THE STEAM PARADOX: ARTISTS AS PRIMARY STEM EDUCATORS IN CROSS-DISCIPLINARY PEDAGOGY

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Abstract. This paper explores the phenomenon I term the "STEAM Paradox," in which artists and creative professionals increasingly assume leadership roles in STEM (Science, Technology, Engineering, and Mathematics) education, particularly within interdisciplinary and project-based learning environments. The study investigates how artist-facilitators employ arts-informed and design-oriented approaches to cultivate innovative thinking, deepen conceptual understanding, and enhance student engagement by rendering technical content more meaningful, experiential, and aesthetically grounded. Drawing on multiple case studies across diverse educational contexts, including K–12 and higher education settings, the research analyzes instructional strategies, collaborative structures, and learning outcomes associated with artist-led STEM initiatives. Findings suggest that such approaches can demystify complex scientific concepts, promote holistic problem-solving, stimulate creativity, and broaden participation among underrepresented learners. At the same time, the study identifies tensions related to professional legitimacy, disciplinary boundaries, assessment standards, and the integration of traditional STEM educators. The paper concludes by proposing a framework for collaborative research and co-teaching models that more systematically integrate artistic and scientific practices into formal curricula, thereby advancing transdisciplinary pedagogy and fostering competencies aligned with 21st-century educational goals.
Keywords: *STEAM education, cross-disciplinary pedagogy, arts integration, creative teaching methods, case studies in education*

Introduction

In the last ten years there has been a global transition in education from one outmoded conception of education to another emergent conception where the formal incorporation of arts into science/technical education are represented: STEAM (as an acronym for Science, Technology, Engineering, Arts, and Mathematics). In other words, there is growing recognition of the value of fostering student engagement with, and comprehension of, the STEM content areas that emphasizes creativity/design narrative/storytelling. Advocates of STEAM argue that an education which integrates art/aesthetic values/art making with learning through science and technology process yields deeper/culturally relevant/new learning. One element of the change that became noteworthy and salient was teachers at the edge in STEM with artists. No longer solely working in collaborations across fields, but generating courses and pedagogy on coding, robotics, environmental modelling and data visualisation themselves. These innovations redefine notions of credentialism in teaching in the sciences outside disciplinary divides and beyond having credentials in the discipline taught. This seems like a redefinition of

how we draw boundaries on what is considered pedagogy: art could allow entry into knowledge about science.

This study is justified because a greater understanding is needed regarding why and how this transition is occurring and what this transition will mean for the future of education. While much of existing literature focuses on positive impacts resulting from integrating arts and STEM (eg. boosting creativity, motivation, and problem-solving skills), there exists relatively little work examining pedagogy in artist-instructor roles or ramifications of authority in technical domains (Shin et al., 2024). This case study of artist-teacher situations offers an opportunity to address these issues while also opening possibilities for novel approaches to cross-disciplinary instruction, and offering insight into the next phases of curriculum development and teacher training.

However, one surprising yet salient outcome of the increasingly widespread implementation of the arts in STEM by way of the STEAM approach, is that it positions artists themselves entering into STEM-related teaching jobs including disciplines such as computer science, robotics, and environmental modelling. These shifts perceptions of disciplinary boundaries while destabilizing epistemic authority regarding pedagogy in the STEM-related fields. More formal types of technical knowledge have more often been prioritized within each of the related STEM fields mentioned, yet the artists involved with the arts including visual and performance art types do not just work alongside others, they are new teachers (Mishra, 2012). For one, having a teacher be an artist itself holds dualities that challenge not only the legitimacy for nonscience teachers in science classrooms working with these students, but also how we value and assess student learning and good teaching. While preliminary evidence points to the beneficial interdisciplinary/creative effects that can be achieved (ie, increased student engagement, innovation, and conceptual understanding), the specific impacts and limits of art-integrated science teaching are not fully understood. The contexts allowing artists to be STEM teachers with insights into effects on students and academic organization will therefore be of interest. Understanding this paradox is essential if we are to create inclusive and innovative schools.

