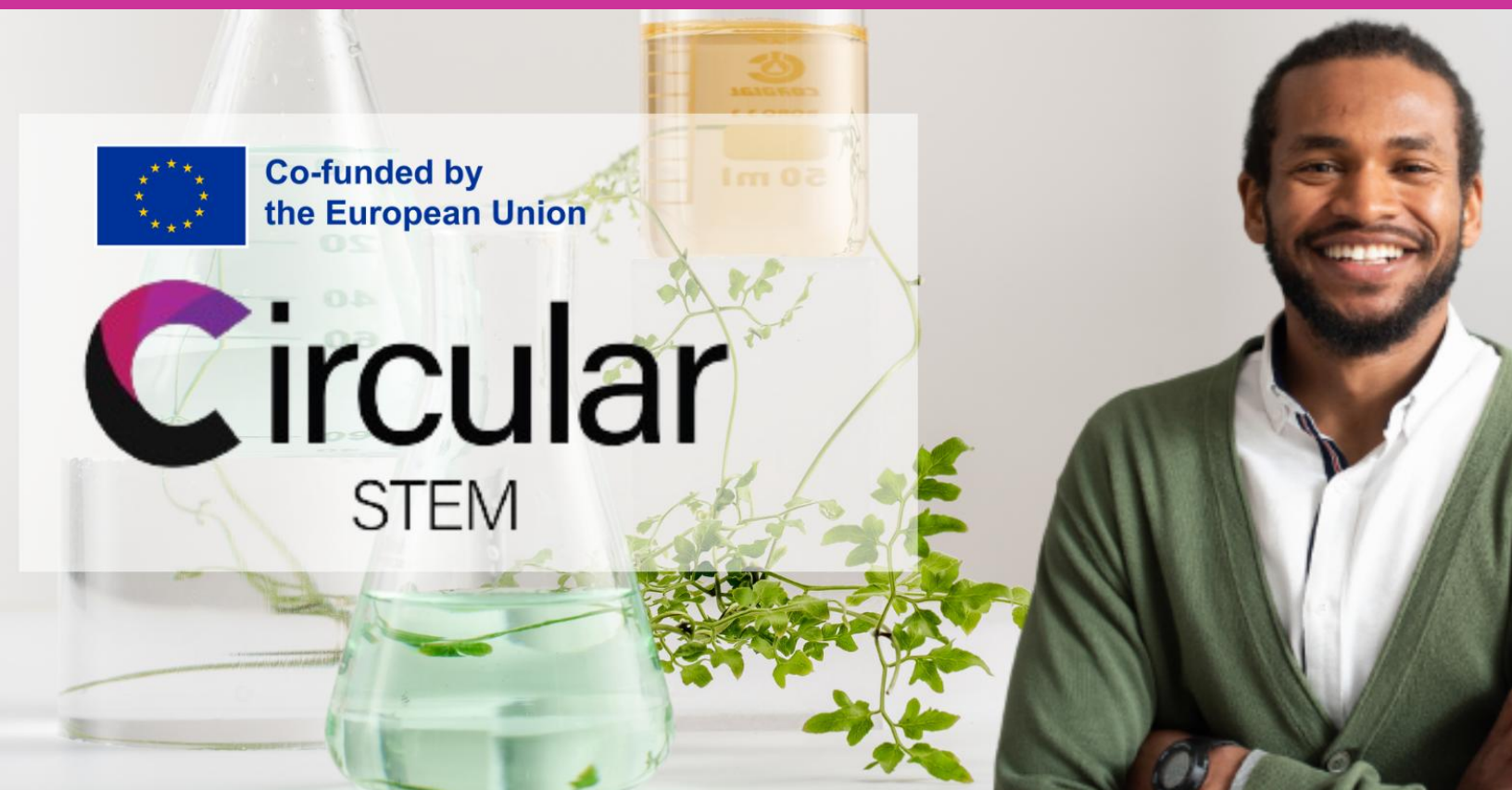




Policy Paper



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Circular STEM

Circular STEM

Boosting Circular Economy Competences for STEM

Teachers



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CONSORTIUM:

