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UNIVERSITY OF JYVÄSKYLÄ
FINNISH INSTITUTE FOR
EDUCATIONAL RESEARCH

Roadmap for

Sustainability Competences

Ecf4clim

Finnish Institute For Educational Research

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Introduction To The Publication

This Roadmap for Sustainability Competences outlines the key drivers for sustainability competencesin educational practice. Its goal is to empower educational communities to take action against climatechange and promote sustainability. The Roadmap was developed during the ECF4CLIM project (AEuropean Competence Framework for a Low Carbon Economy and Sustainability through Education),funded by the European Union's Horizon 2020 research and innovation programme.

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Executive Summary

In the face of sustainability crises, sustainability competences are essential for humankind's survival. This Roadmap for Sustainability Competences outlines the key drivers for sustainability competences in educational practice. Its goal is to empower educational communities to take action against climate change and promote sustainability. The Roadmap was developed during the ECF4CLIM project (A European Competence Framework for a Low Carbon Economy and Sustainability through Education), funded by the European Union's Horizon 2020 research and innovation programme. In this document, the focus is on general education and universities, based on the data it is built upon. However, we observe that the ideas can also be applied more broadly – to other educational institutions, lifelong learning and non-formal education.

Through a transdisciplinary and participatory process conducted in four European countries – Spain, Finland, Portugal and Romania – with the support of technical partners in Hungary and Greece, ECF4CLIM developed, tested and validated this Roadmap for Sustainability Competences through multiple phases. Data was collected through crowdsourcing, and the initial roadmap was tested using participatory action research in project schools and universities. Throughout its development the Roadmap was assessed both internally and externally.

The partners of the ECF4CLIM project, who are the developers of the Roadmap, represent multiple disciplines. This means that, in addition to expertise in sustainability and competences, various academic frameworks and theories have influenced the Roadmap: the Theory of Practice Architectures (TPA), Key Performance Indicators (KPIs) and Environmental Performance, Institutional Theory, Intervention Theory, and the Theory of Expansive Learning.

We understand sustainability competences as the ability to act for sustainability. One essential starting point for this Roadmap was the European sustainability competence framework, GreenComp, which was published in the same spring that the ECF4CLIM project began. This Roadmap expands on the ideas presented in GreenComp: while GreenComp focuses primarily on describing individual-level knowledge, skills and attitudes, this Roadmap broadens the concept of competences from an individual perspective to the spheres of collective competences and technical-material competences. By individual sustainability competences, we mean the knowledge, skills and attitudes that enable individuals to act for sustainability. By collective competences, we refer to the regulations, norms and cultural-cognitive capacities of an organisation that support sustainability action. By technical-material competences, we refer to the equipment, infrastructure and natural environment that enable or support sustainability efforts.

This Roadmap elaborates on competences through four key focus areas that are important for promoting sustainability in educational practices: **engagement, connections, change** and **action**.

Practitioners consider **engagement** to be one of the most important factors in promoting sustainability in education. Engagement with sustainability in schools and universities arises through values, participation and nature.

- **Values** reflect **priorities** and **motives**. They are manifested through personal choices and discourses, statements in documents, and also through the technical-material environment, which reflects values.
- **Participation** includes the perspectives of **fairness** and **inclusion**. It can be promoted through self-reflection, creating opportunities for participatory approaches, and inclusive designs of the technical environment.
- **Nature** refers to **knowledge** based on ecology and sustainability sciences, and the **relationship** between humans, nature and the human-made environment. In addition to personal knowledge, collective knowledge influences decisions on norms and technology.

Many practitioners experience everyday life in schools and universities as complex, with numerous **connections** to manage and a variety of issues to address – such as collaboration with stakeholders, curriculum content, disciplinary boundaries and environmental concerns. To tackle these challenges, attention can be directed to systems, perspectives and problems.

- **Systems** refer to exploring the **complexity** and underlying **roots** of activities. Mapping actors and disciplines, along with their roles and potential to promote sustainability, helps develop individual, collective and technical-material competences. This is achieved by increasing knowledge and skills, facilitating the negotiation of common regulations and norms, and linking technical-material solutions to broader infrastructures.
- **Perspectives** involve understanding **assumptions** and **critically** considering different viewpoints. Networks are composed of diverse perspectives, and working within them broadens individuals' perspectives. Evidence and data-based facts – gained, for example, through measurements – help prevent false assumptions.
- **Problems** refer to identifying current practices by examining individual and collective **behaviours** and assessing individuals' and organisations' environmental **performance** and impact. Individual understanding of problems is supported by established collective structures that reflect on sustainability and enable the measurement of tangible impacts.

For practitioners, it is often easier to focus on concrete **changes** – ways to improve sustainability and reduce environmental impact within their own institutions – rather than relying on abstract visions. They are interested in what concrete options are available to them and what specific changes are needed. Uncertainty and eco-anxiety are part of the process. To address these challenges, attention can be directed to future, adaptation and innovation.

- **The future** is shaped by outlining possible **visions** and translating them into **concrete goals** within the school or university. Individual and collective reflections are essential for establishing shared goals. Understanding the possibilities and limitations of improving technical-material competences is also necessary.
- **Adaptation** means being **flexible** in the face of change without compromising **well-being**, both individually and collectively. The material-technical environment should also be capable of adapting to changes during transformation processes.
- **Innovation** emerges from **creatively** designing novel solutions by leveraging **transdisciplinary** networks as a strength. Individuals' transdisciplinary knowledge is beneficial, while collective cultures and norms that promote cooperation are essential. Technical innovations can support and enable change.

Practitioners frequently discuss both the barriers and enablers that either hinder or support concrete **action** for sustainability. When concrete action plans, structures for cooperation, infrastructure and adequate resources are missing, progress toward sustainability becomes difficult. All levels and actors are needed to work toward common sustainability goals in practice. Amid global sustainability crises, doubts may arise about the relevance of local action in the broader picture. To address these challenges related to concrete action, attention can be directed to advocacy, community and actors.

- **Advocacy** is a two-way activity: education is **steered** toward sustainability and, in turn, the activities of schools **extend** beyond the school or university. Individual competences are crucial, but collective competences that enable advocacy are also essential. Technical innovations can also spread to other educational settings.
- **Community** activities require **leadership** and **teamwork** that facilitate action. The management's competence to lead the process, along with the ability of all actors to cooperate, is vital. Resources are essential for allocating time for collective action and funding necessary procurements.
- **Actors** need both **competence** and **inner resources**. Learning from others and sharing responsibilities according to different roles promotes action. Easy-to-use technical equipment is essential to ensure that the equipment does not remain merely decorative.

All spheres and practical focus areas related to sustainability competences are deeply **intertwined**. Individual sustainability competences are essential when designing regulations or written norms, and when shaping the educational culture. These competences also form the basis for building a sustainable technical-material environment. The technical-material sustainability competences of a school or university promote learning among students, teachers and other stakeholders. They also help to concretise shared collective values and provide data for sustainability planning and assessment. Collective sustainability competences support the efforts of students, teachers and other actors by offering guidelines and shared intentions. They also provide resources for both participatory approaches and technical-material improvements.

Across all areas, the main enablers of sustainability and the promotion of sustainability competences include **management, participatory approaches, cooperation, resources,** and **the motivation** and **commitment** of actors. Supporting **infrastructures, regulations and norms,** and **transdisciplinary knowledge** are also important. If these enablers are missing, they become the main constraints to sustainability in education.

This Roadmap for Sustainability Competences offers a framework to guide education at individual, collective and technical-material levels. The Roadmap is presented on the MAPPA.fi platform in a user-friendly format, making it easy to apply in educational practice and enabling the sharing of materials and tools related to the Roadmap also in the future. We hope this Roadmap will support schools and universities in their sustainability efforts by providing examples that have been proven in practice.

Glossary

The term	Explanation of the term
Collective sustainability competences	The capacity of an organisation to act coherently and purposefully for sustainability.
Cultural-cognitive competences	Internalised, taken-for-granted assumptions enabling or constraining action.
Demonstration site DS	A school or university where action research activities have been conducted as part of the ECF4CLIM project. These sites serve as practical environments for implementing, observing and evaluating research-based interventions in real-world educational settings.
ECF4CLIM	An EU Horizon 2020 project (2021–2025) focusing on sustainability competences. Full project title: A European Competence Framework for a Low-Carbon Economy and Sustainability through Education.
Environmental performance	How well an organisation, product, or process performs in terms of environmental impact.
Hybrid participatory approach	An innovative method that combines elements of research and of engagement to collaboratively address complex issues. It integrates diverse knowledge systems and engagement strategies to enhance inclusivity, responsiveness and contextual relevance in decision making and research.
Individual sustainability competences	Competences that empower learners to embody sustainability values and embrace complex systems in order to take or request action that restores and maintains ecosystem health and enhances justice, generating visions for sustainable futures.
Intertwinedness	A condition in which different perspectives – such as those related to competences – are deeply interconnected and overlapping. Rather than existing as separate or isolated elements, these dimensions influence and shape one another, forming a complex, integrated whole.
Intervention	A set of actions or measures implemented at demonstration sites (such as schools or universities) as part of the research process. These interventions were collaboratively designed by local teams at each site to address specific needs or goals identified within their educational context.
Sustainability Competence Committees (SCCs)	A transdisciplinary committee consisting of students, teachers, organisational staff and representatives from the wider educational community to promote deep reflection and foster the elaboration of views and arguments in a collaborative way.
Sustainability Competence Teams (SCTs)	A team consisting of students, teachers or other staff from educational communities promoting deliberation and reflection on the challenges and competences associated with sustainable development.
Technical-material competences	Institution's capability to avoid or minimise environmental load or improve the environment through technical means or infrastructure improvements.
Transdisciplinarity	An approach to research and problem-solving that transcends traditional disciplinary boundaries by integrating and synthesising knowledge from multiple fields, including academic disciplines and non-academic perspectives.

Figures and Tables

1. Introduction

Learning is key to the sustainability transition needed in response to the most pressing crises of our time: climate change and the loss of biodiversity. Educational institutions, such as schools and universities, serve as hubs for learning and developing sustainability competences. This Roadmap for Sustainability Competences focuses on promoting these competences in practice within educational settings. In this Roadmap, the focus is on general education and universities, based on the data it is built upon. However, we suggest that the ideas can also be applied more broadly – to other educational institutions, lifelong learning and non-formal education.

The Roadmap was developed during the ECF4CLIM project (A European Competence Framework for a Low Carbon Economy and Sustainability through Education)[1] funded by the European Union's Horizon 2020 research and innovation programme. Through a multidisciplinary, transdisciplinary and participatory process conducted in four European countries – Spain, Finland, Portugal and Romania – ECF4CLIM developed, tested and validated this Roadmap for Sustainability Competences. It uses the European sustainability competence framework, GreenComp[2], as a springboard, linking the competences to practical applications in everyday life at schools and universities. Whereas GreenComp is a description of the individual knowledge, skills and attitudes needed for the sustainability transition, this Roadmap is a description of how these competences can be achieved through education. Another difference is that while GreenComp focuses primarily on describing individual-level knowledge, skills and attitudes, this Roadmap for sustainability competences represents not only individual competences but also collective competences and technical-material competences. The goal is to empower the educational community – including administration at various levels, school and university leaders, teachers, students and other stakeholders – to take action against climate change and promote sustainability.