Guided by this gap, the present study seeks to explore the conditions, practices, and implications of artist-led STEM education through a set of interrelated research questions. First, it investigates the factors that motivate artists to become educators in STEM-related learning environments, with particular attention to how institutional, cultural, and systemic changes enable artists to inhabit teaching roles formerly dominated by STEM professionals. Second, the study examines how artist instructors differ from conventionally trained STEM educators in their presentation of STEM content, focusing on the pedagogical strategies, inventive approaches, and conceptual ordering of knowledge employed in technical teaching contexts. Third, it assesses the educational opportunities and barriers experienced by students and schools involved in artist-led STEM initiatives, evaluating both learning outcomes such as engagement, understanding, and creativity, and challenges including credibility, assessment alignment, and resistance from established educational structures. Finally, through in-depth case study analyses, the research identifies effective practices and common pitfalls in artist-led STEM teaching, aiming to inform the development of sustainable cross-disciplinary education models and policies.

This research makes several important contributions to the field of education. Conceptually, it challenges prevailing notions of authority and expertise within STEM education by foregrounding alternative pathways to effective teaching and learning. The

increasing involvement of artists as primary STEM educators signals a shift toward valuing learning processes, experiential engagement, and pedagogical legitimacy rooted in practice rather than formal disciplinary credentials alone. Practically, as schools face mounting pressure to cultivate adaptable, creative, and future-ready learners, artist-led approaches to STEM instruction present a viable and potentially transformative instructional option. Arts-centered pedagogies frequently incorporate inquiry-based, narrative-rich, and learner-responsive methods that support deeper comprehension and broaden participation, particularly among diverse and historically underrepresented student populations. Ultimately, this study contributes not merely a critique of disciplinary divisions, but an empirically grounded understanding of the productive and transformative intersections between creative and technical knowledge within contemporary STEAM education.

Literature review

Transition from STEM to STEAM

The shift of moving from STEM (Science, Technology, Engineering, and Mathematics) into STEAM (adding the Arts) may be linked to greater recognition that creative and innovative are necessary dispositions towards 21st-century education. As the demand for employees to be technologically literate led to STEM emphasis around the world. Then the need for inclusion of the arts became important as it was recognized that simply providing technical training constrained both the nature of learning and the kinds of solution students might possess to prepare them as problem solvers who are also human-centered designers. It's not about how to put more artistic ingredients in STEM education; rather, it's about where its epistemological grounding lies on creativity, on empathy, on aesthetics, on the plurality of other ways of knowing that will produce creative and communicative and civic-minded technocrats through this endeavor. By incorporating art practices through storytelling, visualization, and embodiment, the conception of literacy and competency through STEAM shifts what literacy and competence in a connected and digital world looks like. Recent study indicated that students in STEAM scenarios exhibit higher levels of engagement, critical thinking, and interdisciplinary learning compared to those in students in STEM scenarios. STEAM experiences can also facilitate equity and inclusion by taking into consideration varied student learning styles and cultures (Chappell and Ben-Horin, 2023). The trend toward institutionalized STEAM in maker education, design thinking, and creative technologies calls for a rethinking of what and how we learn and prepare teachers, and success measures. Beyond the curriculum, it represents a shift in mindset from teaching as transmission to deeper learning and more holistic, student-centred inquiry and exploration.

The arts in STEM learning

Integration of arts in the STEM curriculum has recently been demonstrated to revolutionalize this area to enhance learning experiences via cognition and affect. The arts enhance cognitive aspects such as logical thinking and empiricism in STEM but also introduce novel aspects of imagination, emotional quotient, and senses. Their education thereby forms part of an integral human perspective, especially in addressing complex real-world problems (Zhou et al., 2025). Arts in STEM help develop skills such as creativity, visual literacy, or problem framing increasingly valued in modern

innovation environments. While visual arts help understand complicated science concepts using models, diagrams, and simulations, performance and narrative arts allow for easier and longer retention forms representing data, processes, or systems. These cross-fertilization effects increase understanding and appeal, particularly with audiences who wouldn't automatically classify themselves as techie studies students. Moreover, an integrated approach with the arts contributes to inclusive education via diverse learning experiences. Arts-based approaches often provide richer and more empowering learning experiences for students from different cultural, linguistic, or cognitive heritages. This type of inclusion leads to equitable opportunities in learning environments for STEM subjects and serves as an avenue for engaging students from underrepresented groups. Additionally, design thinking, derived from art and engineering, has also been proposed as a successful pedagogical method for STEAM education. Design thinking enables learners to prototype, test, and cycle through the solutions that foster technologically literate and empathic innovators. Consequently, arts are not merely complementary additions to STEM education. Rather they are valuable to supporting interdisciplinarity, emotionality, and confidence.

