

Policy Paper

STEM Competencies for the Circular Economy

Introduction

The transition to a circular economy requires a diverse set of competencies, including technical skills such as circular product design strategies, analytical skills for optimizing supply chains, and interdisciplinary skills for integrating circular principles across various sectors. Traditionally, circular economy initiatives in the EU have focused on recycling strategies, which involve looping materials back into the system. However, for more radical changes to happen in the world's natural resources use, the CE competence development should be done systematically across all disciplines, resulting in a paradigm shift in the way things and whole systems are being designed.

At the core of such transitions are technological innovations, where systems change occurs through the interplay between technology and society. STEM professionals play a crucial role in developing the necessary innovations and driving the transition to a circular economy. Therefore, the European Union of Skills should prioritize and incorporate STEM competencies into the EU's skill development framework policies.

Current challenges

1. In the Nordic region, the national circular economy strategies, with the exemption of Finland, barely recognise the importance of new skills and competence development. Yet, the underlying assumption in all strategies is that Nordic societies and businesses need to rethink how to design and use products and services and re-evaluate how economic value is created¹. This requires new skills and competencies for STEM professionals encompassing the whole value chain of activities within companies:

(i) Sustainable Design & Lifecycle Thinking

- **Cradle-to-Cradle (C2C) Design:** Engineers must design products that are recyclable or biodegradable.
- **Material Science & Green Engineering:** Understanding eco-friendly materials and how to replace finite resources.
- **Product Lifecycle Assessment (LCA):** Using tools like **SimaPro**, **OpenLCA**, or **GaBi** to measure environmental impact.

¹ [Towards a Circular Economy: Skills and Competencies for STEM professionals](#)

(ii) Digital & Smart Manufacturing Skills

- **AI & IoT for Resource Optimization:** Using AI-driven analytics to improve **material efficiency** and **predictive maintenance**.
- **3D Printing (Additive Manufacturing):** Reducing material waste by enabling **on-demand and localized production**.
- **Industry 4.0 & Smart Factories:** Implementing **automation, robotics, and digital twins** for sustainable production.
- **Supply Chain Analytics & Blockchain:** Ensuring transparency and traceability in material sourcing.
- **Reverse Logistics & Waste Recovery:** Managing systems for **reusing, refurbishing, and recycling** products.
- **Closed-Loop Manufacturing:** Designing production processes where waste is reused in new products.

(iv) Renewable Energy & Energy Efficiency

- **Energy Systems Optimization:** Engineers must integrate **solar, wind, and bioenergy** solutions.
- **Battery Recycling & Energy Storage:** Essential for electric vehicle (EV) industries and grid sustainability.
- **Green Hydrogen & Alternative Fuels:** Developing cleaner energy sources for industries.

(v) Interdisciplinary & Business Skills

- **Circular Business Models:** Understanding **servitization, product-as-a-service, and leasing models**.
- **Collaboration & Policy Compliance:** Working with policymakers, legal experts, and economists to meet sustainability standards (e.g., **EU Green Deal, ESG regulations**).
- **Stakeholder Engagement & Communication:** Effectively conveying **technical and environmental benefits** to businesses and consumers.

2. A snapshot analysis conducted on five renowned Nordic universities indicates that CE competencies are not yet universally embedded in Nordic STEM education. None of the analysed programmes had all circular economy competence fully covered². These findings are moreover aggravated by a lack of upskilling opportunities for the teaching workforce at all levels.
3. There is still no globally accepted definition of circular economy skills, reflecting the ongoing evolution of the definition of circular economy itself³. Additionally, these skills partially overlap with those required for green jobs, which also lack a universally agreed definition. In the European context, efforts such as the ESCO classification are working towards establishing clearer definitions. There is a growing consensus on the need for robust skills anticipation

² [Towards a Circular Economy: Skills and Competencies for STEM professionals](#)

³ Julian Kirchherr ^{a b c}, Nan-Hua Nadja Yang ^d, Frederik Schulze-Spüntrup ^e, Maarten J. Heerink ^b, Kris Hartley ^{f (2023)} Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions [Resources, Conservation and Recycling Volume 194](#), July 2023, 107001

methods, also in a context where green and digital skills are deeply intertwined for some occupations and tasks, though the deployment of skills anticipation remains patchy, while state-of-the-art approaches continue to evolve.⁴⁵ EU-funded projects adopt significantly different methodologies for skills anticipation. The extent to which robust skills anticipation methods are applied as a foundation for developing continuing training programs also varies considerably.