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 - Agrupamento de Escolas de Frazão Paços de Ferreira (Portugal) – <http://aefrazao.wix.com>
- Partners:
 - European Digital Learning Network ETS (Italy) – www.dlearn.eu
 - Institute for Contemporary Education (ICE) (Serbia) - <https://www.linkgroup.eu/institutecontemporaryeducation>
 - Politeknika Ikastegia Txorierri (Spain) - www.txorierri.net
 - EKA University of Applied Sciences (Latvia) - www.eka.edu.lv
 - EIT RawMaterials (Germany) -

Website:

<https://circularstem.eu/>

Social media

 Circular STEM

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Executive Summary

The Circular STEM project integrates Circular Economy (CE) principles into secondary Science, Technology, Engineering, and Mathematics (STEM) education to equip students for Europe's green and digital transitions. Despite EU commitments like GreenComp, most schools lack the resources, training, and policy support to embed CE meaningfully into classrooms (Bianchi et al., 2022).

Launched in 2022 with Erasmus+ funding, the project delivers a six-module teacher training program, a digital learning platform, and a Toolbox of 80+ practical resources. These tools promote interdisciplinary, project-based, and inclusive learning.

Pilots across three countries showed strong impact: students engaged with sustainability challenges, and teachers felt empowered to teach CE. Yet, systemic barriers remain. Fragmented curricula, digital gaps, and persistent gender inequality in STEM.

This paper calls for urgent policy reforms in four areas: curriculum integration, mandatory teacher training, investment in digital tools, and inclusive education strategies. Circular STEM offers a tested, scalable model to mainstream sustainability in STEM—what's needed now is bold policy action.



Why Circular Economy in STEM, and Why Now?

Europe's environmental and digital transitions demand a transformation in how we educate. STEM education, long associated with technical knowledge and innovation, must now respond to the urgent challenges of climate change, biodiversity loss, and resource depletion. CE principles provide a timely and necessary framework to guide this shift.

The CE model moves beyond the linear approach of take, make, and dispose. It focuses on resource regeneration, waste minimisation, system redesign, and long-term sustainability. Integrating CE into STEM subjects gives students a more applied understanding of scientific knowledge. It helps them see chemistry, physics, biology, and engineering as tools for solving real-world problems, not just academic disciplines.

Despite decades of EU-level efforts to promote environmental education through strategies such as GreenComp and the European Education Area, CE is still missing from most national STEM curricula. When sustainability is addressed, it is often fragmented, optional, or disconnected from core STEM learning. Teachers report lacking institutional support, professional development, and access to usable classroom resources. Equity gaps persist as well, with girls and students from underserved communities continuing to be underrepresented in both STEM and green skill pathways (Bianchi et al., 2022; European Commission, 2020).

The Circular STEM project was launched to address these gaps. It combines teacher training, interdisciplinary pedagogies, and a digital learning platform to bring CE into classrooms. The initiative supports educators through a modular training program and resource toolbox that aligns with EU frameworks including GreenComp, DigComp, and EntreComp. It also emphasises inclusive, learner-centred education by collaborating with initiatives like [Girls Go Circular](#) and



prioritising access for underrepresented groups (Bacigalupo et al., 2016; Bianchi et al., 2022; Vuorikari et al., 2022).

This policy paper builds on the findings, methodologies, and lessons learned from the Circular STEM project, translating its innovative approaches into concrete policy recommendations aimed at integrating circular economy education within STEM subjects in secondary schools across the EU. It offers evidence-based recommendations for embedding CE competences into STEM education systems across Europe. Strengthening these links is not just a matter of curriculum reform, but of ensuring that the next generation can lead Europe toward a more sustainable, equitable, and resilient future.



Policy Context

The European Green Deal and initiatives like GreenComp, the European Education Area, and the Digital Education Action Plan (2021–2027) emphasize the role of education in Europe's green and digital transitions, calling for sustainability to be embedded in curricula and for ongoing teacher training. However, implementation remains inconsistent across Europe (Bianchi et al., 2022; European Commission 2020).