Current case studies and models

Several recent case studies and educational models have showcased exemplary cases of arts infused STEM, from which productive hybrid learning activities emerge. These projects serve as exemplar instances of how to integrate STEAM in formal educational environments and within informal learnscapes. Artist residency in the science environment is an example. Artists embedded in science laboratories and in-tech environments have helped foster creativity while also inviting reflection from scientists considering elements of their own work from other interpretive positions. One example comes from the Sci Art program at the University of California which has illustrated that through collaboration, it creates other pathways for communication, allows dialogue past traditional meanings, and helps complex ideas be more accessible for public audiences (Lee et al., 2018).

Maker education's proven track record offers an example for how art, design, and engineering concepts can be applied via hands-on, project-based learning activities. Maker space offerings found in libraries or community centers, or classrooms are likely to include access to technology such as 3D printing or coding programs, or materials traditionally used in craft work. One value of maker education is how it allows for iterative design and creativity. This type of learning helps students develop an understanding of concepts and problem-solving skills and the ability to use their own judgement, particularly with opportunities for art making within the activities associated with STEM topics. The case studies established that STEAM is not simply hypothetical but has already been realized differently across contexts. It also illustrated how STEAM may make participation more democratic and equitable in terms of inclusivity due to the value that can be placed on diverse expressions and perspectives of knowing.

Materials and Methods

Research design

For this investigation, we have chosen a qualitative multiple-case study approach. One advantage of using a qualitative case study design is allowing for a comprehensive

understanding of what STEAM looks like in teaching practice and any potential barriers by discipline, along with student experiences across different types of STEAM classrooms (Gammelgaard, 2017). This type of complex teaching across disciplines can be difficult to understand, and a case study design permits an understanding of the complexity of the integration between an art and a science class. For this study, we are conducting a multiple case study with four distinct cases, including formal school settings, community-based programs, museums, and higher education contexts. The diversity across cases enables us to make comparisons. Each case has been identified as a system bounded for the purpose of its potential to reveal insights into artist-led teaching on topics in STEM (Liao, 2016). Studying multiple cases generates within- and across-case themes that document patterns, innovations, and challenges. The research paradigm is constructivist as knowledge is assumed to be a co-construction between the researcher and the participants. Generalizability is not sought so as to arrive at a detailed description of constructing meaning within the context of creative pedagogy (Lichtman, 2023). Especially when we work across disciplines which are typically associated with STEAM in non-traditional configurations. Data will be collected through interviews, classroom observations, and analyses of instructional artefact data. Data collected from various sources offer a more extensive, detailed account of responses gathered (Creswell, 2002).

Selection of case studies

The selection of case studies, especially in education, is typically conducted through purposeful sampling. The inclusion of case studies in this study was purposively sampled to find a range of settings from which artists teach STEM curricula. We are not looking for statistical representation, but analytic generalization wherein we may look deeper through many settings (Palinkas et al., 2021). Case studies identified for inclusion in this study included instances whereby an artist was employed as a professional, teacher of record for STEM curricula that incorporated coding, robotics, and environmental science courses. Examples in K-12 schools, non-conventional learning spaces such as maker labs and community-based learning, and higher education make the breadth and depth of the work possible. Multiple contexts afford the opportunity to compare while illustrating how an institution influences experiences for teaching and learning. Finally, disciplinary convergence is also considered for inclusion, meaning an integrated curriculum or instruction where the boundary between art and other disciplines is intentionally made ambiguous. In this way, the research can examine the impact of the arts' thinking on teaching and learning of and in STEM as well as, given the cultural and socioeconomic variances among the various learning settings, the response of the arts to local needs and values. These criteria will ensure that this study will be able to capture best practices, innovations, as well as challenges in a representative set of types of STEAM activities.