Concrete solutions to put in place

1. Skills prioritisation and anticipation

- The new European Circular Economy Action Plan shall include requirements for Member States to embed skills anticipation and upskilling and reskilling actions in their national circular economy strategies and action plans. The European monitoring framework measuring Member States' progress towards circularity should have a specific focus on skills and a human capital component.
- The European Commission can build on the work already initiated by Cedefop, Eurostat, the OECD and the joint Research Centre in Sevilla to further develop a shared definition for green skills and green occupations, and for circularity across Member States and industry sectors. This will enable consolidated state-of-the-art approaches to skills anticipation and curriculum development for the twin transition⁶.
- In addition to this, The European Commission could enhance skills anticipation by providing monitoring services that leverage real-time analysis of standardized job vacancy data within STEM occupations. This would provide a detailed view of the skills required for specific STEM roles, building on the services already provided by its agency, Cedefop. It could contribute to overcoming the fragmentation in skills anticipation methods deployed in the sectoral partnerships under the Pact for Skills, in the University micro credential initiatives in the European University Alliances, and the European Institute of Technology⁷.

2. Introduce a Circular Economy Competence, CEC framework in all HEI degree programmes and capitalise on and ensure the sustainability of best practices providing concrete skills solutions

- It is recommended to incorporate the following CEC framework (Figure 1) in all HEI degree programmes. The reasoning behind the framework is that the circular economy principles

⁴ [OECD \(2023\) Assessing and Anticipating Skills for the Green Transition](#)

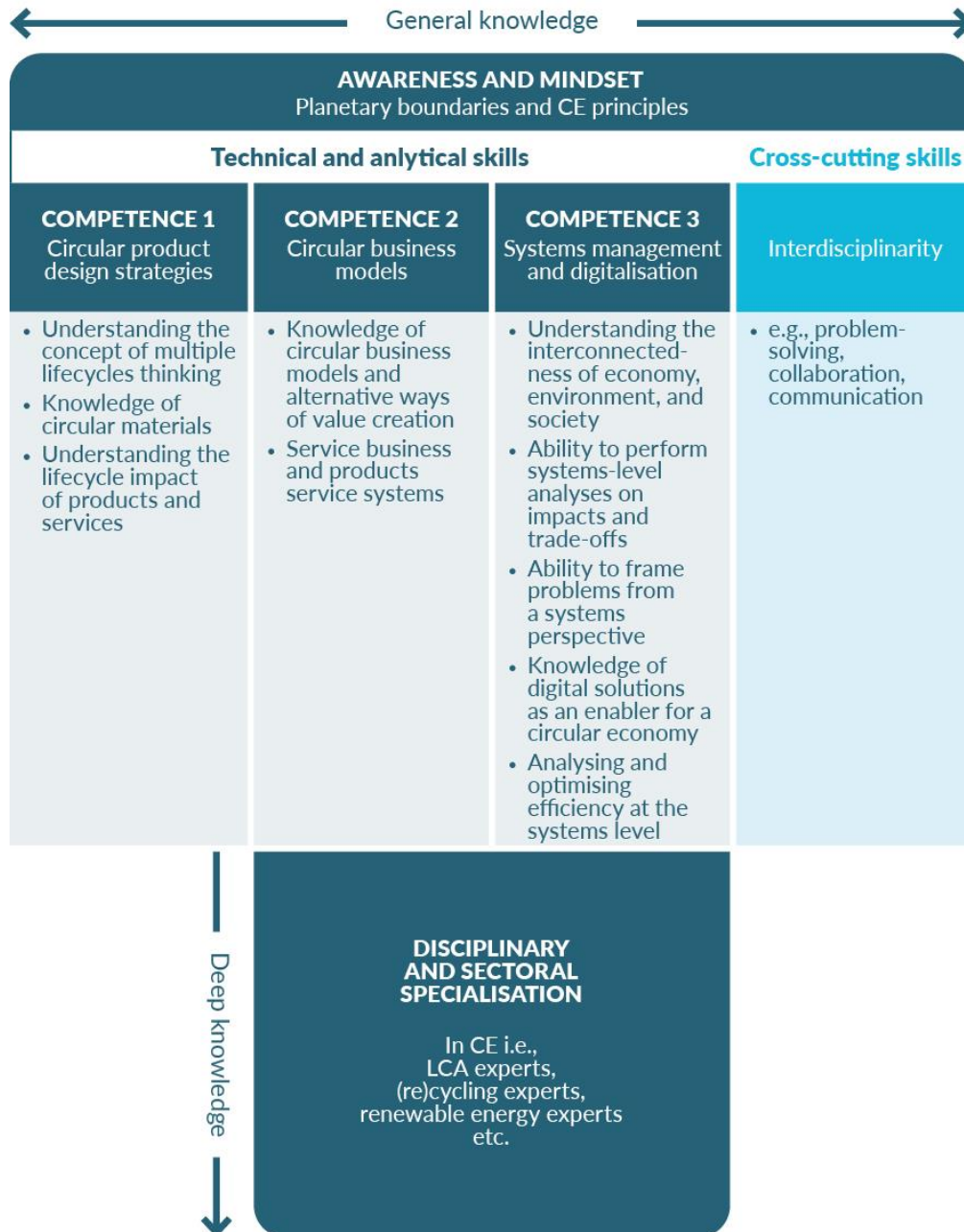
⁵ Joint Research Centre Sevilla https://joint-research-centre.ec.europa.eu/scientific-activities-z/skills-and-competences/skills-intelligence_en

