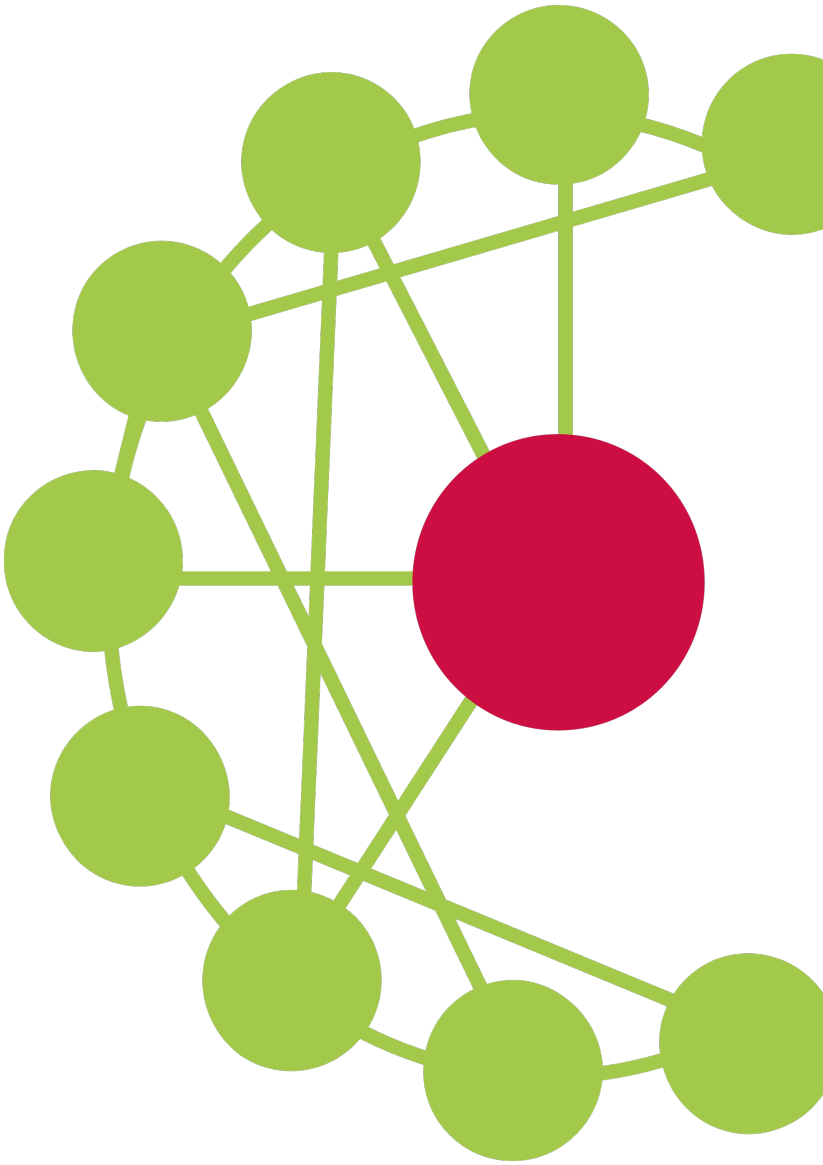
Policy Brief 3. Enhancing STEM Education in Europe through Tested Professional Learning Formats



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DISSEMINATION LEVEL	
X	PU=Public
	PP=Restricted to other program participants (including the EC)
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Executive Summary

The ICSE Academy project has developed and tested innovative professional learning formats to address key challenges in STEM teacher education across Europe. As STEM education plays a vital role in economic growth and innovation, ensuring well-trained and adaptable educators is crucial. However, disparities in STEM teacher training across European countries have created inconsistencies in access to high-quality professional learning opportunities. This policy brief presents evidence-based approaches, including job shadowing, summer schools, and a series of online teacher training called European Workshop series, that have been piloted and evaluated to enhance STEM teaching and learning. The findings indicate that interactive, collaborative, and contextually adaptable professional development formats yield the most significant benefits, helping teachers adopt innovative pedagogies and integrate European educational priorities into their practice. The evaluation of job shadowing highlighted the value of peer learning, yet language barriers and limited student interaction in online formats hindered engagement. Summer schools offered valuable interdisciplinary and intercultural experiences, but time constraints and language limitations remained challenges. The European Workshop series successfully increased teachers' confidence in using digital tools and strengthened their understanding of European priorities such as sustainability and inclusion. To ensure long-term impact, the policy brief recommends scaling up professional learning formats by improving accessibility, strengthening in-person and online engagement, and embedding European priorities in STEM education. Continued support through structured follow-ups, expanded summer school opportunities, and enhanced digital training will be essential for sustaining the progress made. These findings provide clear guidance for policymakers, teacher educators, and stakeholders committed to strengthening STEM education and professional learning at a European level.

