From STEM to STEAM: Developing Transversal Skills through Arts-Integrated STEM Education

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Abstract

The persistent gender gap in STEM education, compounded by declining pupil engagement and insufficient transversal-skills development, constitutes a significant challenge across European school systems. This article argues that integrating the arts into STEM curricula - the STEAM paradigm - offers an empirically supported pathway to address these challenges simultaneously. Drawing on the FIND-STEM project (Fostering Innovations and Nurturing Diversity in STEM Education), an Erasmus+ KA210-SCH small-scale partnership in Greece, Romania, and Portugal (2025-2026), the article synthesises current research on STEAM pedagogy, gender-inclusive education, and transversal-skills development, examining how arts-based and real-world-oriented approaches - delivered through teacher CPD and digital tools such as WebQuests and Digital Breakouts - can increase pupil competence and interest in STEM, particularly among girls aged 7-14.

Keywords: *STEAM education; transversal skills; gender equality; arts integration; teacher professional development; WebQuest; Digital Breakouts; Erasmus+*

1. Introduction

Despite decades of policy investment, STEM education faces converging failures: low student engagement, limited real-world relevance, and a persistent gender gap. Women represented only 30.9% of EU STEM graduates in 2022, with gendered attitudes towards STEM crystallising as early as age six (European Commission, 2025; U.S. National Science Foundation, 2024). Bybee (2013) argues that effective STEM learning must move beyond content transmission towards inquiry-based approaches; OECD (2019) evidence confirms that students widely perceive STEM as abstract and disconnected from real life. The integration of the arts into STEM - STEAM - has emerged as a transformative response. Yakman (2008) formalised STEAM as a framework for integrative curricula contextualising science and mathematics within the full breadth of human knowledge. Henriksen (2014), studying award-winning STEM teachers, demonstrated that exceptional practitioners are deeply creative individuals, arguing that creativity is not a peripheral add-on but a core competency in STEM innovation - a position now endorsed by the EU STEM Education Strategic Plan (European Commission, 2025).

The FIND-STEM project addresses these challenges through a coherent, transnational intervention: a bespoke CPD curriculum integrating arts into STEM for at least 75 teachers, and digital learning tools including WebQuests and Digital Breakouts for 300 pupils (60% girls) across Greece, Romania, and Portugal. This article situates FIND-STEM within the evidence base on STEAM pedagogy, transversal-skills development, and gender-inclusive education.

2. STEAM: Theoretical Foundations, Empirical Evidence, and Gender Inclusion

STEAM dissolves disciplinary boundaries in the service of integrated problem-solving (Quigley et al., 2017), building on constructivist learning theory (Vygotsky, 1978). A critical caveat concerns authenticity: Herro and Quigley (2016) found that teachers frequently reduce the arts to surface-level "add-ons" rather than genuine epistemic tools. Figueiredo et al. (2024) demonstrated the difference empirically - students who created soundtracks for science animations developed both domain knowledge and transversal competences precisely because the artistic task was a real cognitive demand, not decoration.

The empirical evidence for STEAM outcomes is robust. Rodrigues-Silva and Alsina (2023), in a systematic review, found that integrated STEAM proposals consistently yield gains in creativity, critical thinking, and collaboration. Hughes et al. (2022) demonstrated that a STEAM-first instructional approach produces significantly higher science learning gains than STEM - only instruction. These transversal skills - the "21st-century skills" (OECD, 2018; Council of the European Union, 2018).

STEAM also offers a structurally coherent response to the gender gap. UNESCO (2017) identified the primary barriers to girls' STEM engagement as: lack of female role models, perceived difficulty, and limited real-life connection. Beroíza-Valenzuela and Salas-Guzmán (2024) established that the quality of early science education is the most robust predictor of girls' STEM persistence.

3. The FIND-STEM Pedagogical Model

FIND-STEM operates through three tiers. Tier 1 is teacher capacity-building: a six-module CPD curriculum- covering inquiry-based teaching, hands-on learning, digital literacy, gender equality, and assessment - delivered through face-to-face Train the Teacher Courses in all three countries. Zhou et al. (2023), in a meta-analysis of 48 experimental studies, found an effect size of $g = 0.64$ for CPD on teacher self-efficacy, and Herro and Quigley (2016) established that effective STEAM CPD must address content, pedagogy, gender inclusivity, and digital tools holistically to produce durable change in classroom practice.

Tier 2 is the WebQuest and Digital Breakouts Compendium: 18 resources built around interdisciplinary themes (sustainable cities, robotics and AI, climate change, ocean conservation, among others), available in English, Greek, Romanian, and Portuguese. WebQuests scaffold inquiry through a six-part structure promoting higher-order thinking

(Saber et al., 2024); Digital Breakouts embed STEM concepts in collaborative, game-based challenge contexts with documented positive effects on motivation for previously disengaged learners (Khan et al., 2017), reinforced by a badge system consistent with self-determination theory (Ryan & Deci, 2000). Tier 3 is dissemination: three Arts, Creativity and Fun Learning Symposiums for STEM across the three partner countries, targeting 90 teachers, counsellors, and stakeholders as a multiplier beyond the directly trained cohort.

4. Discussion and Conclusion

The evidence reviewed establishes four propositions. First, authentic arts integration develops broader transversal competences than STEM-only instruction. Second, STEAM is a structurally coherent response to the gender gap, aligning STEM learning with the engagement orientations of female pupils. Third, WebQuests and Digital Breakouts are effective STEAM vehicles when designed around authentic, interdisciplinary challenges. Fourth, holistic teacher CPD combining content knowledge, creative pedagogy, gender awareness, and digital tools is the indispensable lever for classroom transformation (Herro & Quigley, 2016; Zhou et al., 2023).

The FIND-STEM model operationalises all four within a single, transnational pedagogical architecture that directly addresses the four strategic priorities of the EU STEM Education Strategic Plan (European Commission, 2025). This model offers a theoretically grounded, replicable framework for STEAM education in European schools - demonstrating that small-scale Erasmus+ transnational partnerships can be among the most cost-effective pathways to systemic educational change.

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