Methods of data collection

This study employs a multi-method approach to gather qualitative data to ensure a comprehensive perspective of how artists incorporate STEM education within STEAM settings. Semi-structured interviews, class observation, and document review offer support for triangulation and insight for inquiry. We conducted semi-structured, face-to-face interviews with artist-instructors and their students; with program administrators or

coordinators, if relevant. We aim to understand subjective perceptions regarding artistic practices as pedagogies, their lived experience navigating as an interdisciplinary teacher, and perceived learning outcomes that arise out of the practice. Semi-structured interviews allow the interviewer the flexibility needed to probe further than what is observable or recorded to understand the perspectives and practices shared. We will conduct direct observations of instructional lessons across selected case study sites. This method helps capture the embodied and aesthetic dimensions of teaching not always documented. The focus will be on observing instructor-student interactions, teaching strategies, use of material resources, as well as connections between disciplines. Detailed field notes will be recorded during and shortly after each activity. Artifacts including instructional content, examples of student work, lesson planning, and institutional artifacts (eg, curricula, mission statements) will be collected and reviewed to gain insight regarding the integration of the principles of STEAM within program structures. Artifacts give background for the interview and observation data; it also supplements the interview data. This strategy ensures an extensive and sufficiently triangulated dataset that would allow within- and between-case analysis to be performed. Data source triangulation provides credibility and validity to the results obtained and supports rich descriptions about the complex phenomenon under investigation.

Data analysis

Data gathered via the interviews, observations, and document analyses will be analyzed using thematic analysis. Thematic analysis can unpack complex educational phenomena in diverse contexts (Braun and Clarke, 2021). Theses can emerge from data with repetition, novelty, and importance of cases in thematic analysis (Braun and Clarke, 2021). Additionally, thematic analysis can help go back to data, review them multiple times, and code strategies, interdisciplinary approaches, institutional barriers, and student experiences.The following 6 phases for analysis will underpin this study: familiarisation with the data; initial coding; generating themes; reviewing themes; refining and defining themes; and, reporting (Nowell et al., 2017). Code generation will be both inductive in relation to the data and deductive as a result of existing scholarship about STEAM and cross-disciplinary education. Analysis will be strengthened by rigor and reliability through data preparation and coding using qualitative data analysis software (eg, NVivo or Atlas.ti). The software facilitates organizing data and composing memos to refine coding for a systematic analysis strategy. In addition, we will conduct a cross-case comparison to find shared experiences and divergences between settings and their explanation. We will be able to explain how different scenarios might affect artist-led STEM education delivery (eg, schools, museums, community labs) (Saldaña and Omasta, 2016). Synthesizing the cases will allow us to understand the facilitators and barriers of best STEAM teaching practices towards theories and models for practice.

Case study

Case study 1: Artist as teacher of a coder class at a K–12 school

This case examines a K–12 school-based coding course led by a visual artist employed as a digital media and graphic design instructor within a STEAM curriculum. Rather than approaching coding as a purely technical skill, the instructor reframed programming as an expressive medium through which students could explore visual

storytelling, animation, and personal narratives. Using platforms such as Scratch, Processing, and Tynker, students were introduced to core programming concepts, such as sequencing, variables, and event-driven logic, through design problems and narrative prompts, reversing the conventional STEM sequence in which technical instruction precedes application. Student engagement in the course was notably high, particularly among learners who had previously been disengaged in traditional mathematics or science classes. Students reported a strong sense of ownership and identity in their work, often describing their projects as reflective of their personal interests and experiences. Administrators also observed increased participation among female students and students from underrepresented backgrounds, attributing this to the open-ended, expressive structure of the course. Although initial skepticism emerged from traditional STEM faculty regarding academic rigor and assessment, institutional support grew as the program aligned with broader school goals related to creativity, digital literacy, and twenty-first-century competencies. The course has since served as a prototype for STEAM integration across the district.

Case study 2: A community-based art and technology lab

This case focuses on a community-based Art and Technology Lab situated in a low-resource urban environment where access to formal STEM enrichment opportunities is limited. Operated by a collective of practicing artists, the lab offers voluntary, project-based workshops in areas such as 3D printing, Arduino programming, wearable computing, and sound art. All technical activities are embedded within artistic inquiry, positioning creative exploration as the entry point into technological learning rather than as an outcome of technical mastery. Pedagogically, the lab emphasizes informal, interest-driven learning supported through mentoring rather than direct instruction. Participants engage in tinkering and experimentation before developing self-directed projects that connect emotional or narrative intentions with technical functionality, such as designing interactive garments that respond to physiological or emotional states. Equity and access are central to the lab's mission, with programming designed to be culturally responsive, bilingual, and free of formal prerequisites. While the lab faces ongoing challenges related to funding stability and alignment with institutional partners seeking standardized outcomes, it functions as an incubator for arts-based STEM experimentation, with several initiatives later adopted by schools, museums, and libraries through strategic partnerships.