⁶ Europe's Circular Economy and its Pact for Skills: working together for an inclusive and job-rich transition? [qe-07-23-330-en-n.pdf](#)

⁷ Reclaiming Europe's Edge: Competitiveness through STEM Talent, p.17 [ane-report-20241127-lowres.pdf](#)

should guide how STEM professionals approach, analyse and solve problems. These principles fundamentally differ from the ones driving the hitherto dominant linear economy⁸.

Figure 1



⁸ [Towards a Circular Economy: Skills and Competencies for STEM professionals](#)

- There is a need for streamlining and ensuring the sustainability of the EU-funded projects, which are proposing concrete skills frameworks. The European Commission needs to ensure the uptake and “commercialisation” of the recommendations and outputs resulting from the funded projects. For example, Engineers4Europe and the European Engineering Skills Council funded by the Erasmus+ programme, have developed a comprehensive skills strategy.⁹ The Skills strategy rests on extensive research and consultation processes to identify both technical and non-technical skills in demand for the dual transition and linked to the Environment Social Governance. There is an inherent risk that the initial efforts to develop a comprehensive skills framework—vital for sustaining circular economy practices within the engineering profession and crucial to green and digital transformation—may be discontinued upon the project’s conclusion.
- Another concrete example is Industrial symbiosis, IS, considered to be an important tool for achieving a circular economy with a growing expectation that the skills directly connected with IS will become even more important in the coming decade¹⁰. Enhancing the competitiveness of companies and entities through skill development ensures that newly created jobs are retained in Europe, which is crucial for maintaining a competitive edge. Hence, the EU Commission should capitalise on the existing best practices, like the SPIRE-SAIS project, co-funded by the Erasmus+ programme¹¹ to effectively incorporate skills development in IS.
In more general terms, IS, which fosters local and regional cooperation, could serve as great learning and inspiration in terms of fostering research and talent attraction, and therefore, the EU Commission needs to establish a repository of regional best practices to stimulate uptake by Members States and industrial sector.
- There is a need to build on various initiatives: the CEC framework developed by Nordic Engineers, the work undertaken within Engineers4Europe and the SPIRE-SAIS project, as well as other measures launched by national engineering organizations in response to the circular economy and the dual transition. There is a need to establish a coherent skills framework and skills taxonomy at the EU level, aligned with European strategies for a dual transition, which can inform national and sectoral strategies and initiatives.
- The European Commission should put in place a governance framework so that the skills framework remains relevant as technologies, processes, materials etc, are evolving. This should occur in close consultation with both national-level and European-level engineering associations.

⁹ [Skills Strategy](#)

¹⁰ [Identifying the skills requirements related to industrial symbiosis and energy efficiency for the European process industry](#)

¹¹ [Skills Alliance for Industrial Symbiosis – a Cross-sectoral Blueprint for a Sustainable Process Industry | A.SPIRE](#)

- It should be assessed how circular economy principles can be integrated into the national engineering curriculum, and/or in the form of dual degrees offered by the University Alliances.
- In parallel, the EU should through the university alliances and EIT KICs ensure funding to develop modular pathways for upskilling and reskilling of STEM professionals including engineers with a special emphasis on the circular economy within different sectoral contexts and technology fields critical to European competitiveness. To spur mobility within and across sectors and across Member States the feasibility of establishing a European certification framework for the circular economy with sector specialisations should be explored.

This paper was produced with the contribution from Hanne Shapiro futures.¹²

¹² <http://www.hanneshapiro.com/>