Applying a hybrid participatory approach rooted in participatory action research and citizen science, ECF4CLIM co-designed the Roadmap with the support of selected schools and universities. Around 1,800 people, researchers, teachers, students and other stakeholders, were involved in this development process (see the data in Annex 1). Initially, a draft roadmap was created in 2022 based on crowdsourcing workshops, online discussions, document analysis and the GreenComp framework. During the co-designed interventions at schools and universities, the initial roadmap was tested, and the effectiveness of the interventions in strengthening sustainability competences and improving environmental performance was evaluated. The data collected were analysed to develop this final Roadmap, which underwent both internal and external validation before being finalised into this document.

In this introductory chapter, we describe the validation process underlying this Roadmap and present the aim of this document. Chapter 2 explains the theories and frameworks that underpin the Roadmap. Chapter 3 describes the methodologies used. Chapter 4 outlines our understanding of intertwined individual, collective and technical-material competences, which form our analytical framework. In Chapter 5, we define our Roadmap for Sustainability Competences in practice. The concluding Chapter 6 includes a visual presentation of the Roadmap and suggests policy actions for promoting sustainability through education.

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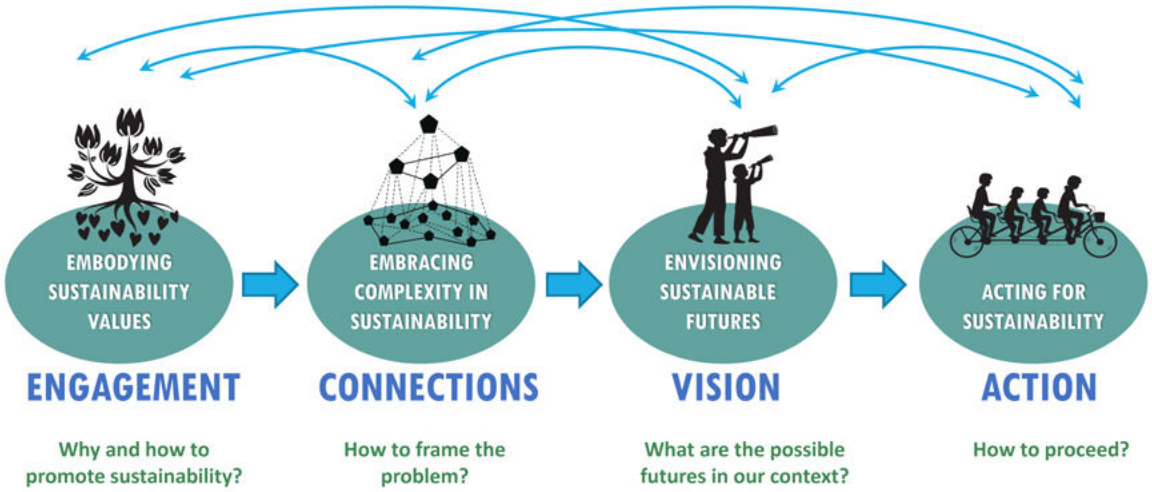
[1] https://ecf4clim.eu/

[2] European Commission, Joint Research Centre (2022). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

Initial roadmap and the validation process

This Roadmap for Sustainability Competences has undergone several phases of validation. Development of the Roadmap began with a crowdsourcing process[3] involving multiple stakeholders, totalling 500 participants, across different countries. The initial ECF4CLIM Roadmap for Sustainability Education[4] (Figure 1) was based on the analyses of crowdsourcing data and document analysis[5], using the GreenComp framework[6] as a springboard. The initial roadmap was presented to stakeholders and used in demonstration sites during interventions, in the planning of the participatory process, and in their reporting.

Figure 1. Initial Roadmap for Sustainability Education (2022).



During the ECF4CLIM project, the roadmap titles – Engagement, Connections, Vision and Action – were discussed several times. For example, questions were raised about why the titles and descriptions of the competences differed in part from those in GreenComp. The titles were intended to briefly describe the key focus areas involved in operationalising GreenComp competences in each area, and how these focus areas manifest in everyday life, being a summary of the main focus areas that emerged during the project in demonstration sites. Based on feedback and experiences from the interventions, we decided to replace the title Vision with Change. In practice, this competence area reflects the characteristics of a change process,

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[3] ECF4CLIM project report D3.1 Participatory will-formation by crowdsourcing. https://ecf4clim.eu/project-reports/ Description of the two-phase crowdsourcing process (spring 2022) is in Chapter 3: Methodology.

[4] ECF4CLIM project report D3.3 The development of an initial ECF. https://ecf4clim.eu/wp-content/uploads/2024/10/D3.3_FINAL.pdf

[5] ECF4CLIM project report D3.2 Analysis of Literature and Existing Policy Frameworks. https://ecf4clim.eu/wp-content/uploads/2024/10/D3.2-Analysis-of-Literature-and-Context-Policy.pdf

[6] European Commission, Joint Research Centre (2022). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286. See also Chapter 2: Concepts, Theories and Frameworks Underlying the Development of the Roadmap, sub-title GreenComp.

with vision being just one component. The title Action was also critically examined, as the practical focus during interventions was on the barriers and enablers of acting for sustainability. Alternatives such as Realisation, Implementation and Execution were considered, but each carried problematic connotations. Since no better alternative was found, the project partners agreed to retain the title Action. Thus, the final areas in this Roadmap for Sustainability Competences are: Engagement, Connections, Change and Action. These are described in detail, based on the ECF4CLIM interventions, in Chapter 5.

Expert analysis, the advisory board, and several other audiences noted that the visual representation (Figure 1) of the initial roadmap was too linear. As a result, new figures were designed for this final version of the Roadmap for Sustainability Competences and presented in Chapters 5 and 7.

The initial roadmap was considered too complicated by educators: it included multiple layers, such as GreenComp, different focus areas of sustainability competence, various roadmap focuses, and both constraints and enablers, all presented in separate parts of the roadmap. In the present Roadmap for Sustainability Competences we have integrated these dimensions and now present the competences in a more cohesive and accessible way.

The first external assessment of the initial roadmap was conducted in December 2022 by seven experts from diverse disciplines. These experts reviewed the initial roadmap and provided comments and suggestions[7]. All 20 main statements from the experts have been carefully considered throughout the project and during the writing of this Roadmap for Sustainability Competences[8]. For example, the concepts of sustainability and competence have been reconsidered; more attention has been paid to interdisciplinarity and the political dimension; the interconnectedness of the different focus areas related to sustainability competence has been better acknowledged; the cyclical nature of sustainability transitions has been emphasised; and all other detailed remarks have been taken into account in the respective sections.

The Finnish team has given multiple presentations at academic conferences and other events on the initial roadmap, collecting comments and suggestions for development of the model. For example, in spring 2025, the ECF4CLIM project held a workshop with the Finnish Association for Nature and Environment Schools for sustainability educators (25 participants) to discuss how the roadmap could be made more usable in educational practice. All these external insights have had an impact on this Roadmap for Sustainability Competences.

The initial roadmap was used and tested at our 13 demonstration sites during three school terms as part of an innovative, hybrid, participatory process involving 61 interventions[9]. The contents of the roadmap have also been regularly discussed during meetings of the ECF4CLIM partners.

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[7] ECF4CLIM project report D3.4 Expert Analysis of the Initial ECF. Report of the ECF4CLIM project. **https://ecf4clim.eu/project-reports/**

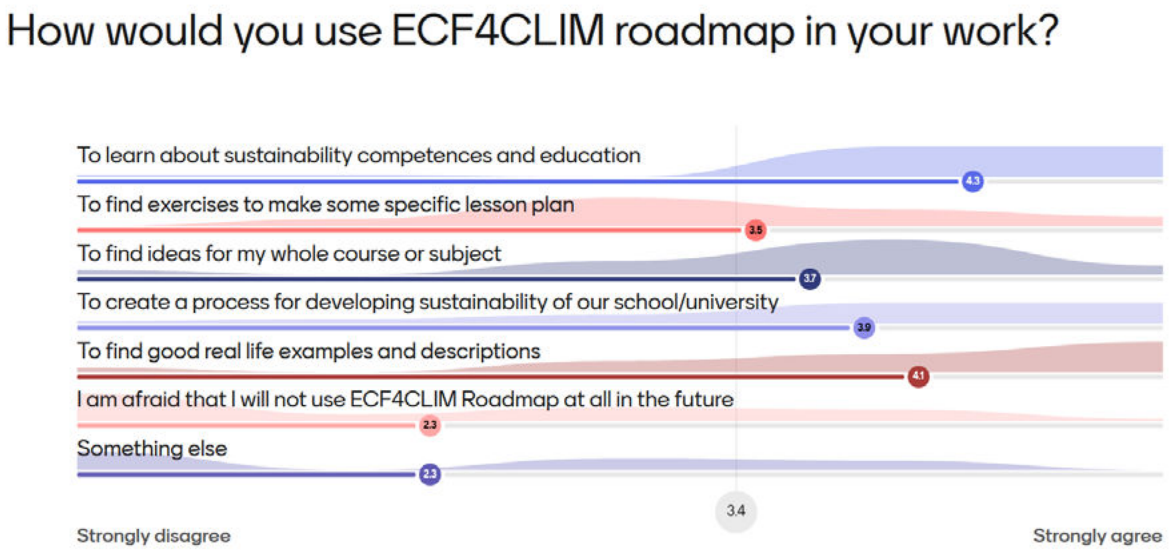
[8] The main arguments from experts and responses to them are presented in Annex 2.

[9] This process is described in Chapter 3: Methodology, under the sub-title Hybrid participatory process.

Internal assessments of the roadmap have been conducted on several occasions. In May 2023, the roadmap was reconsidered during the project's second international face-to-face general meeting in Portugal, where a workshop was organised using the World Café method. The results also emphasised the cyclical nature of the sustainability transition, although the overall structure of the roadmap was considered as good. Contextual issues and the relationships between ecological, social and economic sustainability were brought into the discussion. The engagement of multiple groups was considered important. The discrepancy between words and actions as well as the importance of both individual choices and broader sustainability issues were highlighted. The workshop participants also stressed that teachers and students need a practical, not overly theoretical, approach to implementing ideas in the everyday life of schools and universities.

