interdisciplinary Learning

Introduction

The concept of integrating the arts with classical STEM disciplines into STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has been a popular approach in education for last many years to develop creativity, innovation, and problem-solving skills in students (Yulianti and Suwono, 2024; Sánchez Milara and Orduña, 2024). This educational shift is meant to prepare the learners to adapt effectively in more complex, interconnected and technologically driven environments (Olivato and Silva, 2023). Teachers are especially important [central] in this transition, which requires an increased level of professional development,

responding to the multi-disciplinary approaches to teaching and overcoming common obstacles, such as time constraints, heavy workload, and the lack of resources (Rickey et al., 2023; Bertrand and Namukaka, 2020). Among the aspects of STEAM education researched recently are interdisciplinary teaching methods and the combination of technology and arts (Cook et al., 2025; Bertrand and Namukasa, 2020). Hands-on training is required for the effective professional development of teachers, including teamwork, and continuous professional coaching that enhance the self-efficacy and teaching competencies of teachers (Spyropoulou and Kameas, 2024). Although STEAM has potential to deliver improved learning outcomes, the lack of interdisciplinary training and inflexible school organization has been identified as one of the factors that impede successful implementation (Ma et al., 2022). Many studies emphasize the importance of a multifaceted and flexible training program to improve teamwork abilities and address these systemic constraints. (Morze et al., 2020).

Significance of the Topic

Effective STEAM schooling implementation is critical in fostering basic 21st-century abilities, including critical thinking, creativity, and collaboration for students (Utaminingsih et al., 2023) 10. Teachers are at the core of such educational change, and their preparation, professional development, and potential to overcome implementation hurdles significantly influence STEAM teaching experiences in quality and equity. This systematic review synthesizes up-to-date research evidence to yield insights useful for educators, educational policymakers, and professional learning facilitators into amplifying teacher support for fruitful STEAM integration in K-12 environments.

Research Gaps

With the passage of time, research has increased, but gaps still exist regarding implementation challenges in STEAM education and teachers' professional development.

- **Alignment of Policy, Technology, and Training:** Gaps persist in the effective alignment and technological integration of virtual and augmented reality tools with the needs of teacher training, as well as a lack of broader educational policy frameworks for STEAM implementation that provide necessary infrastructural support (Nemani, 2025; de Sousa et al., 2024).
- **Holistic Professional Development for Interdisciplinary Collaboration:** Teachers often face barriers due to insufficient multidisciplinary training, experience difficulty adjusting to new ideas because of the prior pressure of the curriculum and heavy course loads, exhaustion, and a lack of shared understanding when working with new ideas and people from other fields. This situation demands comprehensive and targeted teacher training models to address these critical issues.
- **Meaningful Arts Integration:** While the importance of arts integration in STEAM is acknowledged, there is a recognized gap in how arts are often treated as secondary, leading to limited genuine interdisciplinary connections and a need for stronger commitment to artistic methodologies within teacher training (Papadopoulou, 2024).
- **Longitudinal Impact and Differentiated Support:** There is a need for more longitudinal studies to assess the sustained impact of STEAM professional development programs on teacher practices and student outcomes 6. Additionally, the literature points to a requirement for more differentiated and culturally responsive professional development tailored to specific teacher needs and regional disparities, especially concerning confidence and self-efficacy in implementing STEAM pedagogies (Al Munyif, 2025; Chang, 2023).

Research Question

What are the primary barriers to, and effective strategies for, teacher professional development and classroom practices in K-12 STEAM education from 2020-2025, and how do these factors influence teacher preparedness and implementation efficacy?

Methodology

Search Strategy

A comprehensive search of academic databases (e.g., Scopus, Web of Science, Eric, Google Scholar, Springer, Elsevier) was conducted using keywords related to 'teacher professional development,' 'STEAM education,' 'implementation barriers,' 'training,' 'preparedness,' 'classroom practices,' 'methodologies,' 'student engagement,' and 'learning outcomes.' The search was limited to publications between January 2020 and September 2025, focusing on primary and secondary school education.