The Circular STEM project (2022–2025) addresses this gap by strengthening the integration of CE competences in STEM education. This policy paper draws on findings from focus groups held in Italy, Spain, Portugal, Germany, Latvia, and Serbia with over 60 STEM educators and experts (September–October 2023). These discussions, alongside a review of national curricula and resources, identified gaps in CE integration and informed the project's future training and teaching resources.

Key Findings from The Report

- In Italy and Spain, CE is discussed more in the context of civic education than science or technology courses. Teacher training on sustainability is rare or voluntary.
- Germany offers curricular autonomy to schools, but integration of CE into STEM subjects is uncommon and relies on individual initiatives.
- In Serbia, CE is not present in national curricula, and there is no formal teacher training on the topic. Educators report a strong interest in sustainability, but lack of resources and guidance prevents implementation.
- Latvia and Portugal show some promising examples of school-based sustainability projects, yet there is no national framework for embedding CE into STEM learning.

Across all countries, teachers report a lack of structured training, teaching materials, and access to digital resources for incorporating CE into their subjects. There is also little coordination between national education strategies and EU-level policy tools like GreenComp.



Identified Gaps and the Added Value of Circular STEM

The key gaps identified through national focus groups and document review include:

- Low integration of CE competences into core STEM subjects, due to absence of clear frameworks, examples, and institutional support.
- Insufficient teacher training and professional development, especially in terms of interdisciplinary teaching and the use of learner-centered and challenge-based pedagogies.
- Gender imbalance in STEM education remains a persistent issue, with underrepresentation of girls in science and technology pathways across all countries.

The Circular STEM project directly addresses these challenges by:

- Developing practical methodologies and resources for embedding CE competences into STEM education, aligned with GreenComp;
- Supporting teachers through structured continuous professional development (CPD) pathways that promote digital literacy, sustainability teaching, and inclusive classroom practices.
- Promoting gender-sensitive approaches to engage all learners in future-relevant fields.

By responding to real needs on the ground, this Policy Paper aims to bridge the gap between EU ambitions and classroom realities, contributing to a more coherent, effective, and inclusive approach to teaching CE through STEM subjects.



Project Outcomes

As it has been mentioned, the Circular STEM project aims to equip teachers with the necessary tools and methodologies to integrate CE principles into STEM education. Through collaborative development among project partners, stakeholder inputs, and field testing, the project has produced a complete training program and e-learning platform that will bring CE to life in classrooms. The outcomes support the goal of integrating sustainability competencies among students—through an entrepreneurial and digitally empowered approach—fostering technical expertise, ethical awareness, and a forward-thinking mindset.

Training Modules Overview

The training methodology consists of six modules that combine theoretical learning with practical activities, emphasizing real-world application, digital literacy, and critical thinking. The training structure was based on an integrated framework developed by the project partners and tested through pilot activities.



FIGURE 1. MODULES

Module 1. Introduction to Circular Economy

Focuses on key CE principles, comparisons between linear and circular models, economic and technological benefits of CE, explanation of eco-design, and real-life applications. Includes interactive activities like creation of infographics and domestic upcycling.

Module 2. Environmental Sustainability and Impact

Covers climate change, biodiversity, responsible consumption, renewable energy, and policy frameworks such as the EU Green Deal. Includes simulations and games for digital learning.

Module 3. STEM in Circular Economy

Demonstrates the interdisciplinary application of STEM for CE, showcasing innovations in recycling, energy, and resource optimization. Includes student challenges and real-world case studies.

Module 4. Digital Literacy and Tools in Circular Economy

Explores the application of digital technologies such as IoT, AR/VR, blockchain and simulation software for understanding and managing circular systems. Includes collaborative platforms and virtual workshops.

Module 5. Circular Economy Challenges and Projects

Presents real and proposed projects addressing CE challenges such as product lifespan extension and reuse of resources (e.g., coffee grounds, used oil, fashion waste). Includes group work and lab-based activities.

Module 6. Career Paths and Future Trends

Helps students and teachers explore emerging career options in CE and sustainability, covering future trends, job roles, skills, and professional development.