In December 2024, during the 7th General Assembly workshop online, researchers, teachers and advisory board members discussed the roadmap in groups, offering recommendations based on their experiences of the project. During the meeting, a Mentimeter poll was used to ask the 36 participants to rate (on a scale of 1–5) several statements about the roadmap (Figure 2). Most respondents expressed interest in learning about sustainability education and competences through the roadmap (average score: 4.3). Participants also agreed that discovering real-life examples and descriptions, as well as creating a process for developing sustainability in their school or university, were important aspects of the roadmap. Many participants voted for finding ideas or exercises for their lessons, courses or subjects. Some participants were interested in 'something else', such as using the roadmap as a model for structuring competences or as a process framework and tool for collaboration. Only a few respondents were uncertain about whether they would use the roadmap in the future.

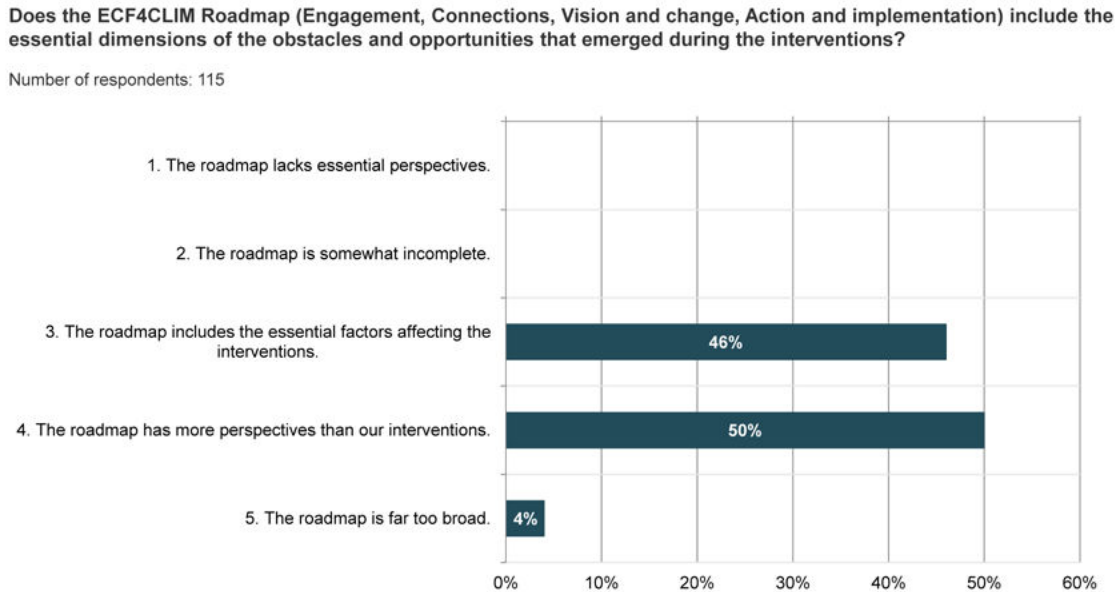
Figure 2. **Possible use of the roadmap according to General Assembly participants.**



The main message from teachers at the 7th General Assembly was that the roadmap should be practical and include examples of good practices. Different social and economic contexts should be taken into account. The MAPPA.fi platform was seen as a good starting point for teachers, but accessibility and visual design should be considered. In addition, student and community engagement, as well as structural challenges, were highlighted as important perspectives.

During spring 2025, the ECF4CLIM team from the University of Jyväskylä designed and conducted for the demonstration sites of ECF4CLIM a simple on-line query with 9 multiple-choice questions and one open question about the relevance of the areas of the roadmap. The query was sent to all demonstration sites through project partners. As a result, based on 115 responses, the main contribution of each competence area of the roadmap was considered important. When asked if the roadmap includes the essential dimensions of the obstacles and opportunities that emerged during the interventions, 46% of respondents stated that the roadmap includes the essential factors affecting the interventions, 50% thought that the roadmap includes more perspectives than their interventions, and 4% assessed that the roadmap is far too broad (Figure 3).

Figure 3. **Assessment of the initial roadmap (2025). Short survey, Question 9.**



At the 8th General Assembly (face-to-face in Tampere) in May 2025 (49 participants), a draft of the new structure for the final Roadmap document was discussed. Participants worked on the content in two groups: teachers talked and wrote about examples from their demonstration sites, while researchers took a more theoretical approach in considering the content. The process continued throughout summer 2025 with multiple meetings and writing tasks, during which all partners contributed the results of their analyses to the roadmap.

In autumn 2025, both internal and final external reviews were conducted, and the roadmap was revised accordingly: some missing perspectives were added, some concepts and sections were clarified, the final chapter was revised and some minor changes made (see Annex 2).

Based on feedback, we decided to disseminate the new, revised Roadmap in three ways. First, this report contains a detailed description of the revised Roadmap, with links to the more detailed results of the ECF4CLIM project, written in various deliverables[10]. In addition, a shorter, user-friendly and practical version has been created for educators and teachers on the MAPPA.fi website[11]. Thirdly, the executive summary of this Roadmap serves also as a policy brief, which is also shared as a separate document.

Aims of the Roadmap for Sustainability Competences

The main aim of the Roadmap for Sustainability Competences is to enhance understanding of the opportunities for promoting sustainability competences in educational settings. We hope that the Roadmap will be useful for a wide range of audiences and contexts. It is designed to help teachers and educators in different contexts to explore the broad scope of sustainability competences with students and the whole educational community, and to design programmes and lessons in practice. It also aims to guide leaders and principals in supporting sustainability efforts, provide educational administrators with tools to remove barriers to sustainability, and help policymakers justify the allocation of resources for sustainability initiatives in education. For researchers, this Roadmap offers a starting point for finding our results, background theories, methodologies and more detailed academic articles for further studies.

The most significant innovation of this Roadmap is the expansion of the concept of sustainability competences from individual competences to include collective and technical-material competences[12]. During the project, interventions at the demonstration sites have shown that all of these spheres are important and interconnected. Collective competences shape the possibilities for sustainability efforts in education, while individual competences are essential for strengthening collective ones, and technical-material competences ensure concrete and direct improvements in the environmental performance of schools and universities.

Thus, the aim of this Roadmap is to promote the development of educational content and practices, rather than to provide tools for measuring individual competences as defined in GreenComp, or to redefine knowledge, skills and attitudes related to sustainability, which are already described there. While the primary emphasis in this Roadmap is on ecological sustainability, we understand it to be deeply intertwined with social, economic and cultural dimensions[13].

The ECF4CLIM project has developed and tested a variety of participatory methods that promote sustainability in education across diverse educational contexts and organisations, involving a wide range of participants. One of the goals of this Roadmap is to disseminate these experiences and provide examples of good practices for promoting sustainability competences in different settings, enabling schools an d universities around the world to learn from them.

In addition, the goal of the Roadmap is to offer readers a window into all the results of the ECF4CLIM project. It provides links to more detailed reports and academic findings, making it easy for those interested in specific themes to access further information.

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[10] https://ecf4clim.eu/project-reports/

[11] https://mappa.fi/en/greencomp-roadmap/

[12] See Chapter 4: Intertwined individual, collective and technical-material competences

[13] See heading: Sustainability competences in Chapter 2: Theories and frameworks

2. Concepts, Theories and Frameworks Underlying Development of the Roadmap

The Roadmap for Sustainability Competences was designed in a multidisciplinary team. This means that the outcome is grounded in a rich variety of concepts, theories and frameworks. This chapter briefly defines the most important ones. Readers can explore them in more detail through the references provided.

Historical perspectives on sustainability

This Roadmap is part of a long tradition of policy actions, strategies and academic research aimed at achieving a sustainable future through education. As early as 1972, the **Limits to Growth** report prepared for the Club of Rome warned that if humanity continued to pursue limitless economic and population growth in a world with finite resources, it would eventually lead to ecological and economic collapse. The report emphasised that a fundamental shift in values and goals is required at the individual, national and global levels. A subsequent report to the Club of Rome in 1979, **No Limits to Learning**, built on this message by asserting that humanity's ability to address global challenges depends not only on technological or economic solutions, but also on transforming how we learn – both individually and collectively. In 2026, the Club of Rome will publish a new book titled No Limits to Hope[14], which seeks to bridge the 'human gap' between knowledge and action and to re-examine humanity's quest for meaning and a good life. One of the ECF4CLIM interventions from Finland – the planning process of a multidisciplinary sustainability transitions study module at the University of Jyväskylä[15] – was accepted and will also be featured in this publication.

The concept of sustainable development was popularised by the World Commission on Environment and Development (WCED) in its 1987 report, 'Our Common Future', known also as the Brundtland report[16]. It defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. It was based on the idea that environmental protection and economic development must go hand in hand.

Another key milestone in the evolution of global sustainable development policy is the Rio Earth Summit (1992), which followed the ideas of the Brundtland report. The main message of the summit was that sustainable development must become a global priority. The first principle of the Rio Declaration on Environment and Development[17] was that human beings are at the centre of concerns for sustainable development. Although the approach was economic and human-centred like in the Brundtland report, the declaration emphasised life in harmony with nature, environmental protection and the precautionary principle.

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[14] No Limits to Hope. Transforming learning for better futures. Call for contribution and concept note. Available: https://www.clubofrome.org/wp-content/uploads/2025/03/NLTH_Call-and-Concept-Note-1.pdf

[15] FN-DS03-IN02: Intervention with a 'Sustainability transitions module'. Described in ECF4CLIM project report D5.2 Report of execution and monitoring of interventions and actions, pp. 487-492. https://ecf4clim.eu/wp-content/uploads/2025/07/D5.2.pdf

[16] World Commission on Environment and Development (1987). Our common future: Report of the World Commission on Environment and Development (The Brundtland Report) (UN Document A/42/427). United Nations. http://www.un-documents.net/ocf-ov.htm

The 2030 Agenda for Sustainable Development[18], adopted by all United Nations Member States in 2015, is a global framework for peace, prosperity and the planet. It defines 17 Sustainable Development Goals (SDGs). The Agenda aims to transform the world by addressing critical issues such as poverty, inequality, climate change and biodiversity loss. One of the goals (Goal 4) is ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. It includes an educational target (4.7) to ensure that all learners acquire the knowledge and skills needed to promote sustainable development. Goal 4 also has targets including social justice and equality, in accordance with social sustainability. While the Agenda focuses on the content of change, it does not include a description of the competences required for this transformation. However, a connection between the SDGs and sustainability competences has been demonstrated by the project A Rounder Sense of Purpose[19].

UNESCO ran a **Global Action Programme** (GAP) on Education for Sustainable Development (ESD) from 2015 to 2019. The goal was to scale up and mainstream ESD at all levels and in all areas of education, and across all sectors of sustainable development. It aimed to empower individuals and societies to transform themselves and their environments for a more just, peaceful and sustainable future; to promote holistic and transformational education that addresses not only content and outcomes, but also pedagogy and learning environments; and to transform social institutions to respond creatively to global sustainability challenges. GAP enabled students to empower themselves to find solutions to sustainability problems close to their own lives, and teachers were trained to develop educational programmes for sustainability. UNESCO launched in 2020 a new initiative called 'ESD for 2030'[20], which builds on the achievements of GAP and aligns more closely with the 2030 Agenda for Sustainable Development. In connection with that, the book **Education for Sustainable Development: A Roadmap**[21] was published. The goal was to unlock concrete action for change and identify specific areas of work, with proposals focused on the organisational and administrative levels.