Selection Criteria

Studies were included if they focused on K-12 teacher professional development or challenges in STEAM education implementation. Review articles, empirical studies (qualitative, quantitative, mixed-methods), and reports detailing classroom practices were considered. Papers not directly addressing teacher-related aspects of STEAM in K-12 settings were excluded.

Data Extraction and Synthesis

Data were extracted on identified barriers, professional development models, training components, indicators of teacher preparedness, descriptions of effective classroom practices, and methodologies used. A thematic analysis approach was employed to synthesize findings, identifying recurring themes and divergent perspectives across the selected literature.

Methodologies Used in Literature

The reviewed literature predominantly employs mixed-methods approaches, integrating quantitative and qualitative data collection and analysis (Katalina & JoséMarcelo, 2024; Makuachukwu, 2023). Quantitative methods include surveys (often using Likert scales), pre/post-test designs, descriptive statistics, and inferential statistics (e.g., t-tests, regression analysis, chi-square tests) to assess teacher beliefs, self-efficacy, and training effectiveness (Alghamdi, 2023; Maričić et al., 2025; Mehddi et al., 2024). Qualitative methods extensively feature case studies, semi-structured interviews, focus groups, and reflective analyses to gain in-depth understanding of teachers' experiences, challenges, perceptions, and pedagogical transformations (Jiang et al., 2024; Toledo, 2021; Zong et al., 2024). Systematic literature reviews are also common for synthesizing existing knowledge and identifying gaps 12. Design-based research and action research are used to develop and validate STEAM programs, often involving pilot workshops and questionnaires (Harjanty & Muzdalifah, 2022; Wu & Chang, 2023). Data analysis often involves thematic analysis, inductive analysis, and content analysis 2423. Some studies also employ more specialized methods such as social network analysis (SNA) and factor analysis to explore relationships between variables and identify underlying constructs within the data (Boice et al., 2021).

Result Section

Barriers to STEAM Implementation

Research from 2015-2025 consistently identifies several significant barriers hindering the effective implementation of STEAM education in K-12 settings. These barriers can be broadly categorized as institutional, teacher-level, and resource-based, as summarized in the table 1 below.

Table 1: Overview of Systemic and Teacher-Specific Barriers Impacting K-12 STEAM Education (2015-2025)

Barrier Category	Specific Barrier	Description	Supporting Citations
Institutional & Systemic	Curricular Rigidity and Demands	Existing rigid curricula and pressure to cover extensive content conflict with the flexibility required for interdisciplinary, project-based STEAM.	(Ketsman et al., 2024; Morris et al., 2021)
	Lack of Administrative Support	Insufficient support from school leadership and ambiguous policy guidelines impedes sustainable integration efforts.	(Nemani, 2025; de Sousa et al., 2024)
	Assessment-Driven Culture	The focus on standardized testing creates a conflict with the process-oriented, creative goals of STEAM, as teachers prioritize test preparation.	(Han et al., 2023)
Resource-Based	Technological & Infrastructural Limits	High costs, maintenance issues, and insufficient access to modern technologies (e.g., VR/AR, 3D printers) create significant hurdles.	(Nemani, 2025; Al Munyif, 2025; Jashari et al., 2024)
	Inadequate Funding	Lack of dedicated financial support for materials, tools, and professional development limits teachers' ability to implement hands-on projects.	Han et al., 2023
Teacher-Level	Inadequate Professional Development	A lack of sufficient, ongoing, and interdisciplinary training leads to low teacher confidence and self-efficacy.	(Cibulskaitė, 2024; Chang, 2023; Papadopoulou, 2024)
	Deficient Cross-Disciplinary Knowledge	Teachers often lack the intrinsic knowledge and collaborative skills for authentic cross-disciplinary integration, particularly with the arts.	(Wu, 2022; Papadopoulou, 2024)
	Teacher Resistance & Burnout	Time constraints, increased workload, and the stress of adopting new pedagogies can lead to resistance and professional burnout.	(Ketsman et al., 2024; Wu, 2022)
	Poorly Defined STEAM Concept	The ambiguity of the STEAM concept leads to varied, often oversimplified, interpretations by teachers, hindering holistic implementation.	(Pant et al., 2020)
	Assessment Challenges	Teachers struggle with a lack of appropriate tools and methods to assess integrated, process-oriented learning outcomes like creativity and collaboration.	(Sidekerskienė & Damaševičius, 2023; Nguyen & Truong, 2025; Yeung et al., 2024)