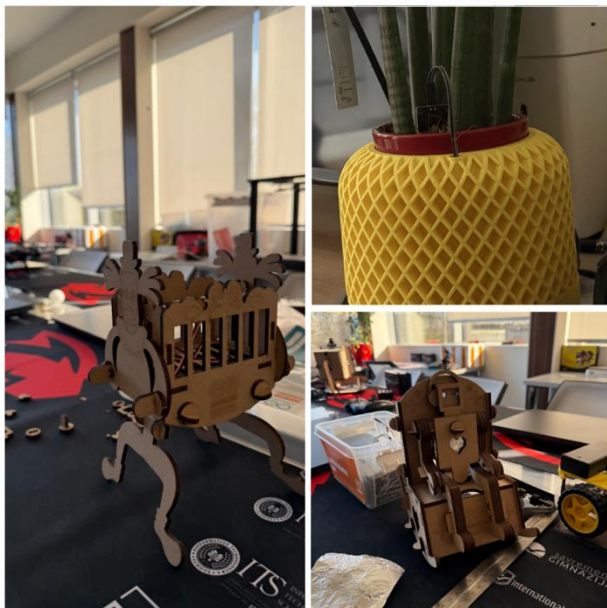
Summary of Pilot Activities

Pilot testing activities were carried out by project partner schools to assess the relevance, engagement level, and educational value of the training materials. Activities were conducted with students from Politeknika Txorierri, Agrupamento de Escolas de Frazão, and the Institute for Contemporary Education (ICE). These activities helped students understand sustainability concepts, apply CE knowledge in real-life scenarios, and develop key competences from the GreenComp and DigComp frameworks.

The activities that were carried out covered topics such as eco-design, sustainable consumption, climate change, resource-efficient



agriculture, and waste reduction. Students explored eco-design and CE principles by creating infographics and videos, which helped them deepen their understanding of sustainability ideas in a creative way. They also addressed the environmental impact of fast fashion by upcycling old textiles and organizing a second-hand market.



Besides, students participated in practical activities like creating a hydroponic garden, to learn about innovative and soil-free farming techniques; and they also took part in an experiment where they transformed cooking oil into soap, so they could realize that

everyday waste can be reused and repurposed.

These pilot activities supported that the training modules were effective in improving students' understanding of CE. It proved how CE can be easily introduced into STEM education through interdisciplinary, hands-on learning that fosters problem-solving, innovative, and sustainability-oriented mindsets. Educators found the training structure flexible and adaptable to various teaching contexts, enabling them to incorporate CE principles into both theoretical lessons and practical activities.

Training Modules and Toolbox

The Circular STEM project focused on enhancing CE competences in STEM education, has resulted in the creation of a high-quality digital learning environment. Complementing the six modules is the Circular STEM Toolbox, a core resource offering over 80 tools and materials. The Toolbox is divided into five main thematic parts, each aligned with specific learning objectives:

