Enhancing Teachers' Capacity for Inclusive and Creative STEAM Education

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Abstract

Teachers are central agents in transforming STEM education into an inclusive, creative and future-oriented learning experience. However, many European schools continue to face three interconnected challenges: insufficient teacher preparation for integrated STEAM pedagogy, persistent gender disparities in pupils' STEM participation, and limited use of real-life, digital and arts-based learning approaches. This article examines how teacher professional development can strengthen inclusive and creative STEAM education, drawing on the FIND-STEM project — Fostering Innovations and Nurturing Diversity in STEM Education — an Erasmus+ KA210-SCH partnership implemented in Greece, Romania and Portugal. The article synthesises current research on teacher professional development, arts-integrated STEM, gender inclusion and digital challenge-based learning, and analyses the FIND-STEM Continuous Professional Development Curriculum and its implementation through national teacher training workshops. Evidence from the project's training phase indicates that a structured CPD model combining project-based learning, hands-on experimentation, WebQuests, Digital Breakouts, gender-aware pedagogy and reflective assessment can significantly increase teachers' confidence and readiness to apply inclusive STEAM methodologies. The article argues that teacher capacity-building is not a supporting component of STEAM innovation but its main condition: when teachers acquire practical tools, inclusive attitudes and creative pedagogical confidence, STEM learning becomes more accessible, meaningful and attractive for diverse pupils, especially girls.

Keywords: STEAM education; teacher professional development; inclusion; gender equality; creativity; WebQuest; Digital Breakouts; Erasmus+

1. Introduction

Across Europe, STEM/STEAM education is increasingly viewed as a strategic priority for economic resilience, digital transformation and democratic participation (Roinioti et al., 2025). The European Education Area presents STEM and STEAM as approaches that develop disciplinary knowledge alongside transversal competences such as problem-solving, critical thinking, and collaboration (European Commission, 2025). Yet, the practical implementation of these goals depends largely on teachers' ability to design learning experiences that are inquiry-based, inclusive, creative and connected to pupils' lives (Segarra-Morales & Rodríguez-Miranda, 2026).

The challenge extends beyond the need for more STEM content. Many pupils experience STEM as abstract, difficult, and disconnected from personal meaning (Bybee, 2013). This is particularly critical for girls, whose participation in STEM pathways is shaped by early experiences, stereotypes, lack of role models and perceptions of belonging (UNESCO, 2017). Teachers therefore need both subject knowledge and the pedagogical capacity to connect STEM with creativity, collaboration, social relevance and future careers (Sanchez Junior & Alves de Sousa, 2023).

This need is directly addressed by the FIND-STEM project (2024). The project defines its main aim as enhancing STEM and STEAM education across Romania, Greece and Portugal by equipping teachers with innovative methodologies that are inclusive, diverse, gender-equality-oriented, real-world-based and creative. It identifies teachers as the first lever of change and links teacher training to broader objectives: increasing pupils' STEM engagement, strengthening girls' participation, developing transversal skills and connecting STEM to real-life challenges.

The project's CPD course confirms this orientation: the curriculum is designed to promote active STEM learning, project-based learning, inquiry-based learning, experiential learning, digital readiness, WebQuests, Digital Breakouts and creative learning activities. This article examines FIND-STEM as a model of teacher capacity-building for inclusive and creative STEAM education. It argues that effective STEAM professional development must integrate five dimensions: conceptual understanding of STEM/STEAM, creative and inclusive methodology, hands-on and project-based learning, digital challenge-based tools, and reflective assessment.

2. Teacher Professional Development as the Engine of STEAM Innovation

The literature on teacher professional development consistently shows that isolated training events rarely transform classroom practice unless they are practical, collaborative, content-rich and connected to teachers' real contexts (Darling-Hammond et al., 2017). In STEAM education, this requirement becomes even more important because teachers are asked to cross disciplinary boundaries, redesign tasks, manage collaborative learning and address inclusion simultaneously.

STEAM extends beyond the addition of art activities to science lessons. It is a pedagogical approach in which artistic, creative, and design-based thinking become meaningful ways of investigating and expressing scientific and technological ideas. In this sense, the teaching of STEAM is a purposeful integration across disciplines where learning tasks integrate content knowledge, inquiry, creativity, collaboration and real-world problem-solving (Quigley, Herro, & Jamil, 2017). Yakman (2008) conceptualised STEAM as an integrative framework that connects science and mathematics with the broader human and social dimensions of knowledge. Henriksen (2014) further argued that creativity is not peripheral to STEM but central to innovative STEM teaching.