[17] United Nations (1992). Rio Declaration on Environment and Development. United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3–14 June 1992. https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf

[18] https://sdgs.un.org/2030agenda

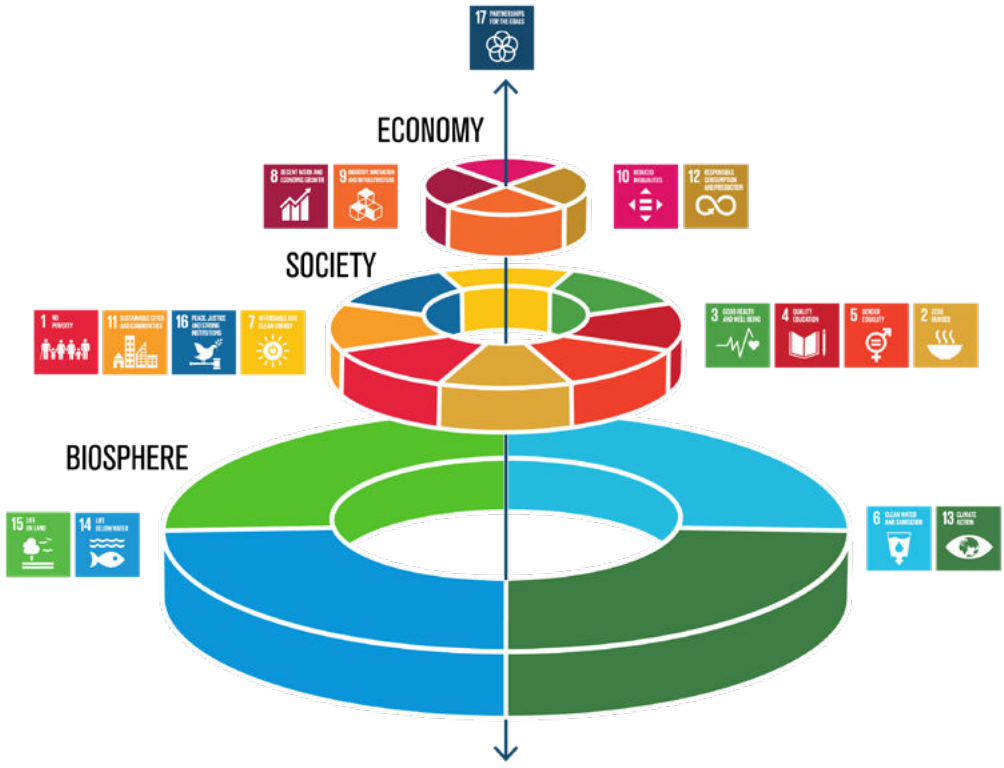
[19] https://aroundersenseofpurpose.eu/

[20] https://www.unesco.org/en/sustainable-development/education/esd-net

[21] UNESCO (2020). Education for sustainable development: A roadmap. United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.54675/YFRE1448

Describing sustainable development in terms of three pillars – environmental, social and economic – has become widespread[22]. Later, the cultural dimension of sustainability was also introduced alongside these three[23], and the equality of the pillars has been questioned. The Sustainable Development Goals, for example, have been illustrated as a 'wedding cake'[24] where the ecological dimension (the biosphere) forms the foundation, the social dimension (society) comes next, and the economy is built on top (Figure 4). In this Roadmap, we adopt this understanding, focusing on the major crises of our time: climate change and biodiversity loss. Simultaneously, we recognise the importance of social justice, equity and community well-being as essential prerequisites for sustainability efforts[25]. We view just transition, including inclusive educational policies, gender equality and territorial equity, as indispensable principles[26].

Figure 4. **The SDGs wedding cake. Figure by Azote for the Stockholm Resilience Centre, Stockholm University. CC BY-ND 3.0.**



[22] Purvis, B., Mao, Y. & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. Sustain Sci 14, 681–695. https://doi.org/10.1007/s11625-018-0627-5

[23] Una Europa. (2022). Introduction to Sustainability [MOOC]. https://courses.mooc.fi/org/uhinar/courses/introduction-to-sustainability

[24] https://www.stockholmresilience.org/research/research-news/2016-06-14-the-sdgs-wedding-cake.html

[25] See e.g. Tarozzi, M. & Bourn, D. (2023). Pedagogy of Hope for Global Social Justice: Sustainable Futures for People and the Planet. London: Bloomsbury Publishing Plc. https://doi.org/10.5040/9781350326293

Walsh, Z., Böhme, J., Lavelle, B. D., & Wamsler, C. (2020). Transformative education: Towards a relational, justice-oriented approach to sustainability. International Journal of Sustainability in Higher Education, 21(7), 1587-1606. https://doi.org/10.1108/IJSHE-05-2020-0176

[26] Kortetmäki, T., Timmermann, C., & Tribaldos, T. (2025). Just transition boundaries: Clarifying the meaning of just transition. Environmental innovation and societal transitions, 55, 100957. https://doi.org/10.1016/j.eist.2024.100957

Since sustainability was first conceptualised, several related terms and frameworks have broadened our understanding of the environmental impact of human activities. For example, the concepts **weak and strong sustainability**[27] challenge a purely economic perspective: weak sustainability assumes that natural capital (like forests and clean air) can be substituted by human-made capital (like technology or infrastructure). In contrast, strong sustainability argues that certain natural resources are irreplaceable and must be preserved to maintain ecological balance. Additionally, the concept of Planetary Boundaries[28] outlines the environmental limits within which humanity can safely operate. These boundaries include factors such as climate change, biodiversity loss and biogeochemical flows, and exceeding them could lead to irreversible environmental damage.

In any case, the concept of sustainability has faced criticism for its human-centred approach, leading to the development of alternative frameworks. For example, the concept of **planetary well-being** highlights the profound interdependence between the health of human societies and the vitality of Earth's ecosystems, and it recognises the intrinsic value of both human and nonhuman life[29].

In this Roadmap for Sustainability Competences we define sustainability, in line with planetary wellbeing and referring to the GreenComp[30] framework, as follows:

Sustainability means prioritising the needs of all life forms and of the planet by ensuring that human activity does not exceed planetary boundaries.

Sustainability competences

Referring to GreenComp[31]:

A sustainability competence empowers learners to embody sustainability values, and embrace complex systems, in order to take or request action that restores and maintains ecosystem health and enhances justice, generating visions for sustainable futures.

In this Roadmap, we have consciously and deliberately reinterpreted and redefined the concept of competence such that it does not refer solely to the abilities or potential of individuals ('learners'). Traditionally, according

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[27] Neumayer, E. (2010). Weak versus Strong Sustainability. Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781849805438

[28] https://www.stockholmresilience.org/research/planetary-boundaries.html

[29] Aaltonen, V. A., Hiljanen, M., Layne, H., Lehtonen, A., Löyttyniemi, M., Mykrä, N., Virtanen, A. S. & Heikkinen, H. L. T. (2024). Education for planetary well-being. In M. Elo, J. Hytönen, S. Karkulehto, T. Kortetmäki, J. S. Kotiaho, M. Puurtinen and M. Salo (Eds.), Interdisciplinary perspectives on planetary well-being (pp. 246–258). Taylor & Francis. https://doi.org/10.4324/9781003334002

Kortetmäki, T., Puurtinen, M., Salo, M., Aro, R., Baumeister, S., Duflot, R., Elo, M., Halme, P., Husu, H-M., Huttunen, S., Hyvönen, K., Karkulehto, S., Kataja-aho, S., Keskinen, K. E., Kulmunki, I., Mäkinen, T., Näyhä, A., Okkolin, M-A., Perälä, T., Purhonen, J., . . . Kotiaho, J. S. (2021). Planetary well-being. Humanities & social sciences communications, 8(1), 1–8. https://doi.org/10.1057/s41599-021-00899-3

[30] European Commission, Joint Research Centre (2022, p. 12). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

[31] See next section.

to dictionary definitions, competence is understood as 'the ability to act'[32] or 'the ability to do something well'[33]. These definitions typically refer to individual capabilities. However, social communities can also be seen as possessing the ability to act. This broader meaning is evident, for example, in legal discourse, where competence can refer to 'the power of a [...] business, court, or government to deal with something or take legal decisions'[34]. On this basis, we have introduced the term collective competences.

In this Roadmap, in addition to the aforementioned meanings, we also use the concept of technical-material competences, which further broadens the scope of the term. We justify the use of this concept on the grounds that technical and material conditions can sometimes be decisive for the ability of both individuals and social entities to act. These fundamental conditions, prerequisites for the agency of individuals and social groups, could also be referred to as capabilities.

In this Roadmap, we adopt a broad interpretation of sustainability competences, aligning it with the principles of planetary well-being. We acknowledge that we are extending the concept of sustainability competence beyond its original meaning, but we have made this decision to ensure consistency in the key concepts of this report. Moreover, there can be no 'final' understanding of sustainability competences as the concept is constantly evolving through new understandings and changing contexts.

In Chapter 4, **Intertwined Individual, Collective and Technical-Material Competences,** we elaborate further on the spheres of sustainability competences.

GreenComp

The European Sustainability Competence Framework, GreenComp, developed by the European Commission and the Joint Research Centre[35], identifies a set of sustainability competences designed to support education programmes. Its aim is to help learners develop the knowledge, skills and attitudes needed to think, plan and act with empathy, responsibility and care for our planet and public health. The framework comprises four interrelated competence areas, each further divided into three interlinked and equally important competences (see Table 1). In total, GreenComp outlines 12 sustainability competences, supported by 169 detailed descriptions of relevant knowledge, skills and attitudes.

The development of GreenComp was one of the policy actions outlined in the European Green Deal, intended as a catalyst to promote learning on environmental sustainability across the European Union. GreenComp was based on an extensive literature review[36] as well as expert and stakeholder consultations. It was designed to be applicable in any learning context and has been officially recommended by the European Council[37] for use at all levels of education and lifelong learning.