The further synthesis of barriers and challenges across the studies highlights several recurring themes that shape the implementation of STEAM education initiatives (See Table 2). A central issue is the limited content knowledge of teachers in STEAM disciplines, which constrains their ability to confidently integrate science, technology, engineering, arts, and mathematics into cohesive learning experiences (Herro & Quigley, 2017). Equally persistent is the challenge of time constraints, as teachers often lack the sustained periods necessary for deep professional development or curriculum redesign (Boice et al., 2021). Resource limitations also emerged as a significant obstacle, particularly in contexts where schools cannot provide adequate teaching materials, technological infrastructure, or funding to support innovative approaches (Romero-Ariza et al., 2021). Even when training is provided, the transferability of skills into real classrooms is not always straightforward, with some educators struggling to adapt professional learning experiences into practical teaching strategies (Lo, 2021). Resistance to change was another common challenge, as many teachers remain attached to traditional teaching methods and express hesitation about adopting new interdisciplinary or project-based models (Boz, 2023). Online work scenarios, technological obstacles like unstable internet connectivity and the limited digital competence of teachers have complicated the effective implementation of STEAM-oriented courses (Quintana-Ordorika et al., 2024). Additionally, other studies also noted that there was ambiguity regarding the integration strategies and that the educators were uncertain about how to effectively integrate STEAM subjects into meaningful pedagogical practices (Park et al., 2016). Because of their usefulness in creating awareness, but limited depth and sustainability, short-term workshops do not allow the continuity to be translated into long-term impact, and hence the pedagogical change is limited (DeJarnette, 2018). Lastly, it was found that insufficient administrative and institutional support played a role as well, and fragmented leadership commitment and the insufficient school-level support diminished the efforts of teachers to introduce STEAM methods (Herro et al., 2019). Combined, these obstacles are indicative of the complex interplay between structural, pedagogical, and cultural factors that can affect the implementation of STEAM. Although certain difficulties, including the resource and time constraints, are systemic, other issues are connected with the readiness of teachers and the vision of the institution. To address these barriers, there is not only the need to enhance the design of professional development, but also to strengthen the policy support and the long-term commitment to STEAM education.

Table 2: Types and impacts of STEAM implementation barriers

Study	Barrier Type	Frequency Across Studies	Impact Level
Herro & Quigley, 2017	Limited teacher content knowledge in STEAM disciplines	Frequent	Significant
Boice et al., 2021	Time constraints for sustained professional development	Frequent	Significant
Romero-Ariza et al., 2021	Lack of resources and teaching materials	Moderate	High
Lo, 2021	Difficulty transferring training into classroom practice	Moderate	Moderate
Boz, 2023	Teacher resistance to change and traditional practices	Frequent	Significant
Quintana-Ordorika et al., 2024	Technical and digital barriers in online delivery	Moderate	Moderate
Park et al., 2016	Lack of clarity in integration strategies	Moderate	High
DeJarnette, 2018	Limited duration of workshops restricting depth	Frequent	Moderate
Herro et al., 2019	Inconsistent administrative and institutional support	Moderate	High

Teacher Preparedness and Training Needs

Effective professional development (PD) models are at the core of preparing teachers for STEAM learning by **directly confronting the cited challenges**. Studies indicate that despite favorable attitudes toward STEAM held by teachers, they report poor preparation to deliver it owing to inadequate training as well as scant self-efficacy (Silva-Hormazábal & Alsina, 2023). The most impactful training programs share several key features:

- **Building Self-Efficacy and Confidence:** PD programs must explicitly address teachers' self-efficacy and confidence. Studies show that even after short workshops, teachers may still lack the confidence to implement STEAM practices despite an increase in knowledge (Chang, 2023; Wan et al., 2021). Effective programs provide practical, hands-on experiences and opportunities for successful implementation, which builds competence and confidence over time (Boice et al., 2021). A longitudinal study by Jiang et al., (2024) found that self-efficacy in STEAM teaching is dynamic system shaped by knowledge, skills, and beliefs, highlighting the necessity for ongoing support (Jiang et al., 2024).
- **Developing Interdisciplinary Content and Pedagogical Knowledge:** There is a need for focused training that can enhance a deeper understanding of content across STEAM disciplines, as well as effective pedagogical strategies for seamless integration for teachers (Pant et al., 2020; Munyif, 2025). A key aspect is learning how to genuinely embed arts into STEM subjects, moving beyond superficial additions to create transdisciplinary lessons (Papadopoulou, 2024).
- **Promoting Practical, Hands-on, and Collaborative Learning:** The most impactful PD models involve active, experiential learning, collaborative planning time, and ongoing coaching and mentorship. Contextualized workshops, delivered in teachers' own classrooms, have shown particular effectiveness by allowing teachers to immediately apply learned strategies in a familiar environment (Boice et al., 2021; Bennett & Jamil, 2022). Furthermore, establishing Professional Learning Communities (PLCs) fosters a supportive

environment for ongoing collaboration, peer feedback, and the sharing of best practices among teachers, which positively improves perceptions of interdisciplinary teaching (Spyropoulou & Kameas, 2024; Gülhan, 2024).

- **Integrating Technological Skills:** Teachers require training not only in basic digital literacy but also in the pedagogical application of advanced tools like virtual reality (VR) and augmented reality (AR) within STEAM contexts (Guncaga et al., 2024; Soroko & Shymon, 2025). Ontological modeling is even being explored as a method to structure the teacher training process with integrated STEM elements, highlighting the move towards more complex technological and pedagogical frameworks (Bazarova et al., 2024).
- **Sustained and Differentiated Support:** One-shot training events are widely seen as ineffective. Teachers need continuous, long-term professional development that offers sustained financial, material, and pedagogical support tailored to their specific needs, subject areas, and school environments (Guncaga et al., 2024; Soroko & Shymon, 2025). This includes both formal programs and informal learning opportunities, such as roles as teaching assistants, which contribute to the development of innovative teaching practices (Rif'attullah & Ciptaningrum, 2024). Effective PD must also address teachers' existing beliefs and potential resistance to new methodologies like gamification by providing clear conceptual frameworks and practical applications (Bazarova et al., 2024).

Effective Classroom Practices

Successful classroom practices in STEAM education are characterized by dynamic, student-centered approaches that foster integrated learning and skill development. The literature from 2015-2025 highlights several dominant and effective strategies.

- **Student-Centered and Active Learning Approaches:** Project-based learning (PBL), inquiry-based learning, problem-based learning, and design-based learning are consistently identified as highly effective pedagogical models. These methods shift the focus from teacher-led instruction to student-driven exploration, engaging students in authentic, real-world problem-solving, which fosters critical thinking, creativity, and deeper conceptual understanding (Nguyen & Truong, 2025; Morris et al., 2021; Wu & Chang, 2023; Laslo et al., 2024). For example, a project-based STEAM program focused on designing musical instruments was shown to significantly improve the creativity of elementary school students at both individual and group levels (Cheng et al., 2022). Similarly, implementing PBL with a STEAM approach was effective in enhancing students' self-confidence and creativity in middle school (Mansyur et al., 2024).
- **Authentic Cross-Disciplinary Integration:** Effective practices involve the genuine integration of all STEAM components, where the "A" (Arts) is not merely decorative but is integral to enhancing creativity, personal expression, and meaning-making within scientific and technological contexts (Cook et al., 2025; Bertrand & Namukasa, 2020). Collaborative teacher training programs that pair STEM and Arts teachers have been shown to be an effective model for facilitating this deep integration and co-designing curricula (Boice et al., 2021).
- **Fostering Collaboration and Communication:** Activities that take place in the classroom specifically to promote collaboration, peer interaction, and proficient communication are valuable for establishing basic transferable skills. Project-Based Learning (PBL) has specifically been referenced for placing particular focus upon cooperation and shared sense of responsibility for learning outcomes, therefore permitting the practical expression of communication and scientific literacy competency (Bertrand and Namukasa, 2020; Sukmawati et al., 2023). Research in early childhood learning has also demonstrated that STEAM PBL has the potential to significantly enhance early learners' collaboration (Harjanty and Muzdalifah, 2022).