However, teachers often need support to move from decorative arts integration to authentic STEAM. Herro and Quigley (2016) found that STEAM implementation requires teachers to develop new understandings of disciplinary integration, collaboration and design-based pedagogy. Professional development must therefore offer concrete classroom strategies alongside theoretical guidance. Recent evidence from Romania reinforces this need (Frentescu Tordai, Cretu, & Lavicza, 2026). While teachers increasingly recognise STEAM as valuable for developing twenty-first-century competences, their confidence in implementing STEAM practices remains moderate and participation in professional development remains limited. This gap between perceived value and implementation capacity suggests that STEAM innovation

requires structured training, curriculum alignment, assessment tools and collaborative support, especially in resource-constrained educational contexts.

The FIND-STEM CPD curriculum (2025) reflects this principle through six modules: Introduction to STEM Education; Creative and Inclusive Teaching Approaches; Methodological Framework for Hands-On Learning; Digital Literacy and Technology Integration; Addressing Gender Equality and Inclusivity; and Assessment Strategies. The course description explicitly links these modules to active STEM fundamentals, innovative instruction, project-based and inquiry-based learning, experiential learning, girls' engagement, gender equality, digital transformation and the creation of WebQuests and Digital Breakouts. This structure is important because it treats teacher capacity as multidimensional. Teachers are supported to use activities while also rethinking classroom culture, pupil participation, assessment, digital learning, and inclusion. In this sense, FIND-STEM aligns with research showing that professional development is most powerful when it combines knowledge, practice, collaboration and reflection.

3. Inclusion, Gender Equality and Creativity in STEAM Classrooms

Inclusive STEAM education requires teachers to recognise that participation in STEM is shaped by identity, confidence, classroom interaction and cultural messages about who "belongs" in science and technology. The FIND-STEM project conceptualizes gender equality as a central priority, noting that pupils' low STEM interest is linked to perceived difficulty, lack of real-life connection, lack of attractiveness and limited identification of talents and career pathways. It also highlights the need to combat gender disparities in transversal skills through equal access and stimulated interest in STEM.

This orientation corresponds with international research. UNESCO (2017) emphasised that girls' STEM participation is affected by social norms, family expectations, teaching practices and the visibility of female role models. Beroíza-Valenzuela and Salas-Guzmán (2024) similarly found that early educational experiences strongly influence girls' persistence in STEM. Therefore, inclusive STEAM pedagogy must do two things at once: challenge stereotypes and redesign learning so that pupils encounter STEM as meaningful, collaborative and open to different forms of expression.

Arts integration can contribute to this aim. Creative tasks allow pupils to model, visualise, narrate, design, perform and communicate STEM ideas through multiple modes. This can benefit diverse learners because it expands the ways pupils can enter a problem and demonstrate understanding. It also helps connect STEM with emotion, imagination and social meaning. Filipe et al. (2024) found that integrated STEAM experiences can foster the development of creativity when the artistic work is cognitively meaningful rather than decorative.

In FIND-STEM, inclusion is treated as a core principle embedded in both the content of the CPD curriculum and the methodology of teacher training. The project aims to transform STEM education by combining creativity and arts integration, gender equality and inclusion, digital innovation, and real-life learning. This reflects a clear theory of change: policy priorities can influence pupils' learning experiences only when teachers develop the confidence, attitudes, and practical competences needed to translate them into everyday classroom practice.

4. Digital Challenge-Based Learning: WebQuests and Digital Breakouts

Digital tools can either reproduce passive learning or create richer forms of inquiry. The difference lies in pedagogy. FIND-STEM focuses on WebQuests and Digital Breakouts because

both formats structure pupils' learning around challenge, collaboration, exploration and problem-solving.

WebQuests are inquiry-oriented activities in which learners use curated digital resources to investigate a problem, complete a task and produce an outcome. They are particularly suitable for STEAM education because they can combine scientific research, creative production, teamwork and real-world decision-making. Digital Breakouts, inspired by escape-room logic, ask pupils to solve puzzles and unlock challenges through critical thinking, communication and collaboration. In the FIND-STEM model they are used to make STEM more engaging, participatory and accessible.