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[32] Oxford English Dictionary (2025). https://www.oed.com/

[33] Cambridge Dictionary (2025). https://dictionary.cambridge.org/

[34] Cambridge Dictionary (2025). https://dictionary.cambridge.org/

[35] European Commission, Joint Research Centre (2022). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

[36] Bianchi, G. (2020). Sustainability competences. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/200956

[37] European Council (2022). Council adopts recommendation to stimulate learning for the green transition and sustainable development. Press release from the European Council 16.6.2022. https://www.consilium.europa.eu/en/press/press-releases/2022/06/16/council-adopts-recommendation-to-stimulate-learning-for-the-green-transition/

GreenComp was published just a few months after the ECF4CLIM project began. The project decided to use GreenComp as a springboard. This Roadmap for Sustainability Competences focuses on operationalising the competences using GreenComp to structure the areas of sustainability competence and helping readers move from theoretical concepts and EU recommendations to practical applications, grounded in academic research. The GreenComp competences are discussed in more detail in Chapter 4: **Four Practical Focus Areas Related to Sustainability Competences Based on the Interventions.**

Table 1. **GreenComp areas, competences and descriptors in GreenComp (pp. 14-15).**

Area	Competence	Descriptor
1. Embodying sustainability values	**1.1 Valuing sustainability**	To reflect on personal values; identify and explain how values vary among people and over time, while critically evaluating how they align with sustainability values.
	1.2 Supporting fairness	To support equity and justice for current and future generations and learn from previous generations for sustainability.
	1.3 Promoting nature	To acknowledge that humans are part of nature; and to respect the needs and rights of other species and of nature itself in order to restore and regenerate healthy and resilient ecosystems.
2. Embracing complexity in sustainability	**2.1 Systems thinking**	To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between systems.
	2.2 Critical thinking	To assess information and arguments, identify assumptions, challenge the status quo, and reflect on how personal, social and cultural backgrounds influence thinking and conclusions.
	2.3 Problem framing	To formulate current or potential challenges as a sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems.
3. Envisioning sustainable futures	**3.1 Futures literacy**	To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.
	3.2 Adaptability	To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
	3.3 Exploratory thinking	To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.
4. Acting for sustainability	**4.1 Political agency**	To navigate the political system, identify political responsibility and accountability for unsustainable behaviour, and demand effective policies for sustainability.
	4.2 Collective action	To act for change in collaboration with others.
	4.3 Individual initiative	To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet.

Theoretical foundations of this roadmap

Practice architectures

The conceptual broadening of competence is informed by the theory of practice architectures[38], which offers a robust framework for understanding how human action is shaped, enabled and constrained by the conditions in which it unfolds. According to this theory, practices are not simply what individuals do – they are socially, materially and discursively mediated arrangements in which people participate. In this view, competences are not merely internal attributes or external behaviours but are formed and enacted within practices. These practices, in turn, are made possible – and shaped – by practice architectures, which consist of cultural-discursive arrangements (sayings), material-economic arrangements (doings), and social-political arrangements (relatings). These dimensions closely correspond to the expanded notion of the three spheres of competences we propose in this Roadmap in Chapter 4. The dimensions of Practice Architectures also guide the critical development of four practical focus areas related to sustainability in educational settings in Chapter 5.

KPIs and environmental performance

Environmental performance refers to the verifiable performance of a society to manage its impact on the environment. In the Roadmap, environmental performance refers to the concrete environmental impact of the educational organisation's buildings, premises and behaviour.

Key Performance Indicators (KPIs) translate broad sustainability ambitions into concrete, measurable metrics that can be tracked over time. A KPI is a quantifiable measure that captures how well an organisation is achieving its critical objectives in the environmental domain. This means converting the abstract goal of 'improving environmental performance' into numbers such as litres of water per student, kilograms of CO_2-equivalent per commuter-kilometre, percentage of on-site renewable energy, or cubic metres of waste recycled per week. This process of operationalisation is rooted in two complementary streams of theory.

First, performance measurement theory frames KPIs as part of a linked system of inputs, outputs, outcomes and strategic impacts. This view shows how performance measurement systems should balance multiple dimensions to inform decision making and continuous improvement[39]. Environmental KPIs apply the same logic to the school's ecological footprint, breaking a complex system into manageable, monitored metrics[40].

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[38] Kemmis, S., & Grootenboer, P. (2008). Situating praxis in practice: Practice architectures and the cultural, social and material conditions for practice. In P. S. P. Salo, & S. Kemmis (Eds.), Enabling Praxis: Challenges for education (3 ed., Vol. 1, pp. 37-64). Sense Publishers.

Reimer, K. E., Kaukko, M., Windsor, S., Kemmis, S., & Mahon, K. (Eds.). (2024). Living well in a world worth living in for all: Volume 2 – Enacting praxis for a just and sustainable future. Springer Nature. https://doi.org/10.1007/978-981-97-1848-1

[39] Neely, A., Gregory, M., Platts, K. (2005). Performance measurement system design: A literature review and research agenda. Int. J. Oper. Prod. Manag. 25, 1228–1263. https://doi.org/10.1108/01443570510633639

[40] Lizana, J., Manteigas, V., Chacartegui, R., Lage, J., Becerra, J.A., Blondeau, P., Rato, R., Silva, F., Gamarra, A.R., Herrera, I., Gomes, M., Fernandez, A., Berthier, C., Gonçalves, K., Alexandre, J.L., Almeida-Silva, M., Almeida, S.M. (2021). A methodology to empower citizens towards a low-carbon economy. The potential of schools and sustainability indicators. J. Environ. Manage. 284, 112043. https://doi.org/10.1016/j.jenvman.2021.112043

Second, environmental management standards, particularly ISO 14031 (2021), provide the authoritative framework for Environmental Performance Evaluation. ISO 14031 distinguishes between:

- **Operational Performance Indicators (OPIs)**, which track tangible aspects of the environmental footprint (energy consumption, emissions, waste volumes), and
- **Management Performance Indicators (MPIs)**, which assess the effectiveness of the processes that influence those outcomes (e.g., percentage of staff trained in eco-procurement, existence of green procurement procedures).

By combining OPIs and MPIs, ISO 14031 ensures that measurement drives both understanding of 'what happened' and accountability for 'why it happened'[41].

Empirical research consistently shows that organisations which systematically integrate both Operational Performance Indicators (OPIs) and Management Performance Indicators (MPIs) into a formal environmental management system achieve significantly better outcomes across energy, water, waste, emissions, and related dimensions[42]. This evidence reinforces the decision to embed a dual-indicator KPI framework in ECF4CLIM – ensuring that every metric we track reflects not only 'what happened' (OPIs) but also 'how and why' (MPIs) and thus drives continuous improvement in school environmental performance.

Within the particular framework of the ECF4CLIM project, this theoretical foundation is realised through:

- **A balanced KPI portfolio** across six sectors – transport, green procurement, green spaces, energy, water, and waste – so that both operational outcomes (e.g., kWh/m^2/year, m^3 water/student/year, kg CO2/student/year) and management processes (e.g., training rates, procurement policies, maintenance routines) are captured.
- **Normalisation and scoring**, in which raw KPI values are converted into a 0–5 performance scale by referencing the range observed across pilot schools. This step echoes performance measurement best practice, ensuring comparability.
- **Participatory embedding**, where the very act of measuring – via technical audits, behaviour surveys and community workshops – serves as an intervention in itself, building capacity, shifting mindsets, and reinforcing management processes that support long-term environmental improvement.

By operationalising 'environmental performance' in this way, KPIs become both rigorous and empowering. This dual emphasis on precise measurement and inclusive management is what ultimately drives verifiable gains in environmental performance within educational settings.

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[41] Fet, A.M., 2023. Analytical Frameworks, Impact Categories, Indicators and Performance Evaluation, in: Fet, A.M. (Ed.), Business Transitions: A Path to Sustainability: The CapSEM Model. Springer International Publishing, Cham, pp. 77–87. https://doi.org/10.1007/978-3-031-22245-0_8

[42] Darnall, N., Sides, S., 2008. Assessing the performance of voluntary environmental programs: Does certification matter? Policy Stud. J. 36, 95–117. https://doi.org/10.1111/j.1541-0072.2007.00255.x

Melnyk, S.A., Sroufe, R.P., Calantone, R., 2003. Assessing the impact of environmental management systems on corporate and environmental performance. J. Oper. Manag. 21, 329–351. https://doi.org/https://doi.org/10.1016/S0272-6963(02)00109-2

Sroufe, R., 2003. Effects of environmental management systems on environmental management practices and operations. Prod. Oper. Manag. 12, 416–431. https://doi.org/10.1111/j.1937-5956.2003.tb00212.x

Institutional theory

Institutional theory[43] is widely used in organisational research to understand the development and functioning of organisations. Institutional theory conceptualises institutions, such as markets, marriage, or organisations, as comprising three 'pillars': regulative, normative and cultural-cognitive. The regulative pillar sees institutions as constituted by rules that are essentially coercive and require participants to act in a particular way. The normative pillar comprises norms that rely on the participants to recognise appropriate ways of acting. Finally, the cultural cognitive pillar works at the level of internalised, taken-for-granted assumptions. Institutional theory was chosen to theorise our understanding that the ability of individuals to take action towards sustainability is framed through the organisations they are part of. For example, the actions of teachers are enabled or constrained by school curricula and resources, not merely by the individual competences of the teachers. Similarly, schools and universities are enabled or constrained by national regulations and guidelines and by their own policies and resourcing, but also by the beliefs, values and actions of the people who make up the organisation. The mechanisms through which these constraints and enablements work are classified under the regulative, normative and cultural-cognitive pillars conceptualised by institutional theory.

We have conceptualised our focal concept, collective sustainability competences[44] , drawing from institutional theory and the understanding that organisations are nested in different spheres of actions and authority[45]. The regulative element was defined as stemming from the supranational, national or regional/local regulations or curricula that enabled or mandated the organisation's activities. The normative element was seen to comprise the organisation's own strategies, policies and procedures. Finally, the cultural-cognitive element was seen as pertaining to the beliefs, habits and routines of the groups and individuals that constitute the organisation.

Intervention theory as a tool for evaluation

The concept of 'intervention theory' is central to theory-based evaluation approaches[46]. An intervention theory[47] consists of the various and sometimes internally contradicting assumptions held by the involved actors concerning the relations between actors, inputs, outputs and outcomes of a policy, the policy context in which the intervention takes place, and normative theories[48].

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[43] Scott, W. R. (2001). Institutions and organizations: Ideas, interests, and identities. London: Sage.

[44] Nokkala, T., Lehtonen, M., Lehtonen, A., Trenc, J. E., Mykrä, N., Heikkinen, H., & Lopez, A. P. (2024). Collective sustainability competences of universities as a nested institutional space. Higher education quarterly, 78(4). https://doi.org/10.1111/hequ.12552

[45] Hüther, O., & Krücken, G. (2016). Nested organizational fields: Isomorphism and differentiation among European universities. In: Elizabeth Popp Berman and Catherine Paradeise (ed.) The university under pressure, pp. 53–83. Research in the Sociology of Organizations, Volume 46. Emerald Group Publishing Limited. https://doi.org/10.1108/S0733-558X20160000046003

[46] Terms such as programme theory and theory of change are likewise often used, yet we prefer intervention theory as a concept that covers the entire range of possible policy measures, at various levels and scales of application.