Introduction

STEM (Science, Technology, Engineering, and Mathematics) education is critical for fostering innovation, economic growth, and preparing students for the future workforce (OECD, 2021). Furthermore, STEM education is fundamental to Europe's economic growth, innovation, and societal progress (EU STEM Coalition, 2016). The demand for STEM-related workforce is increasing in Europe, yet there remains a shortage of qualified professionals in these fields across European countries (ESDE, 2023), and this is expected to further increase in the upcoming years. Recent studies indicate that fewer than 10% of European students graduate in STEM-related disciplines, with some countries like Bulgaria, Cyprus, and Hungary reporting even lower rates (Eurostat, 2022). Therefore, STEM education has been gaining momentum (i.e. Almukhambetova et al., 2023) and has been a central element of various reform efforts and curriculum changes in EU countries (i.e. EU STEM Coalition, 2020; Fondaziaone Deloitte, 2022). Despite the emphasis on STEM education in EU countries, international study results continue to show a decline in attidutes and achievement in STEM (OECD, 2023).

Teacher professional learning plays an important role in enhancing STEM teaching and learning, by providing educators with opportunities to develop their pedagogical knowledge, integrate emerging technologies, engage in professional learning communities and exchange experiences, and adopt student-centered approaches (Morris et al., 2021). Professional learning plays a crucial role in improving STEM teaching and learning outcomes, particularly in Europe, where the need for a highly skilled and adaptable STEM teaching workforce is more pressing than ever. With rapid advancements in technology and evolving educational challenges, continuous professional learning ensures that teachers remain equipped with the latest pedagogical approaches, technological tools, and cross-disciplinary strategies to engage students effectively. Research highlights that investing in well-structured professional development formats leads to improved student achievement, increased teacher confidence, and a stronger alignment of classroom practices with contemporary STEM education priorities (Shernoff et al., 2017).

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Ensuring the improvement of STEM education requires continuous professional development for teachers and teacher educators to keep pace with evolving pedagogical practices and technological advancements, but also to support the knowledge sharing from different practices within Europe. Research highlights that teachers' content knowledge and self-efficacy directly impact student outcomes, making professional learning opportunities essential for improving STEM instruction (Evagorou & Konstantinidou, 2025). However, teacher training varies significantly across European countries, with many lacking structured programs for interdisciplinary STEM teaching (Evagorou & Konstantinidou, 2023). In-service training is often optional, and in some countries, no dedicated STEM teacher education policies exist (Evagorou, Puig, Bayram & Janeckova, 2024). This inconsistency poses challenges in preparing teachers to implement innovative, inquiry-based, and technology-enhanced STEM teaching methods. Additionally, STEM teacher professional development must address broader societal concerns, such as inclusion, sustainability, and gender equity in STEM fields (OECD, 2021). The ICSE Academy project aims to bridge these gaps by promoting collaborative learning formats, including job shadowing, summer schools, and a European Workshop series (online training) for STEM teachers and teacher educators, fostering a more cohesive and effective European STEM education strategy (Konstantinidou & Evagorou, 2024). Strengthening professional learning at the European level ensures that STEM teachers are well-equipped to engage students in meaningful and future-oriented STEM learning experiences.

This policy brief presents tested professional learning formats designed to enhance STEM education across Europe. These formats were developed as part of the ICSE Academy, a three-year project funded under Erasmus+ (Erasmus-EDU-2021-PEX-TEACH-ACA) that began in June 2022 and will conclude in May 2025. The project brings together a consortium of 13 higher education institutions (HEIs) from 13 European countries, along with educational policymakers and model schools as associated partners. The geographical distribution of the ICSE Academy partners spans from Spain in the South-West to Turkey in the East and Norway in the North, covering diverse cultural, social, and economic backgrounds. This diversity ensures that the project develops and tests professional learning formats in a wide range of contextual settings, enhancing their transferability and scalability across Europe.