The project planned a WebQuest and Digital Breakouts Compendium containing 18 resources, available in English, Greek, Romanian and Portuguese, connected to themes such as sustainable cities and renewable energy, robotics and artificial intelligence, climate change and biodiversity, ocean conservation, virtual reality and mathematical mysteries. These themes are significant because they connect STEM with global issues and everyday life. They also create opportunities for pupils to see STEM as socially meaningful, not merely technical.

The CPD course prepares teachers to design and use such digital resources. Its digital literacy module guides users through the steps to build WebQuests and Digital Breakouts, while its wider curriculum links digital tools to challenge-based STEAM education and inclusive classroom practice. This combination reflects the logic of the FIND-STEM CPD model: digital tools are introduced as elements of structured learning sequences in which teachers plan, guide, assess, and adapt pupils' engagement with STEM challenges.

5. Evidence from FIND-STEM Teacher Training Implementation

The FIND-STEM teacher training implementation provides encouraging evidence that short, intensive and practice-oriented CPD can strengthen teachers' confidence across multiple competence areas. According to data collected through the CPD implementation phase, 83 teachers were trained across Greece, Romania and Portugal, exceeding the original target of 45. It also reports strong confidence growth in all 10 competence areas, high readiness to implement WebQuests and Digital Breakouts, and strong reinforcement of gender-inclusive STEM approaches.

The training in Romania took place in Pitești, 18–19 November 2025 and involved 49 teachers from urban and rural schools from the Argeș region. Teachers highlighted the importance of critical thinking, creativity, hands-on experiments, digital tools and collaborative teamwork. The reported confidence scores were high: 4.55/5 in promoting critical thinking, 4.51/5 in providing hands-on activities and 4.37/5 in designing digital learning tasks.

In Greece the training was held at the 1st Primary School of Rafina on 5-6 November 2025 with 13 teachers. The Greek implementation focused on pre- and post-confidence comparison. Teachers reported gains of +2.03 in promoting gender equality and inclusion, +2.07 in evaluating their own STEM practices, +1.73 in designing project-based learning activities and +1.53 in implementing hands-on activities. Practical activities, digital resources usefulness and overall experience were rated 5.00/5.

The training was held in Estarreja, Portugal on 12, 20 and 24 November 2025 with 21 teachers. It was organised in two groups to support deeper engagement and collaboration. Teachers reported confidence gains of +2.00 in designing hands-on activities, +1.86 in implementing project-based learning, +1.68 in designing WebQuest activities and +1.41 in implementing

assessment strategies. They particularly valued the practical use of WebQuests, exchange of classroom experiences, project-based learning and inclusive classroom practices.

These findings should be interpreted as early implementation evidence rather than final impact evaluation. They measure teachers' self-reported confidence and readiness, not yet long-term changes in pupil outcomes. Nevertheless, they are highly relevant because teacher self-efficacy is a recognised predictor of pedagogical persistence and innovation. The consistency of results across three countries suggests that the FIND-STEM CPD model is transferable across different educational contexts.

6. Discussion and Conclusion

The FIND-STEM experience supports four main conclusions. First, inclusive STEAM education depends on teacher capacity. Curriculum reform, digital tools and project resources matter, but they become meaningful only when teachers can translate them into classroom practice.

Second, effective CPD must be practical and coherent. FIND-STEM's strength lies in combining theory with usable methodologies: project-based learning, inquiry, hands-on experimentation, digital challenges, gender-aware teaching, and assessment. Teachers left the training with strengthened awareness and ready-to-use approaches for classroom implementation.

Third, inclusion must be built into pedagogy. In FIND-STEM, gender equality is promoted through task design, active classroom participation, real-life relevance, collaborative learning, and recognition of diverse forms of creativity.

Fourth, digital innovation is most powerful when it supports inquiry and collaboration. WebQuests and Digital Breakouts are effective because they organise learning around meaningful challenges, structured inquiry, and shared problem-solving.

In conclusion, FIND-STEM demonstrates that teacher professional development can be a powerful mechanism for transforming STEM into inclusive and creative STEAM education. By investing in teachers first, the project creates the conditions for classrooms where pupils investigate real problems, use digital tools critically, express scientific understanding creatively and participate more equally. Its early implementation results suggest that even small-scale Erasmus+ partnerships can generate high-value pedagogical innovation when professional development is carefully designed, transnationally enriched and grounded in inclusive values.

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