[47] Hansen, M.B. & Vedung, E. (2010). Theory-Based Stakeholder Evaluation. American Journal of Evaluation 31 (3), 295-313.

[48] For Hansen and Vedung (2010, 300), 'normative theory' consists of 'Notions concerning why the various aspects of the situation that are supposed to be affected by the intervention are preferable or not preferable to the situation without the intervention or with another intervention.'

An intervention theory specifies how, i.e. through which mechanisms and pathways, the actor in question believes that a given intervention will produce its desired outcomes. Policy instruments are typically based on and justified by an 'official' intervention theory, based on assumptions about human behaviour, relations between actors, etc. However, these implicit or explicit hypotheses often do not coincide with the diverse assumptions held by the involved actors and stakeholders. Collective exploration, reflection and juxtaposition of the various implicit and explicit intervention theories can foster social learning by helping the participants to discover and critically re-examine their own assumptions, and better understand those held by others. Particularly useful is the systematic joint exploration of the various intervention theories prior to the intervention in light of the observed outcomes as well as the knowledge and experience gained. Earlier research and experience on the role of evaluations and indicators in policymaking has indeed shown that learning generated during the collective processes of evaluation and indicator elaboration can be even more influential than the final 'product' itself, i.e. the evaluation report or the use of a specific indicator set[49].

Building on these insights, ECF4CLIM sought to generate learning through both individual and collective reflection concerning the interventions. This was achieved through interviews with selected participants at the demonstration sites and through group discussions within the Sustainability Competence Teams (SCTs) and **Sustainability Competence Committees** (SCCs), in which participants reflected upon and discussed their assumptions concerning selected interventions and ECF4CLIM as a whole[50].

Theory of Expansive Learning

The Theory of Expansive Learning[51] explores how individuals and groups learn in complex, evolving activity systems. The Theory of Expansive Learning emphasises learning as a collective transformation of practices, not just individual knowledge acquisition. Rooted in Cultural-Historical Activity Theory (CHAT), it views learning as embedded in social, cultural and historical contexts. A key concept is the activity system, where subjects, tools, rules, community and division of labour interact dynamically. Contradictions within or between these elements drive change and innovation. Learning and change occur through cycles of questioning, analysing, modelling and implementing new practices – called expansive cycles. The theory supports collaborative learning, where knowledge is co-created through dialogue and reflection. The Theory of Expansive learning supports the notion drawn on in this Roadmap for Sustainability Competences of the cyclic development of educational practices and competences of sustainability[52].

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[49] Forss, K., Rebien, C. C., & Carlsson, J. (2002). Process Use of Evaluations: Types of Use that Precede Lessons Learned and Feedback. Evaluation (London, England. 1995), 8(1), 29-45. https://doi.org/10.1177/1358902002008001515

Lehtonen, M., Sébastien, L. & Bauler, T. (2016). The multiple roles of sustainability indicators in informational governance: between intended use and unanticipated influence. Current Opinion in Environmental Sustainability 18: 1–9. https://doi.org/10.1016/j.cosust.2015.05.009

[50] See more: Chapter 3: Methodology, and its sub-chapter Participatory process and methods.

[51] Engeström, Y. (1987/2014). Learning by expanding. An activity-theoretical approach to developmental research. 2nd ed. Cambridge University Press. https://doi.org/10.1017/CBO9781139814744

Engeström, Y. & Sannino, A. (2010). Studies of expansive learning. Foundations, findings and future challenges. Educational Research Review, 5(1), 1-24. https://doi.org/10.1016/j.edurev.2009.12.002

[52] Mykrä, N., Lehtonen, A., Nokkala, T., & Heikkinen, H. L. T. (2023). Ekspansiivinen oppiminen kohtaa kestävyysosaamisen (Expansive Learning meets sustainability competence). Kasvatus, 54(3), 271-276. https://doi.org/10.33348/kvt.131358

3. Methodology

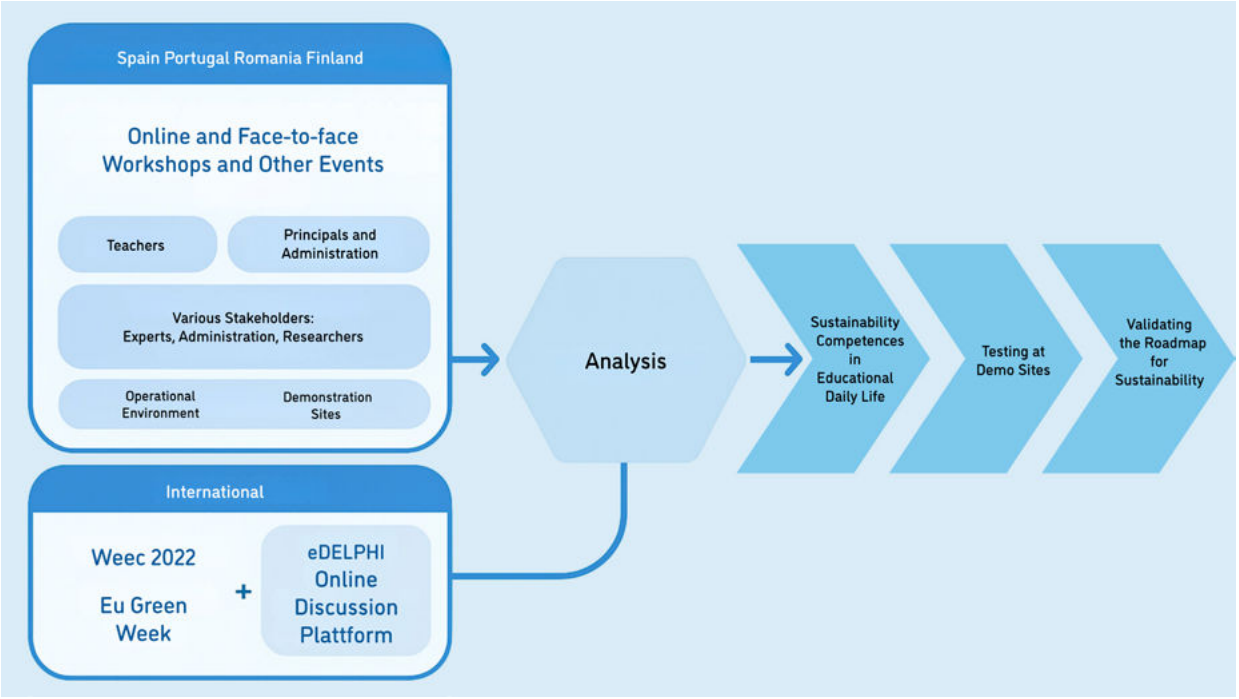
This Roadmap for Sustainability Competences is designed on the basis of large transdisciplinary data (Annex 1). The methodology is based on the theoretical background and frameworks described in the previous chapter. The methodologies have two important perspectives: first, collecting information about the most relevant sustainability competences, challenges and opportunities in the everyday life of schools and universities and, second, developing new methodologies to promote sustainability competences in educational settings.

We introduce here the main methods used: 1. Crowdsourcing through workshops and eDelphi discussion; 2. Policy document analysis; 3. Hybrid participatory process and methods; and 4. KPI analysis. Annex 1 presents the data collected in table form.

Crowdsourcing through workshops and eDelphi discussion

The crowdsourcing phase of the study, carried out in spring 2022[53] , constituted the basis for our initial roadmap that was tested during the interventions (Figure 5).

Figure 5. **Crowdsourcing process in the ECF4CLIM project.**



[53] ECF4CLIM project report D3.1 Participatory will-formation by crowdsourcing. https://ecf4clim.eu/project-reports/

The aim of the crowdsourcing process was to engender a collective meaning-making process in terms of education for sustainability. A large international group of students, parents, teachers, principals and experts in education were engaged in discussions on how to develop sustainability education. The crowdsourcing process was implemented through two different but mutually supportive crowdsourcing methods. First, a set of 'Dream and nightmare school of sustainability' workshops was organised in four project countries and, based on these, online discussions for international audiences were facilitated on the eDelphi platform.

The aim of the Dream and Nightmare workshops was to stimulate discussions on participants' experiences regarding the enablers and constraints of sustainability education using the Method of Empathy-Based Stories (MEBS). These workshops brought together approximately 506 participants across 31 sessions. The collected data included a report from each workshop, recordings, and a total of 1,790 Post-it notes reflecting who does what and why in the imagined 'dream' or 'nightmare' school of sustainability. After the workshops, online eDelphi discussions for international audiences were facilitated to obtain a deeper understanding of the issues addressed in the crowdsourcing workshops (68 active participants). The findings, derived from both inductive and deductive qualitative analysis, were processed in the initial roadmap[54].

Policy document analysis

A document search was conducted for all legislation on sustainability and education affecting each of the schools and universities involved in ECF4CLIM. Likewise, internal regulations of each centre related to sustainability (both in terms of the centre's organisation and its teaching content) were compiled. A prior analysis was conducted in 2022[55], completed in 2025, updating the notable changes from that date to the present in each school and university[56].

Once all the information was collected, the first step in the analysis was to see whether external regulations allow or oblige the organisation to promote sustainability. As for regulative competences, the national regulatory framework may have a constraining role, for example, by obliging schools to include sustainability in their curriculum. Likewise, national, regional and municipal regulations may have an enabling function by allowing schools to select their own energy provider. Similarly, for the analysis of normative competences, the first step was to check whether the organisation had set up its own strategies, policies, plans and programmes for sustainability.

[54] ECF4CLIM project report D3.3 The Development of an Initial ECF. **https://ecf4clim.eu/project-reports/**

[55] ECF4CLIM project report D4.1. Collective competences for sustainability. **https://ecf4clim.eu/wp-content/uploads/2024/10/D4.1.pdf**

[56] ECF4CLIM project report D6.1. Collective competences for sustainability. **https://ecf4clim.eu/wp-content/uploads/2025/07/D6.1.pdf**

The analysis reports from the demonstration sites were structured under the following sections:

1. Identifying sustainability-related documents: Which legislative and regulatory acts constrain or enable the sustainability activities of schools and universities? Which strategies, plans and programmes relating to sustainability has the school or university established for itself?

2. Main changes since 2022: In 2025, data were updated, seeking to identify and understand the legislative and policy changes that had occurred in different countries and demonstration sites.

3. Identifying the key elements of competences: 'Plan' (roadmaps, strategies, action plans, foresight activities, scenario planning exercises), 'Do' (rights, duties, and responsibilities to act), 'Check' (ex post and on-going evaluations designed to monitor, follow up and evaluate the outcomes/consequences of actions taken), and 'Revise' (mechanisms established to ensure continuous learning and periodic revision of plans, implementation and evaluation of SD-related activities).

4. Responsibilities & leadership: Allocation of duties and responsibilities, ownership, leadership, cooperation, etc. For a given sustainability-related aspect, who is or are empowered to act, who carries the lead responsibility, cooperation and coordination between the involved actors, and who decides.