The Context: ICSE Academy

ICSE Academy focuses on three core missions: (1) establishing a sustainable European partnership for STEM teacher education, (2) developing and testing effective, accessible, and transferable professional learning models for pre- and in-service STEM teachers, and (3) informing policy on evidence-based approaches to STEM teacher education. Through collaboration, mobility, and an emphasis on a European dimension, the project aims to address critical challenges such as the shortage of qualified STEM teachers, and the integration of digital and sustainable development skills into STEM teaching. The professional learning formats tested during the project include job shadowing of STEM educators and application of job shadowing insights through case studies, summer schools for STEM teacher professional development, and European Workshop series. These approaches ensure that STEM educators are supported in adopting innovative and research-based teaching practices while fostering cross-border cooperation and knowledge exchange across Europe. By synthesizing lessons learned from these tested formats, this policy brief provides key recommendations for policymakers, teacher educators, and stakeholders committed to strengthening STEM teacher education and professional learning across Europe.

Job Shadowing

Job shadowing in the ICSE Academy was designed as a peer-learning format where STEM initial teacher education (ITE) and continuous professional development (CPD) providers observed each other's teaching sessions. Job shadowing was conducted mainly online, with some in-person sessions, and the aim was to allow educators to learn from best practices across different European contexts. The process involved two phases: (1) attending and reflecting on the observed session, and (2) adapting and testing the session in the shadowing partner's own context.

Summer Schools

The summer schools were designed as immersive, interactive professional development experiences for STEM in-service and pre-service teachers. Two summer schools were held: one in Utrecht (2023) and one in Prague (2024). These programs featured lectures, seminars, and

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workshops on topics such as inquiry-based learning, interdisciplinary teaching, sustainability, diversity, and the use of technology in STEM education.

European Workshop series

The online professional development format called European Workshop series consisted of a structured series of workshops delivered in Moodle with Webex for the live sessions. The workshops covered EU priorities, including digital competencies, sustainability, and inclusion, while also addressing STEM-specific pedagogical approaches as shown in Table 1 below. The online European Workshop series was divided in three Clusters, with each Cluster consisting of three sessions.

Table 1. Outline of European Workshop series

Cluster	Description	Duration
Trends in STEM Education	Explores modern STEM education approaches, focusing on inquiry-based learning, sustainability in STEM education, transdisciplinary teaching, and socio-scientific issues.	3 sessions per cluster, 2 hours per cluster
Diversity and Inclusion	Focuses on inclusive teaching strategies, task redesign for diverse classrooms, and equity in STEM education.	3 sessions per cluster, 2 hours per cluster
Technology and Digital Competences	Covers digital competencies, including AI, 3D printing, and gamified learning for STEM instruction.	3 sessions per cluster, 2 hours per cluster
Assessment in STEM	Examines formative and summative assessment methods used across different European educational systems.	3 sessions per cluster, 2 hours per cluster

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Methodology

The different professional development formats were contacted in different stages of the ICSE Academy. The job shadowing process was divided into two phases: In the first phase, participants observed the sessions and provided feedback and reflections on their potential transferability. The second phase involved adapting the observed session based on the feedback and testing its implementation in a different context. Data collection for job shadowing relied on a structured reporting template that included descriptions of the activity, its objectives, the participants involved, and the learning questions of the shadowing partner. Additionally, participants provided summaries of their observations, as well as reflections on the lessons learned. To ensure a more comprehensive evaluation, a detailed lesson observation form was later introduced.

Summer schools: In total**,** 54 teachers and future teachers attended the Utrecht summer school**,** while the Prague summer school had 41 participants from 11 countries**.** Data collection for evaluating the summer schools involved pre-event surveys to gather background information on participants, as well as post-event evaluation surveys that assessed knowledge gains, engagement levels, and the perceived relevance of the content.

European Workshop series: 295 teachers participated in the pre-test phase, with 212 completing the post-test. Data collection for the online European Workshop series involved administering pre-workshop questionnaires to measure teachers' motivation for the teaching career, attitudes towards internationalization, teacher professional development needs related to the European priorities and knowledge and skills to integrated those European priorities into STEM teaching. Participants also provided reflections on the effectiveness of the sessions.

Findings and Analysis

Job Shadowing

Findings indicated that job shadowing was informative and inspiring, though online sessions were sometimes limited by language barriers and lack of interaction with students. A case study approach was used to assess the effectiveness, accessibility, and transferability of professional

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learning activities that were job-shadowed across the 13 partner countries. Each country conducted an in-depth investigation of one professional development activity that was job-shadowed, gathering data through semi-structured interviews, observations, and reflections from the professional learning providers. The findings were used to identify best practices and determine which activities could be successfully transferred to other contexts. Key insights revealed that professional development was most effective when it was practical, hands-on, and aligned with teachers' everyday challenges. The evaluation of job shadowing activities indicated that the format was widely appreciated by participants, with many noting that observing different educational approaches was both informative and inspiring. A key takeaway from the job shadowing experiences was the recognition that on-site visits provided significantly richer insights compared to online observations. Participants often found it challenging to fully grasp the depth of interactions in online settings. One observer commented, *"Although it wasn't possible for me to follow the group work and parts of the discussion afterwards (due to technical reasons), I got some fresh perspectives on diversity and inclusion in science education"*.