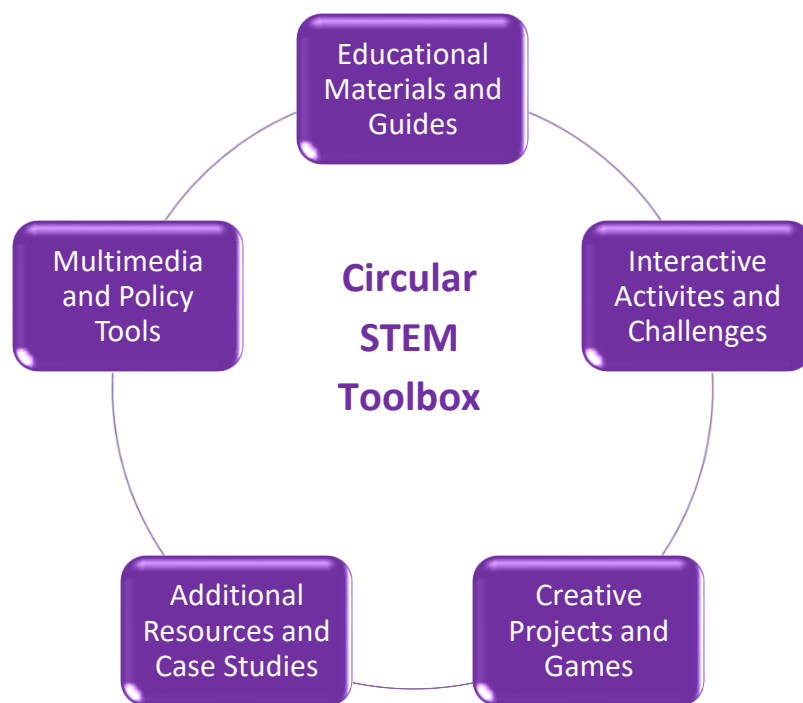


FIGURE 2. TOOLBOX

Educational Materials and Guides – Includes introductory lessons and conceptual resources such as Challenging Common Conceptions, Designing for a Circular Economy, and thematic videos.

Interactive Activities and Challenges – Hands-on tools like Product Lifecycle Analysis, Eco-Footprint Warrior, and team challenges designed to encourage problem-solving and collaboration.

Creative Projects and Games – Practical, student-friendly tasks such as upcycling competitions, idea generation for circular businesses, and games like the Circular Economy Puzzle.

Multimedia and Policy Tools – A diverse mix of infographics, research reports, policy simulations (e.g. Global Climate Policy Summit), and video materials.

Additional Resources and Case Studies – Climate-related tools (e.g. Footprint Calculator, Climate Reanalyzer), case studies, and evaluation tools including quizzes and self-assessment tasks.

The Toolbox combines newly created materials with carefully curated external resources, supporting multiple learning styles and teaching formats. It is designed to be adaptable, interactive, and inclusive.

Testing and Teacher Engagement

The platform and its resources underwent two structured testing phases to ensure quality, usability, and relevance:

During the Alpha Test, conducted by internal project staff across six partner institutions, teachers evaluated the platform's design, content, interactivity, and overall usability. They praised the logical structure, richness of resources, and ease of navigation. Recommendations were made to improve font sizing, mobile compatibility, forum accessibility, and the visibility of interactive components. This feedback directly informed platform refinements.

The Beta Test involved 15 external teachers across three partner countries who had not previously engaged with the project.

Their evaluations were overwhelmingly positive, with most scoring the platform and materials between 8 and 10 out of 10 across all categories.

Teachers appreciated the content's clarity, practicality, and alignment with school curricula. Suggestions included the addition of a visual map of resources and improvements to document viewing functionality. The Toolbox's balance of theory and practice, along with its inclusion of games and challenges, was particularly well received.

"The platform is functional and intuitive, offering up-to-date and well-structured educational resources. The Toolbox contains rich and practical content, aligned with the principles of the circular economy. The digital environment is highly interactive, making it engaging for users."

Mónica Costeira
Teacher

Digital Tools and Inclusion

A core strength of the Circular STEM platform is its integration of digital tools and inclusive practices. The Moodle environment supports independent, self-paced exploration, while embedded videos, quizzes, simulations, and forums promote engagement. The materials were developed to accommodate different learner

profiles and teaching contexts, with attention given to accessibility, screen readability, and device compatibility.

While the main language of delivery is English, feedback from participants highlighted the need for multilingual support and simplified navigation to ensure broader accessibility, particularly for non-native speakers and mobile users. These improvements are currently under review for the platform's final release.



Policy Challenges in Embedding Circular Economy Competences in STEM Education

The integration of CE competences into STEM education presents several critical policy challenges that hinder systemic change across European education systems. The most pressing include fragmented curricula, unequal access to teacher training, a lack of practical teaching resources, and persistent gender disparities in STEM-related fields. Addressing these barriers requires harmonised action at both the European and national levels, underpinned by aligned curriculum frameworks, teacher professional development policies, and inclusion strategies.