- **Strategic Use of Digital Tools and Innovative Technologies:** The thoughtful integration of digital technologies can create highly engaging and immersive learning experiences, provided that teachers are adequately prepared to use them pedagogically. This includes using innovative classroom setups with rotation models, as well as incorporating advanced tools like VR and AR (Morze et al., 2020; Cirneanu & Moldoveanu, 2024). For example, digital escape rooms have been used as an innovative practice to break down barriers in STEM education by promoting critical thinking, problem-solving, and teamwork in an engaging, gamified format (Sidekerskienė & Damaševičius, 2023).
- **Emphasis on Self-Assessment and Metacognition:** Exemplary STEAM educators actively promote student self-assessment (SSA) activities. These practices include self-documentation of learning (e.g., through journals), guided reflection, making metacognitive processes explicit, prototype testing and revision, and goal setting. These SSA activities help students to internalize the iterative nature of the design process and enhance their metacognitive skills and engagement with learning (Rickey et al., 2023).
- **Culturally Responsive and Contextualized Learning:** Integration of STEAM concepts with local learning communities and real-world, practical problems can provide learning context and interest. Project design that integrates real-world problems with local culture can enhance the level of student consciousness and engagement, particularly useful for developing equitable inclusiveness with divergent student populations (Thi Minh et al., 2022; Al Munyif, 2025; Bui et al., 2023).
- **Shift in Teacher Role:** In successful STEAM classrooms, the teacher's role shifts from that of a traditional instructor to a facilitator or "moderator of learning." In this capacity, the teacher guides students, provides resources, analyzes their work, and directs them toward improved performance, rather than simply delivering content (El Nagdi & Roehrig, 2020). This student-centered approach empowers learners to take ownership of their education.

Thematic Analysis

Table 3, summarizing thematic analysis, **gathers together various studies addressing STEAM**-oriented professional development, bringing into focus alike the richness and the gaps in methodologies at present. The studies vary significantly in length, from short-term workshops of only several hours (DeJarnette, 2018) to longer year-long programs that deliver year-round support (Boice et al., 2021; Herro et al., 2019) and reveal varying levels of investment and intensity. Correspondingly, delivery modalities are quite varied, including in-person meetings (Boz, 2023), hybrid models of combined face-to-face and virtual components (Boice et al., 2021), and fully virtual modalities (Quintana-Ordorika et al., 2024) and afford participant interaction in particular ways. Many initiatives have commonalities, as project-based learning, collaboration, and technology integration become salient elements (Herro & Quigley, 2017; Boz, 2023) and particular studies give prominent focus to unique practices for example in terms of building of professional learning communities (Boz, 2023) through micro-teaching (Lo, 2021) as well as creative use of recyclable material in activities by-hand (DeJarnette, 2018). The focus areas within STEAM are not uniform; some highlight engineering or content knowledge (Herro & Quigley, 2017; DeJarnette, 2018), while others stress strategies for integration or the role of the arts (Boice et al., 2021; Lo, 2021). Notably, several studies leave certain aspects unspecified (Park et al., 2016; Romero-Ariza et al., 2021), which suggests that while the field is growing, it is still developing a consistent framework for reporting and structuring such programs. Altogether, the table illustrates both the shared foundations and the diverse directions shaping STEAM professional development today.