Language barriers emerged as a recurring issue, particularly for observers who did not understand the language spoken in the observed class. In some cases, this challenge was mitigated through access to translated pre-session materials. However, *"Observers struggled to follow the content when it was presented in a language that they were not familiar with. Some felt this hindered their full participation (D4.1)"*. Despite this, participants found that many of the pedagogical techniques observed were adaptable to different contexts.

A notable challenge in job shadowing was the difficulty of adapting particular observed lessons to different educational contexts**.** While some methods were easily transferable, others required specific institutional support, such as laboratory resources or smaller class sizes, which were not always available. As one observer in Lithuania pointed out, *"If universities do not have access to the necessary resources, it would be difficult to implement the same methods"*. Time constraints were also a factor, as sessions were sometimes too short for observers to engage deeply with the materials and discussions.

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Summer Schools

Feedback highlighted the strengths of the program, particularly in terms of intercultural exchange and the opportunity to apply learning to classroom settings. However, some participants noted challenges, such as the need for more structured guidance and difficulties in maintaining interdisciplinary balance. A participant commented, “The summer school provided me with valuable insights into STEM education from different cultural perspectives, but I found it challenging to apply all concepts directly to my own teaching” (D3.1). Feedback from participants highlighted the importance of intercultural collaboration and interdisciplinary learning. A participant from the Prague summer school noted, *"Working and learning with learners from all over the world increased my intercultural competence”*. Another participant from the Utrecht summer school emphasized the balance between theoretical and practical learning, stating, *"The workshops focused both on general didactical approaches and also offered a variety of activities that could be incorporated in the classroom”*.

However, some participants faced challenges related to time constraints and the applicability of certain content to their own teaching environments. One participant remarked, *"Our educational system is not ready for this kind of transformation"*, suggesting that while the summer school provided innovative teaching methods, local curriculum constraints sometimes made implementation difficult. Another challenge identified was language barriers, with some participants struggling to follow oral instructions in English. It was recommended that future summer schools include written guidelines for activities to accommodate diverse language abilities.

One of the key successes of the summer schools was their emphasis on hands-on learning and group collaboration. Activities such as design thinking workshops and socio-scientific issues discussions allowed participants to actively engage with new teaching methodologies. The success of these methods suggests that active-learning strategies are more transferable across different educational systems compared to more theoretical approaches.

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European Workshop series

The evaluation of the European Workshop series, as assessed through the pre- and post-questionnaire responses, revealed significant insights into teachers' motivation, professional development needs, and their evolving perceptions of European priorities such as sustainability, digitalization, and inclusion in STEM education. A detailed analysis of the findings from the evaluation is available in Quesada, Ariza, Abril, Pecina and Mass (2025). The results indicated that teachers entered the program with high motivation levels, particularly regarding their enthusiasm for the teaching profession and their openness to international collaboration. These levels remained stable throughout the program, with no significant decline, suggesting that participation in the ICSE Academy helped sustain their engagement. One of the key findings was that teachers who initially had moderate exposure to European priorities exhibited a notable increase in their awareness and perceived importance of integrating these elements into their teaching practices. As one participant noted, *"Before the training, I was aware of sustainability issues, but now I feel equipped with practical strategies to embed them in my science curriculum"*.

A crucial outcome of the evaluation was the significant improvement in teachers' self-reported knowledge and skills concerning digital tools and interdisciplinary STEM teaching, indicating that participants felt more confident in applying these concepts in their classrooms. Teachers' perceived need for professional development increased after training, indicating that new methods and priorities increased their awareness of continuous learning. One respondent stated, *"The training made me realize how much more I need to learn, especially about using AI and technology effectively in STEM education"*. Despite these gains, challenges remained, particularly in maintaining engagement in an online format and ensuring that all participants could fully translate their learning into practice. However, the overwhelmingly positive responses, with over 60% of teachers expressing a strong willingness to participate in similar training in the future, underscored the program's effectiveness in fostering ongoing professional growth and reinforcing the importance of European educational priorities in STEM teaching.