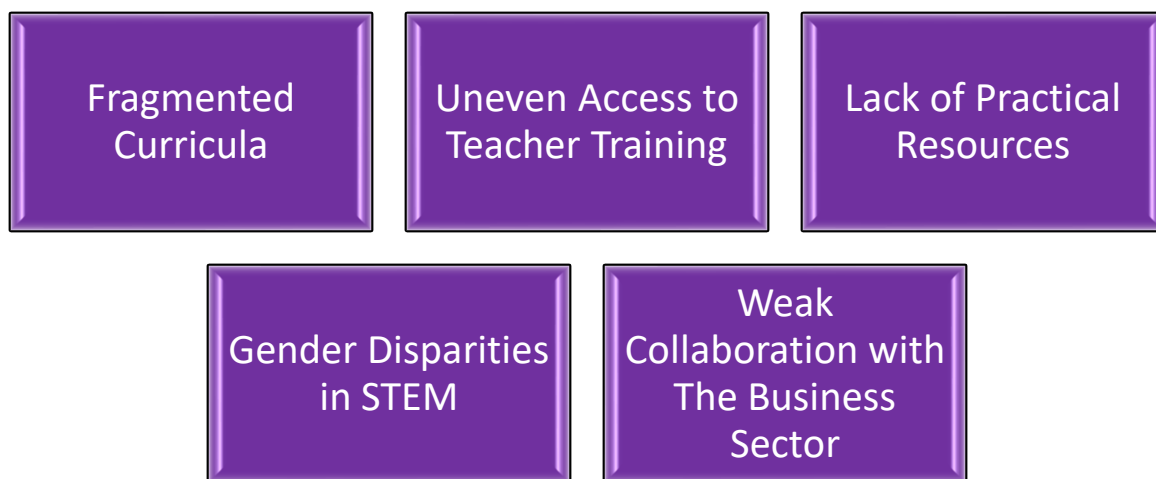


FIGURE 3. POLICY CHALLENGES

Fragmented Curricula

Curricular fragmentation remains a structural challenge across EU Member States. In Portugal, for example, despite recent reforms such as the Perfil dos Alunos à Saída da Escolaridade Obrigatória (2017), which promotes key competences including sustainability and problem-solving, implementation across disciplines remains uneven. Similarly, European initiatives like the European Education Area (European Commission, 2020) call for more coherent curricular approaches, yet

integration of CE themes within STEM subjects is still sporadic. Effective policy must ensure that CE concepts are embedded as cross-cutting themes throughout science, technology, engineering, and mathematics education, as recommended in the GreenComp framework (Bianchi et al., 2022).

Uneven Access to Teacher Training

Access to CPD that includes CE competences is inconsistent. The Portuguese National Strategy for Environmental Education 2020 (ENEA 2020) promotes lifelong environmental education but lacks specific focus on CE within STEM. At the EU level, the Digital Education Action Plan 2021–2027 highlights the need for teacher training in green and digital skills, yet implementation depends heavily on national structures. A coordinated policy is needed to mandate and fund CE-related CPD, particularly using flexible, modular formats to accommodate varying teacher schedules and contexts (Agência Portuguesa do Ambiente 2017; European Commission 2020).

Lack of Practical Resources

Many educators lack access to engaging, real-world teaching materials. Initiatives such as the [Circular STEM Academy](#) (developed within this project) and the European Schoolnet’s repository of resources aim to fill this gap, but broader dissemination and integration into official curricula are necessary. The Portuguese curriculum reform of “Aprendizagens Essenciais” allows some flexibility for contextualised, project-based learning, yet CE topics are not explicitly prioritised.

Gender Disparities in STEM

The underrepresentation of girls in STEM, especially in fields related to engineering and technology, continues to pose a significant challenge. European policy, including the Gender Equality Strategy 2020–2025, and Portuguese education initiatives (such as “Engenheiras por um Dia”) promote gender-inclusive approaches, but sustained impact requires structural curriculum reform and

inclusive pedagogical strategies. Embedding CE themes—which resonate strongly with values of care, equity, and future-oriented responsibility—can help attract more girls into STEM by connecting science with societal relevance.

To overcome these challenges, EU and national policymakers must enact targeted reforms that align curricula with CE principles, ensure equitable access to teacher training, invest in high-quality teaching resources, and promote gender equity in STEM education. Aligning these efforts with frameworks such as GreenComp, ENEA 2020, and Perfil dos Alunos can ensure meaningful and sustainable change.

Weak Collaboration with The Business Sector

Collaboration between schools/universities and companies engaged in circular practices is still poorly supported by public policies. There is a lack of programmes linking STEM education to the real-world context of the circular economy, such as internships, interdisciplinary projects, or industrial challenges. This disconnect limits students' acquisition of practical skills and the potential for joint innovation between the education and business sectors.