Case study 3: Teaching environmental modelling using an art professor from a university

This university-based case study examines an interdisciplinary course titled Data Landscapes: Environmental Modelling through Visual Art, taught by an artist faculty member within a multidisciplinary environmental studies program. The course integrates geospatial technologies such as GIS and remote sensing with visual art practices, encouraging students to explore environmental issues, including climate change, land use, and ecological systems, through data visualization, installation art, and spatial narratives. The pedagogical premise is that scientific data alone cannot fully address the ethical, emotional, and societal dimensions of environmental problems. Students from both environmental science and art backgrounds participated in the course, producing data-driven artworks that required scientific interpretation alongside

critical reflection on visual representation and public perception. Assessments indicated that science students developed greater ethical awareness and communicative sensitivity in presenting data, while art students acquired technical competencies in data literacy and modelling previously inaccessible in conventional studio courses. Although the course initially faced institutional resistance regarding academic legitimacy, its success led to increased administrative support. The case illustrates how artist-led pedagogy can extend scientific research, public engagement, and interdisciplinary scholarship.

Case study 4: K12 sculptor-engineer co-Led museum-based STEAM program

This case explores a museum-based STEAM program delivered through a large science museum, where sculptors and mechanical engineers collaboratively facilitate interactive learning experiences for children and families. The program, Building the Future: Art, Machines, and Human Innovation, centers on kinetic sculpture and mechanical design, enabling participants to explore concepts such as balance, torque, circuitry, and energy transfer through hands-on construction and artistic experimentation. Modular activities invite learners to create wind-powered sculptures or robotic creatures using simple materials, positioning aesthetic intuition and engineering logic as equally valuable forms of knowledge. The informal museum setting supports embodied and collaborative learning, with participants engaging physically and socially in problem-solving processes. Observations and participant feedback revealed heightened motivation when projects incorporated narrative or imaginative elements, often guided by sculptors. Initial concerns from museum staff that artistic components might dilute scientific rigor were addressed through evaluation data demonstrating substantial conceptual understanding, creative risk-taking, and increased participation among underrepresented groups in STEM. As a result, the museum institutionalized a broader STEAM initiative, expanding artist–engineer collaborations across exhibits and professional development programs, and positioning the case as a model for transdisciplinary public education.

Results and Discussion

Artist-instructor pedagogical styles

Across all case studies, a prominent finding is the emergence of distinct pedagogical styles developed by artist-instructors in STEM contexts. Unlike traditional STEM pedagogy that often privileges content transmission, technical proficiency, and standardized outcomes, artist-led instruction foregrounds aesthetics, narrative, exploration, sensory experience, and embodied learning. These teaching modes originate from the instructors' own artistic practice, including iterative, open-ended processes, and are translated into STEM learning spaces in ways that encourage experimentation and conceptual flexibility. Such approaches create learning environments that emphasize the construction of knowledge through experience, allowing students to manipulate materials, question assumptions, and explore multiple solutions rather than focusing solely on correct answers or procedural mastery. Artist-instructors consistently prioritize the creative process over fixed outcomes, encouraging learners to engage in exploration and iterative problem-solving. In coding or wearable technology workshops, for example, students were invited to experiment with circuits or program scripts before formal instruction in technical logic, allowing experiential

discovery to guide understanding. Narrative framing also plays a crucial role, making technical content personally meaningful and culturally situated. Students encounter STEM concepts through stories, metaphors, or design challenges that connect their learning to human, social, or ethical dimensions. In environmental modelling courses, students engaged with data visualization not merely as a technical skill but as a medium to explore fairness, social impact, and visual ethics, linking abstract concepts to lived experience. Material engagement and embodied learning further characterize artist-led pedagogy. Physical manipulation, spatial reasoning, and sensorimotor activities help students internalize abstract scientific principles, from energy flow to systems equilibrium. Such strategies provide multiple perceptual entry points into STEM content, supporting diverse learners who may struggle with conventional instruction. Across settings, authority within the classroom is also redistributed: instructors position themselves as facilitators, collaborators, or co-learners rather than sole knowledge holders. Assignment interpretation is flexible, and students are empowered to negotiate, reframe, or extend tasks. This approach both destabilizes traditional hierarchical dynamics and integrates creative insight with technical reasoning, offering a model for transdisciplinary, student-centered STEM learning.