5. Resources: Identify whether the actors possessed the requisite financial, human, time and cognitive resources needed for the achievement of any given competence, leading to action and desired outcomes.

6. The contents of sustainability competences: What, if anything, the analysed documents said about the substance of sustainable development?

The aim was not to conduct an in-depth analysis, but instead to focus on two key distinctions. First, a distinction was made between competences relating to teaching objectives and methods on the one hand, and technical and organisational aspects on the other. The second key distinction concerned the dimensions and temporality of sustainability. To what extent did the documents specify and characterise sustainability as composed of interacting dimensions (environmental, social, economic) as opposed to focusing on only one (often the environmental dimension)? Were intergenerational aspects addressed explicitly (equity not only between social classes and groups but also between present and future generations)?

Participatory process and methods

The ECF4CLIM hybrid participatory approach, rooted in participatory action research[57], and partially based on the STAVE tool[58] (Systematic Tool for Behavioural Assumption, Validation and Exploration) developed, tailored and operationalised in the EU Pachelbel project[59], allows the educational community to jointly identify, understand, assess and evaluate their own sustainability-related competences and obstacles to improvement. Individuals are not passive subjects but active agents in the research process and in drawing conclusions from what they learn. Creativity and transdisciplinarity are fundamental components in this hybrid participatory approach. Rather than education, which is limited to instruction and the transfer of knowledge, creativity supports innovation and problem-solving to address complex ecological problems[60].

Strengthening the capacity for reflection, rethinking existing knowledge and assumptions through iteration and interactions within and between different actors[61], and transdisciplinarity between academia and 'outside world' citizens and stakeholders holding various types of experiential knowledge[62] have been the critical elements in ECF4CLIM's participatory approach and behind this Roadmap. Complex problems require participation, openness and new and diverse forms of knowledge[63] as well as disciplinary integration[64]. Adaptability and sensitivity to context[65] have also been crucial in the process.

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[57] Kemmis, S. K., & McTaggart, R. M. (2014). The action research planner: Doing critical participatory action research. Springer. https://doi.org/10.1007/978-981-4560-67-2

[58] Horlick-Jones, T., & Prades, A. (2015). Translating between social worlds of policy and everyday life: The development of a group-based method to support policymaking by exploring behavioural aspects of sustainable consumption. Public understanding of science (Bristol, England), 24(7), 811-826. https://doi.org/10.1177/0963662514525556

Espluga, J., Konrad, W., Mays, C., Oltra, C., Poumadère, M., & Prades, A. (2016). How to address citizens' practices and policies on sustainability? A consultative tool for brokering policy-related knowledge between the worlds of policymaking and everyday citizens' life. Evidence & policy, 12(3), 381-404. https://doi.org/10.1332/174426416X14738559545991

Prades, A., Horlick-Jones, T., Barnett, J., Constantin, M., Enander, A., Espluga-Trenc, J., Konrad, W., Poumadère, M. and Rosenhead, J. (2016). Shining a light on citizens' everyday environment related behaviours. In A. Martinuzzi & M. Sedlacko (eds.) Knowledge Brokerage for Sustainable Development, pp. 189-207. Saltaire (UK): Greenleaf Publishing. https://doi.org/10.4324/9781351285483

Prades, A., Espluga, J., Horlick-Jones, T. (2017). Hybrid Focus Groups as a Means to Investigate Practical Reasoning, Learning Processes and Indigenous Activities. In: Barbour, R., Morgan, D. (eds) A New Era in Focus Group Research, pp. 179-204. Palgrave Macmillan, London. https://doi.org/10.1057/978-1-137-58614-8_9

[59] http://pachelbel.eu

[60] Sandri, O. J. (2013) Exploring the role and value of creativity in education for sustainability, Environmental Education Research, 19:6, 765-778. https://doi.org/10.1080/13504622.2012.749978

[61] Prades et al. (2017), see above.

[62] Ortiz, G., & Climent-Gil, E. (2020). A transdisciplinary framework for environmental impact assessment: Opportunities and resistances among practitioners in Spain. Environmental Impact Assessment Review, 81, 106339.

[63] Bergmann, M., & Jahn, T. (2008). CITY: mobil: a model for integration in sustainability research. Handbook of transdisciplinary research, 89-102.

Jahn, T., Bergmann, M., & Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. Ecological economics, 79, 1-10.

[64] Gibbons, M., Limoges, C., Scott, P., Schwartzman, S., & Nowotny, H. (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. SAGE Publications Ltd.

[65] Wickson, F., Carew, A. L., & Russell, A. W. (2006). Transdisciplinary research: characteristics, quandaries and quality. Futures 38(9), 1046-1059.

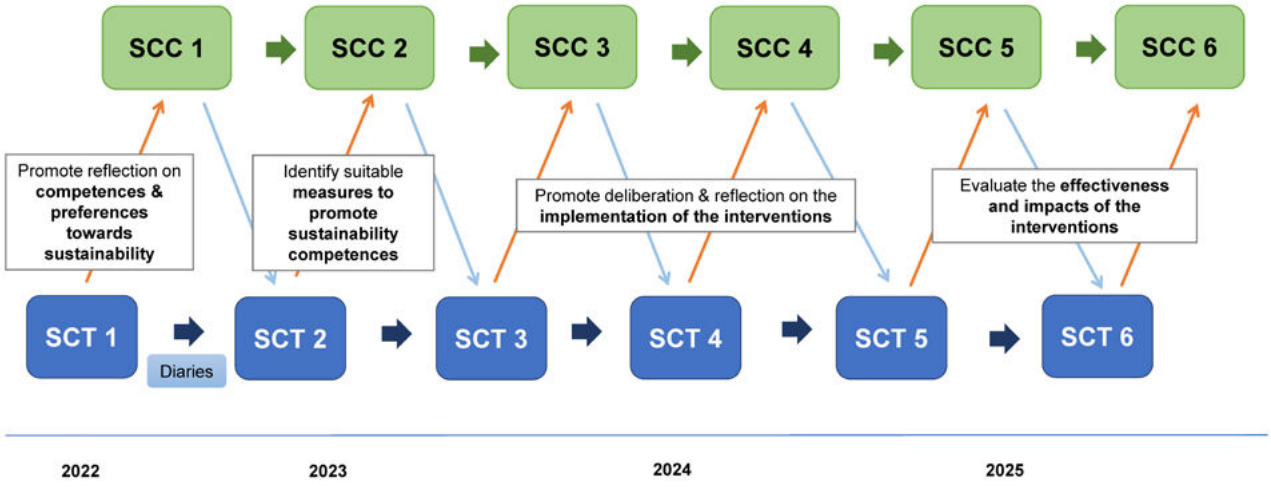
At each Demonstration Site, two types of innovative organisational structures were set up:

- Sustainability Competence Teams (SCTs), composed of members of the educational community at each Demonstration Site (students, teachers, staff).
- Sustainability Competence Committees (SCCs), including also representatives from the wider educational community, such as experts, public authorities, NGOs, and members of other education services.

During the project, a series of 6 SCTs and 6 SCCs were developed in each of the 13 educational institutions participating in the project (demonstration sites, DS) in order to discuss and reflect on sustainability competences and practical ways to promote them. Around 1,800 participants, including students, teachers, staff and representatives of the wider educational community, were actively engaged in understanding their sustainability competences, co-designing interventions to promote them and assessing and evaluating the outcomes of the learning experience.

To foster reflection and ownership, the SCTs and SCCs meet several times throughout the project (Figure 6).

Figure 6. **Sequences of relationships between SCTs and SCCs.**



SCT/SCCs 1 & 2 engaged participants in reflection on the starting point of our schools in terms of sustainability competences: How is sustainability understood? How is it integrated into school activities? What are the individual and collective sustainability competences? From this starting point, 159 interventions to empower the educational community and promote sustainability competences were co-designed.

SCT/SCCs 3 & 4 promoted reflection on ongoing interventions in the DS: How are the interventions evolving? Is there a need for modifications? From this reflection, preliminary insights on the impact of the interventions on individual and collective competences, as well as on environmental performance, were gathered.

SCT/SCCs 5 & 6 engaged all involved actors in participatory evaluation of the interventions. Participants explored and possibly revisited their 'intervention theories' in light of the experience gained: Did the intervention operate as expected? Which unanticipated factors constrained or facilitated the improvement of sustainability competences? (Theory-based stakeholder evaluation)

In addition to this, time was devoted to discussing the different steps of the Roadmap in these sessions (Engagement in session 3, Connections in session 4, Change in session 5, and Actions in session 6).

During the SCT and SCC workshops, several tools were used, including deliberative workshops and open debates, mind maps, oval maps, short surveys, and evaluation questionnaires.

Key Performance Indicator (KPI) analysis

To capture the evolution of environmental performance, ECF4CLIM implemented two clearly differentiated assessment phases: a comprehensive baseline audit of all six sectors (transport, green procurement, green spaces, energy, water, waste)[66], and a targeted post-intervention evaluation[67], reported in Deliverable 6.3, focusing solely on those sectors where each demonstration site carried out concrete interventions.

During the baseline phase, each pilot school completed a comprehensive environmental audit that combined existing data review with on-site checks and community questionnaires. Schools provided up to five years of energy and water bills, lists of equipment, maintenance logs and basic building details to help shape the audit. On-site, teams used uniform checklists to map green space areas and weigh and categorise the waste produced. At the same time, students and staff filled out simple surveys about how they commute, their purchasing choices (e.g. use of recycled paper or participation in eco-driving training) and their recycling habits.

Subsequent to data collection, these measurements were translated into the previously defined result- and process-oriented KPIs and then scaled to a 0–5 range by comparing each school's values against the full pilot-group distribution. Sectoral scores were then averaged to yield an overall ECF4CLIM score, providing an exhaustive picture of environmental performance at baseline.

Once concrete interventions were implemented (WP 5), the final evaluation adopted an intervention-centric approach. Rather than re-audit all six sectors, Deliverable 6.3 concentrated on those sectors where each school operates – such as installing solar panels, setting up recycling stations, or developing their green spaces. For these targeted sectors, the same KPI definitions and normalisation procedures from the baseline were used, enabling a clear 'before vs. after' comparison of short-term impacts (e.g. reductions in water use or CO_2 emissions).

[66] ECF4CLIM project report D4.3 Baseline Assessment of the Environmental Performance. **https://ecf4clim.eu/wp-content/uploads/2024/10/D4.3.-Baseline-assessment-of-the-environmental-performance.pdf**

[67] ECF4CLIM project report D6.3 Post-Implementation Environmental Assessment of Selected Educational Establishments. **https://ecf4clim.eu/wp-content/uploads/2025/07/D6.3.pdf**

Sectors lacking robust post-intervention quantitative data were assessed through structured qualitative reflections. These forms captured the project's long-term educational and organisational benefits, such as:

- Enhanced individual competences (greater environmental awareness and behavioural change among students and staff);
- Strengthened governance (creation of sustainability committees, integration of low-carbon themes into curricula); and
- Consolidated routines (maintenance protocols for green spaces, formal green procurement procedures).