Policy Recommendations

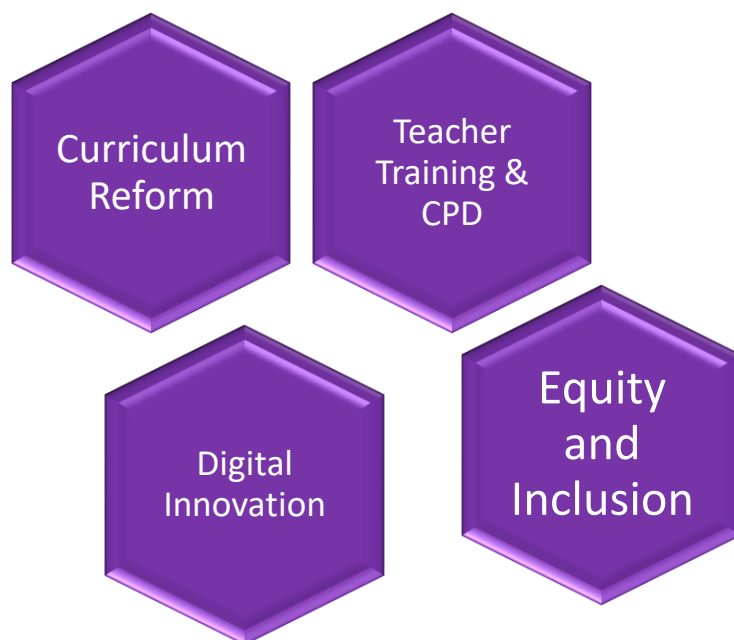


FIGURE 4. POLICY RECOMMENDATIONS

Curriculum Reform

Integrating CE principles into STEM education requires a shift from traditional, siloed subject teaching to a cross-disciplinary, learner-centred model that reflects the interconnected challenges of the 21st century. The Circular STEM project promotes embedding CE concepts across all STEM disciplines using real-life, local sustainability problems that resonate with students and support systemic thinking.

The training developed in the project supports this approach through project-based learning (PBL), inquiry-based methods, and the integration of digital tools. Lessons incorporate eco-design, life cycle thinking, energy/resource management, and sustainable innovation all within familiar STEM contexts.

Curricula should align with the GreenComp framework, fostering competencies such as systems thinking, adaptability, and acting for sustainability. Modules should

be modular, flexible, and co-designed with teachers, allowing alignment with national education priorities and classroom realities.

Key Policy Recommendations:

- Integrate CE into national STEM curricula through real-life, interdisciplinary challenges.
- Align curricular content with GreenComp, EntreComp, and DigComp to support systems thinking and innovation.
- Provide curricular toolkits that support localized implementation and hands-on project work.

Teacher Training & Continuous Professional Development (CPD)

To successfully embed CE education into STEM, teachers must be equipped with the right knowledge, tools, and pedagogical strategies. The Circular STEM project has developed a comprehensive teacher training programme consisting of six modules, covering CE fundamentals, environmental impact, STEM applications, digital tools, real-world challenges, and green career paths.

The training draws on GreenComp, EntreComp, and DigComp frameworks, and emphasizes active, inclusive, and gender-sensitive learning. Teachers engage in simulations, design thinking, data analysis, and collaborative digital activities to build confidence in delivering CE-related STEM content.

Training is delivered through a flexible e-learning platform – the [Circular STEM Academy](#) – offering self-paced, modular content accessible to all educators regardless of background or location.

Key Policy Recommendations:

- Mandate GreenComp-aligned CPD for all STEM educators, emphasizing CE integration.
- Support national accreditation of modular, flexible e-learning resources for teachers.

- Promote teacher networks and communities of practice to scale innovative CE-STEM teaching methods.
- Ensure inclusivity by incorporating strategies for gender equity and digital empowerment into CPD.

Digital Innovation

In the context of Circular STEM, digital innovation is not an add-on. It is a core enabler. Integrating CE principles into STEM relies on teachers having access to digital tools, platforms, and training that bring complex, interdisciplinary concepts to life in practical, engaging ways.