Student experience and learning outcomes

The impact of artist-led STEM instruction on student experience was consistently positive across case studies, influencing engagement, understanding, confidence, and collaboration. Students reported that artist-instructed environments were more enjoyable, empowering, and less intimidating than traditional STEM classrooms. Hands-on, open-ended, project-based learning grounded in narrative and aesthetics was particularly effective in sustaining interest. In the K–12 coding program, students previously disengaged from traditional math or science lessons expressed pride and enthusiasm in their creative projects, demonstrating emotional investment and ownership over their learning. This engagement was further amplified when learners could visualize and personalize their work, making abstract technical content accessible and meaningful. Conceptual understanding also benefited significantly from the integration of artistic approaches. Storytelling, physical modeling, and design-based assignments enabled students to visualize complex concepts such as energy transfer, environmental systems, and data structures. In the university environmental modelling course, students demonstrated the ability to connect scientific information with ethical considerations and social implications, reflecting a deeper understanding of both content and context. Additionally, student confidence and creative agency increased through exposure to iterative processes and the normalization of failure as a productive part of learning. Art students acquired new technical skills such as coding and GIS, while science students developed greater comfort with ambiguity and creative thinking. Social collaboration was another major outcome. Co-production and team-based learning within artist-led settings facilitated peer-to-peer learning across disciplines and enhanced awareness of diverse perspectives and skill sets. Flattened classroom hierarchies encouraged broader participation among girls, minority students, and neurodiverse learners. In community or museum contexts, collaborative projects also fostered civic engagement and introduced learners to potential STEAM-related career pathways. Overall, student experiences indicate that artist-led pedagogical practices enrich STEM learning by increasing engagement, supporting conceptual integration,

promoting agency, and cultivating collaborative skills essential for twenty-first-century education.

Tensions and difficulties

Despite demonstrable benefits, artist-led STEM education faces ongoing challenges related to legitimacy, assessment, institutional structures, and sustainability. Authority and expertise often become points of tension; instructors' lack of formal STEM credentials leads to skepticism from administrators, colleagues, and sometimes students. Even when student outcomes are strong, artist-instructors frequently encounter professional disadvantages, including limited recognition, fewer institutional resources, and constrained career pathways. These tensions are particularly pronounced in formal educational contexts, where rigid disciplinary boundaries can impede innovative cross-disciplinary practices and marginalize non-traditional expertise. Assessment challenges also persist. Traditional metrics focusing on correctness and standardization are poorly suited to arts-integrated approaches that emphasize creativity, iteration, and process. Consequently, artist-led programs struggle to demonstrate measurable success to administrators or funding bodies, limiting opportunities for institutional support or policy endorsement. Structural barriers, including inflexible schedules, rigid curricula, and certification limitations, further hinder the integration of artist-instructors. Cultural divides between art and science can exacerbate these difficulties, with artistic knowledge often devalued or perceived as supplemental rather than central to STEM learning. Sustainability and scalability remain critical concerns. Many successful artist-led initiatives rely on specific institutional contexts, motivated individuals, or short-term funding, making replication challenging. Without systemic support, these programs risk remaining isolated exemplars rather than catalysts for broad educational transformation. Addressing these challenges requires coordinated policies that recognize interdisciplinary teaching as legitimate, support cross-disciplinary staff development, and foster institutional cultures conducive to creative, integrative approaches in STEM education.

Theoretical implications

Artist-led STEM education presents both practical and theoretical challenges, raising fundamental questions about knowledge, pedagogy, and disciplinary boundaries. Findings suggest the need for epistemological pluralism, where visual, kinesthetic, emotional, and narrative ways of knowing are valued alongside logic and analytical reasoning. Such approaches challenge rigid disciplinary silos and enable transdisciplinary learning that goes beyond merely adding art to STEM. By integrating interpretive and exploratory processes, artist-instructors offer alternative pathways to understanding complex systems, fostering adaptive thinking and creative problem-solving. The role of the teacher is also reconceptualized. Artist-instructors destabilize the traditional STEM educator archetype, positioning themselves as collaborators and co-creators who facilitate dialogue, uncertainty, and iterative learning. This redistribution of authority promotes participatory classroom cultures, enabling students to exercise agency while developing skills in collaboration, design, and adaptive reasoning. Incorporating aesthetics into STEM education further legitimizes artistic practices as forms of knowledge rather than solely as communication tools. By linking intuition, beauty, and sensibility with technical reasoning, artist-led pedagogy fosters