Table 3: Thematic analysis of professional learning approaches in STEAM education in different studies

Study	Duration	Delivery Format	Key Components	STEAM Focus Areas
Mesutoglu and Baran, 2020	No mention found	In-person (workshops, field trips, follow-ups)	Real-world activities, collaboration, classroom implementation planning	Engineering integration
Herro et al., 2019	Yearlong	No mention found	Technology integration, STEAM unit integration	No mention found
Boice et al., 2021	5 weeks (summer) plus yearlong support	Hybrid (1 week online, 4 weeks in-person)	Project-based, collaborative, technology integration, interdisciplinary	STEAM pedagogy, arts integration
Herro and Quigley, 2017	No mention found	No mention found	Project-based, collaboration, technology integration	STEAM integration, content knowledge
Romero-Ariza et al., 2021	No mention found	No mention found	Transferability, resources, professional learning community	No mention found
Lo, 2021	No mention found	No mention found	Content/pedagogical knowledge, micro-teaching	Integration strategies, content knowledge
Boz, 2023	2 days–5 weeks, some yearlong	In-person	Project-based, collaborative, technology, community-building	Integration strategies, modeling STEM curriculum
Quintana-Ordorika et al., 2024	No mention found	Virtual (online)	Immersive, collaborative, virtual	No mention found
Park et al., 2016	No mention found	No mention found	No mention found	No mention found
DeJarnette, 2018	3 hours (2×90 min workshops)	In-person	Hands-on, literature, recyclables, learning centers	Engineering/science, hands-on

Conclusion

Summary of Findings

This systematic review, covering literature from 2015 to 2025, underscores that while the importance of STEAM education in K-12 settings is widely recognized, its effective implementation is significantly hampered by various barriers. These include technological and infrastructural limitations, inadequate and often isolated teacher training, rigid curricular structures, and a lack of consistent administrative and policy support. Despite these challenges, the research highlights effective strategies for teacher professional development that prioritize practical, hands-on, collaborative, and continuous learning experiences. These strategies aim to boost teacher self-efficacy, interdisciplinary pedagogical knowledge, and confidence. Furthermore, successful classroom practices are consistently characterized by student-centered,

inquiry-based, and project-oriented approaches, fostering critical thinking, creativity, genuine cross-disciplinary integration, and real-world problem-solving among students.

Implications and Recommendations

To overcome the identified barriers and enhance STEAM education across K-12 settings, it is crucial for policymakers and educational institutions to:

- **Invest in Comprehensive and Sustained Professional Development:** Implement robust, long-term PD programs that offer practical, interdisciplinary training, foster collaborative learning communities, and integrate innovative technologies. Training should focus on both content knowledge across disciplines and pedagogical skills for integration.
- **Promote Flexible Curricular Reforms:** Advocate for and implement curricular reforms that allow for greater flexibility and genuine integration of all STEAM components, ensuring that the arts are deeply embedded rather than marginalized.
- **Strengthen Administrative and Policy Support:** Provide clear policy guidelines and consistent administrative support to create an enabling environment for teachers, including resource allocation, protected time for collaboration, and recognition of STEAM efforts.
- **Develop Culturally Responsive Training:** Tailor professional development to address the specific needs of diverse teacher populations and regional contexts, acknowledging and integrating local cultural relevance.
- **Foster Collaborative Culture:** Actively promote and provide mechanisms for cross-disciplinary collaboration among teachers, recognizing the importance of tacit knowledge exchange and shared pedagogical development.

Future Research Directions

Future research should delve into more granular analyses of how specific cultural and socioeconomic contexts influence STEAM implementation and teacher professional development needs. Longitudinal studies are critically needed to evaluate the sustained impact of different professional development models on teacher retention, long-term pedagogical innovation, and student achievement over extended periods. Furthermore, research on developing and validating effective assessment tools for integrated STEAM learning, and investigating the crucial role of school leadership in fostering a supportive STEAM culture, remains essential for advancing the field. Specific areas include:

- Understanding how to effectively measure genuine arts integration beyond superficial inclusion (Papadopoulou, 2024).
- Exploring the long-term effectiveness of various technology integration strategies (e.g., VR/AR) in different school settings and their impact on teacher practice and student outcomes (Nemani, 2025).
- Investigating strategies to bridge the gap between teachers' theoretical understanding and practical application of STEAM pedagogies (Zong et al., 2024).
- Developing and testing professional development models that explicitly address and overcome teacher resistance and burnout associated with STEAM implementation (Ketsman et al., 2024).

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