To help address that gap, the project developed the [Circular STEM Academy](#), a free and open-access digital learning platform. It offers lesson plans, training modules, toolkits, and activity guides that follow the GreenComp framework. Built for and by teachers, the platform helps educators feel more confident and capable of teaching CE topics using student-centred methods and real-world examples.

The platform also encourages collaborative learning. Teachers can share experiences, adapt materials for their local contexts, and co-create lessons that connect CE with core STEM subjects. Pilot testing in partner schools showed that teachers are far more likely to teach CE when they have access to high-quality, localized, and easy-to-use digital resources.

To support implementation, the project also provides practical guidance for integrating digital literacy and technology into CE-STEM training. Teachers are trained not just in what to teach, but how to use digital tools for sustainability, data analysis, and systems thinking in their classrooms.

Key policy recommendations:

- Fund and expand open-source CE-STEM platforms by using the [Circular STEM Academy](#) as a model.
- Require GreenComp-aligned digital CPD for STEM educators.
- Provide devices, infrastructure, and connectivity support to low-income and rural schools to ensure universal access to CE-STEM learning.

- Encourage public-private collaboration to create interactive, gamified learning resources tailored to CE topics.
- Promote digital integration within teacher training modules using the Circular STEM digital literacy framework.

A digitally equipped teaching force, backed by high-quality content and pedagogical autonomy, is essential for delivering sustainability education that is future-proof and accessible.

Equity and Inclusion

The shift to a circular economy must be just, inclusive, and representative of all communities. In partnership with initiatives like [Girls Go Circular](#), Circular STEM trains teachers to apply gender-inclusive practices and create classrooms where girls and marginalized students feel welcomed into STEM and sustainability spaces. The project's materials are built with cultural and linguistic diversity in mind so students can see their own experiences reflected in what they are learning.

By rooting teaching in project-based, learner-centered approaches, and by anchoring STEM lessons in local sustainability challenges, the project helps students see how science connects to their everyday lives. This doesn't just improve engagement. It builds a deeper sense of belonging and purpose especially for students from communities most impacted by climate change.

Equity is also embedded in how teacher training is delivered. Modules emphasize communication, collaboration, social justice, and self-efficacy, equipping educators to foster inclusive classrooms that go beyond just checking a box.

Key policy recommendations:

- Integrate gender-sensitive teaching methods into CE-STEM training programs so educators can identify and challenge unconscious bias in the classroom.
- Design CE-STEM learning materials that reflect the cultural and linguistic realities of students across regions.



- Establish inclusive metrics, such as student feedback, regional reach, and gender balance, to gauge the effectiveness of CE-STEM programs.
- Provide funding for community participation, outreach, and peer mentoring programs that include minority voices in CE-STEM discussions and classrooms.
- To incorporate gender-inclusive CE-STEM learning routes into national education strategies, strengthen and formalize collaborations with programs such as [Girls Go Circular](#).
- Encourage teacher preparation programs to use project-based pedagogy, which improves teamwork, communication, and systems thinking.

Inclusion and equity are not secondary objectives. They are essential to creating a successful green transition. STEM education must benefit everyone if it is to help the transition to a circular economy. This entails ensuring that every student, irrespective of gender, background, or place of residence, has the resources, know-how, and self-assurance necessary to create a more sustainable future.

Conclusion

The Circular STEM project represents a critical step in aligning education with Europe's sustainability and digital transformation goals. It offers a scalable model for embedding CE principles into STEM education through practical, flexible, and inclusive approaches. By equipping teachers with modular training, digital tools, and interdisciplinary resources, the project empowers educators to transform classrooms into incubators of climate-conscious, future-ready problem solvers.

However, widespread impact depends on coherent policy support. That includes embedding CE content across STEM curricula, mandating Green Comp-aligned teacher training, ensuring universal digital access, and closing persistent equity gaps. Policymakers must act now to ensure these innovations are not isolated initiatives, but integrated and institutionalized practices.

Education is the foundation of a sustainable future. Circular STEM shows how that foundation can be built—with creativity, collaboration, and a clear commitment to equity. The tools are ready. The vision is set. The next step is scale.



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