The evaluation also highlighted several challenges and areas for improvement in the online training program. While the increase in teachers' knowledge and skills was evident, some participants reported difficulties in fully engaging with the content due to the online format. Technical issues,

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such as connectivity problems and unfamiliarity with digital tools, were common barriers. As one participant noted, *"Some of the activities were difficult to follow due to internet disruptions, and I would have benefited from additional technical support"*. Another challenge was the variation in prior knowledge among participants, with some teachers struggling to keep up with advanced digital competencies while others found certain sessions too basic. Additionally, while international collaboration was a key component of the program, time zone differences and asynchronous communication limited real-time interaction among participants from different countries. Despite these challenges, teachers overwhelmingly valued the structured approach to integrating European priorities into STEM education. The study also revealed that while motivation remained stable, long-term engagement with professional development remained a concern, with some teachers expressing the need for more follow-up support to sustain their learning. A participant emphasized this point, stating, *"I now see the value of digitalization in education, but I need continued guidance on how to implement it effectively in my classroom"*. These findings suggest that while the online training successfully enhanced teachers' competencies, future programs could benefit from additional scaffolding, technical support, and more structured follow-up initiatives to ensure sustained impact.

In conclusion, the evaluation methodologies for job shadowing, case studies, summer schools, and the European Workshop series were designed to assess effectiveness, accessibility, and transferability across different professional learning formats. The use of qualitative and quantitative data collection methods provided valuable insights into the strengths and challenges of each approach. While the online aspects of the professional learning formats increased accessibility, language barriers and engagement difficulties posed challenges. Similarly, job shadowing and summer schools facilitated valuable cross-border learning experiences, but required further adaptation to different educational contexts. Future iterations could benefit from enhanced scaffolding, multilingual support, and structured pre-training sessions to improve participation and knowledge retention across all professional learning formats.

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Key Insights

The policy brief highlights the urgent need to enhance STEM education across Europe through structured and evidence-based professional learning formats. The ICSE Academy has tested and refined various approaches, including job shadowing, summer schools, and the European Workshop series, to bridge gaps in STEM teacher training. Findings suggest that professional learning formats are most effective when they are practical, interactive, and aligned with teachers' daily challenges. The evaluation of job shadowing revealed that peer observation significantly contributes to professional growth, but online-only shadowing limits engagement due to language barriers and the lack of direct student interaction. Teachers participating in summer schools benefited from intercultural exchanges and interdisciplinary collaboration, yet time constraints and language limitations posed challenges to full engagement. Meanwhile, the European Workshop series was successful in enhancing teachers' confidence in integrating digital tools and European priorities into STEM education, though issues such as varying levels of digital competence and difficulties with real-time interaction affected participation.

A central theme of the policy brief is the importance of professional learning formats that incorporate European educational priorities, particularly sustainability, inclusion, and digitalization. Teachers who participated in the project gained a deeper understanding of these priorities and felt better equipped to implement them in their classrooms. The findings underscore that motivation for professional development remains high, but there is a need for ongoing support and structured follow-up initiatives to ensure lasting impact. The brief calls for scalable and transferable professional learning models that can be adapted across diverse educational contexts, ensuring that all STEM educators—regardless of location—have access to high-quality training opportunities.

Recommendations

- **Mobility**: Mobility is not promoted adequately enough among teachers, especially given the finding that only 30% of teachers have participated in international mobility. The requirements

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for participation in such events through Erasmus+ KA1 for Teachers and Blended Intensive Learning Programs are quite low. An important recommendation is to place an emphasis on disseminating such training events in teacher audiences and supporting them with the application process.

- **Upgrading teaching habits to meet the needs of the 21st century**: ICSE Academy has provided evidence the European Worskhop series had a medium to strong impact on teachers beliefs on their need for professional development. This implies that teacher training can potentially support the demand of further professional development of teachers, change their teaching habits and in the long term increase the teaching quality. An important recommendation is to provide consistetly online teacher training.
- **Increase accessibility to professional learning**: Ensure that all STEM educators, regardless of location, have access to structured, research-based professional development opportunities. Teacher training events with easy application processes, like the summer schools, or similar intensive formats can be used to attract teachers across Europe, increase mobility among teaches and especially improve their attitudes towards mobility.
- **Enhance the effectiveness of job shadowing**: Prioritise in-person shadowing experiences that can give more interaction between the educators, or provide structured translation and interactive support for online sessions.
- **Address digital competency gaps**: Some of the teachers experienced technical difficulties , or difficulties linked to a diverse range of digital skilss that have hindered their participation in the online training. One recommendation is to offer scaffolded training for teachers with different levels of digital literacy to ensure full engagement with technology-enhanced learning.
- **Foster cross-border collaboration**: Encourage European-level networking opportunities and partnerships to support long-term professional growth and exchange of good practices and practical activities that have been proven to work in other countries.

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