systems thinking, multidimensional problem-solving, and ethical reflection. Finally, these approaches expand conceptions of educational success, emphasizing creativity, critical thinking, engagement, and societal relevance alongside conventional content mastery. This model aligns with post-disciplinary education frameworks, advocating flexible, integrative knowledge practices that equip learners to address complex, twenty-first-century challenges.

Conclusion

The findings of this study highlight the educational significance of artists serving as primary or co-equal educators in STEM contexts across multiple levels and settings. Across the cases, artist-led instruction consistently foregrounded creativity, experiential learning, and aesthetic reasoning as integral components of STEM teaching. Rather than relying on transmission-oriented approaches, artist-instructors employed narrative, inquiry, investigation, and design-based learning strategies that enabled students to construct scientific and technical understanding through meaningful, situated experiences. These pedagogical orientations offered students multiple ways of engaging with STEM concepts, reframing technical knowledge as something that could be explored, interpreted, and expressed. Importantly, the cases demonstrated enhanced student engagement, motivation, and achievement, particularly among learners who had previously struggled in conventional STEM environments. Artist-led approaches reduced barriers to participation by validating diverse ways of knowing and learning, thereby making STEM more inclusive and accessible across formal, informal, and community-based contexts. At the same time, persistent institutional challenges were evident, including limited structural support, unclear credentialing pathways, and ongoing concerns about disciplinary legitimacy. While the educational outcomes of artist-led STEM teaching were consistently positive, the findings suggest that such practices cannot be sustained or scaled without systemic changes that formally recognize and legitimize interdisciplinary pedagogies.

The ability of artists to teach STEM effectively carries important implications for educational practice and policy. At a pedagogical level, the findings underscore the need to reconsider traditional definitions of expertise, curriculum design, and instructional authority in STEM education. Artist-led teaching emphasizes learner self-efficacy, curiosity, and confidence by creating environments in which experimentation, iteration, and creative risk-taking are normalized. These qualities are particularly relevant in contemporary educational landscapes increasingly shaped by digital, hybrid, and nontraditional learning formats, where learner motivation and persistence are critical. From a policy perspective, the study points to the necessity of transforming teacher credentialing systems and professional development structures to better accommodate interdisciplinary teaching roles. Existing certification frameworks often marginalize artist-instructors despite evidence of their effectiveness, limiting the sustainability of STEAM initiatives. Curriculum innovation should move beyond the superficial addition of art to STEM and instead support genuinely transdisciplinary learning experiences that reflect authentic problem-solving practices. Furthermore, arts-integrated STEM education shows strong potential for advancing equity and inclusion, particularly for underrepresented and underserved student populations. To realize this potential, institutional leadership, funding mechanisms, and accountability systems must be

aligned to support collaborative teaching models, shared planning structures, and assessment practices that value creative and multimodal learning outcomes.

While this study contributes to a growing body of research on STEAM education, it also highlights several areas requiring further investigation. Longitudinal research is needed to examine the sustained impacts of artist-led STEM learning on students' academic trajectories, career pathways, and creative development, particularly for learners from historically marginalized groups. Future studies should also explore a wider range of educational environments, including rural, low-resource, and international contexts, to better understand how artist-led models operate under varying cultural, socioeconomic, and institutional conditions. In addition, comparative research examining artist-led and traditionally taught STEM courses would provide valuable empirical insights into the specific mechanisms through which arts integration influences learning outcomes. Mixed-methods approaches that combine qualitative classroom analysis with quantitative measures of achievement could strengthen the evidence base for STEAM pedagogy. Finally, further research is needed to address institutional and policy barriers, including credentialing requirements, funding models, and evaluation systems. Developing assessment instruments capable of capturing the multimodal and process-oriented outcomes of STEAM learning, such as creativity, systems thinking, collaboration, and aesthetic reasoning, will be essential for legitimizing and sustaining artist-led approaches within evolving STEM education ecosystems.

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Conflict of interest

The authors confirm that there is no conflict of interest involved with any parties in this research study.

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