Crucially, because the pilot schools differ widely in climate, resources, student age range, and local support, final KPI scores were not aggregated into a cross-school ranking. Instead, each school received a customised dashboard of sector-specific scores alongside qualitative insights, supporting continuous improvement within its unique context. This two-phase design – broad six-sector profiling at baseline followed by precision-targeted, intervention-based KPI calculation and complementary qualitative review – ensured both comprehensive initial evaluation and meaningful measurement of short-term impacts, while still recognising the deeper, long-term transformations that extend beyond what quantitative KPIs alone can capture.

The KPI calculations produced knowledge about possibilities in educational practice. They helped to identify some of the essential constraints and enablers in schools and universities, thus promoting the development of this Roadmap for Sustainability Competences.

Limitations and Strengths of the Methodology Used

The partners of the ECF4CLIM project, who are the developers of the Roadmap, represent multiple disciplines. The methodologies used in the development of this Roadmap stem from the fields of engineering, sociology, philosophy, organisational sciences, and education – especially sustainability and environmental education. The researchers of the ECF4CLIM project conducted workshops and collected data using methods they were not previously familiar with. This means that the data may not have been collected in an identical manner at every intervention site. Despite this discrepancy, the multidisciplinary team and the various academic frameworks enriched the project and helped challenge some of the self-evident assumptions within individual disciplines. In doing so, they fostered the core idea of this Roadmap: that the three spheres of sustainability competences – individual, collective, and technical-material – are deeply intertwined. Promoting sustainability in educational institutions cannot be effectively pursued solely through technical, behavioural, or organisational endeavours. The multidisciplinary process has made it possible to reach understandings that would not have been achievable from a single disciplinary perspective.

Another limitation arises from differences between the participating countries. Infrastructures, administrative practices, organisational cultures and available resources vary significantly. For example, in Finland, many technical solutions – such as online energy metering, waste metering and recycling – had already been implemented before the project began. As a result, the demonstration sites did not find it useful to introduce double-metering solely to obtain comparable data for the project. Instead, they focused on participatory approaches involving students and fostering cooperation among school leaders, teachers and students. These kinds of approaches proved more challenging in countries with more hierarchical traditions. In some countries, resources from the ECF4CLIM project were essential for improving basic infrastructure. In contrast, Finnish schools did not consider lack of funding the main constraint on sustainability-related procurement. Rather, lack of time was identified as the most critical issue. The ECF4CLIM project helped address this by providing substitute teachers and workshops, allowing educators to focus on developing sustainability education within their institutions. Additionally, these cross-country differences broadened the understanding of key constraints and enablers in educational institutions more generally.

During the ECF4CLIM project, different interpretations of how sustainability competences should be understood became evident. This Roadmap aims to integrate these diverse understandings into a single framework through a practical approach. We encourage future projects on sustainability competences to continue along this multidisciplinary path, as there is still much progress to be made.

4. Intertwined Individual, Collective and Technical-material Sustainability Competences

Traditionally, the concept of competences, and more specifically, sustainability competences, has been considered from an individual perspective, as described in Chapter 2. During the ECF4CLIM project, it became evident that the entire community's ability to act in building a sustainable future is essential, and that material and technical conditions play a significant role as either constraints or enablers of sustainability. In educational practice, it is important to distinguish between different but interrelated spheres of competence: individual competences, collective competences, and technical-material competences, because these spheres face different barriers and enablers and require different modes of action to be effectively promoted. This chapter introduces a novel three-fold definition of sustainability competences, based on the experiences and analyses conducted during the ECF4CLIM project. This interpretation forms the foundation of the Roadmap for Sustainability Competences described in **Chapter 5: Four Practical Focus Areas related to Sustainability Competences Based on Interventions.**

Individual sustainability competences

In defining individual sustainability competences, we rely on the GreenComp definition[68]:

Individual sustainability competences empower learners to embody sustainability values and embrace complex systems, in order to take or request action that restores and maintains ecosystem health and enhances justice, generating visions for sustainable futures.

Individual sustainability competences focus on knowledge, skills and attitudes. They refer to a person's internal qualities and abilities and are actor-dependent. The GreenComp framework described in Chapter 2 elaborates individual sustainability competences.

In ECF4CLIM, we assume that individual sustainability competences are not only essential for students but also for teachers, administrators and other stakeholders in educational settings. This understanding aligns with the lifelong learning approach: no one is ever fully 'ready' or completely competent in sustainability because contexts evolve and new phenomena emerge.

Furthermore, in ECF4CLIM, individual competences are always situated: they are developed and exercised within specific social, cultural and material contexts. This means that individual sustainability competences are deeply intertwined with collective and technical-material competences.

We define **individual competences** as:

The development of a combination of personal qualities and qualifications, i.e., the knowledge, skills and attitudes that individuals need in order to achieve certain goals through their actions and activities[69].

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[68] European Commission, Joint Research Centre (2022, p. 12). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

[69] Vare, P., Rieckmann, M. & Lausselet, N. (2022). Introduction. In: P. Vare, N. Lausselet & M. Rieckmann (eds.). Competences in education for sustainable development: Critical perspectives. Cham: Springer, 3–10. https://doi.org/10.1007/978-3-030-91055-6_1

In our case, these goals are promoting sustainability and planetary wellbeing[70].

Thus, individual competences refer to individuals' personal qualities and abilities and constitute one of the three spheres of competence in our roadmap towards sustainability. These personal qualities and abilities develop (or otherwise) within specific collective and technical-material contexts, which can either stimulate or constrain an individual's capacity to act.

Collective sustainability competences

The ability of an organisation to act is shaped by more than just the competences of individual members or leaders. It emerges from collective dynamics that go beyond the sum of individual competences and efforts. We have elaborated the definition of collective sustainability competences based on institutional theory and practice architecture described in Chapter 2:

Collective sustainability competences refer to the capacity of an organisation to act coherently and purposefully for sustainability, which coevolves with the nested institutional space made up of the constant interaction of the human, material, institutional, symbolic and discursive environment external and internal to the organisation and its communities[71].

Collective sustainability competences consist of enabling and constraining factors that shape the capacity of a community or organisation to promote sustainability and support the development of individual sustainability competences. These competences are influenced by how the community or organisation engages with its operational environment, which itself co-evolves with the collective competences of the community in question. Collective sustainability competences arise through relational dynamics, such as communication, shared goals and collective decision making.

The actions of organisations and individuals may result from complying with regulations and established norms, or be based on internalised, taken-for-granted understandings (Figure 7):

- **Regulative competences** (external to the organisation): Derive from written rules (laws, regulations) that stipulate how sustainable development is to be considered and promoted and by whom.
- **Normative competences** (internal to the organisation): Norms and values reflected and institutionalised in the organisation's own strategies, programmes of action, plans, guidelines, result agreements concluded with authorities at different levels of governance, etc.
- **Cultural-cognitive competences**: Internalisation of regulative and normative competences as taken-for-granted social norms of normal and acceptable behaviours; translation of regulative and normative competences into the organisation's operating culture, daily routines, habits and practices. Internal interpretive processes are shaped by external cultural frameworks and also by the professionals involved and broader cultures at various levels.

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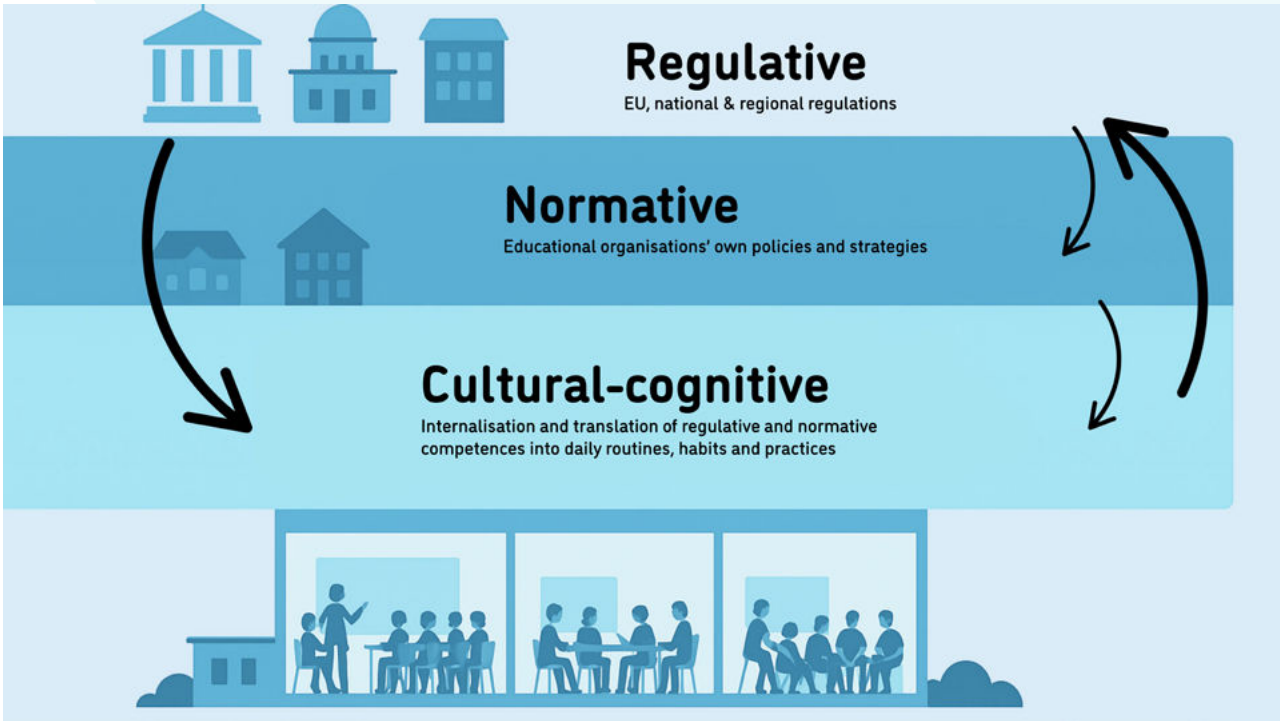
[70] Elo, M., Hytönen, J., Karkulehto, S., Kortetmäki, T., Kotiaho, J. S., Puurtinen, M., . . . Kortekallio, K. (2024). Interdisciplinary perspectives on planetary well-being. Routledge, Taylor & Francis Group. https://doi.org/10.4324/9781003334002

[71] Nokkala, T., Lehtonen, M., Lehtonen, A., Trenc, J. E., Mykrä, N., Heikkinen, H., & Lopez, A. P. (2024,16). Collective sustainability competences of universities as a nested institutional space. Higher education quarterly, 78(4). https://doi.org/10.1111/hequ.12552

Figure 7. Collective sustainability competences.



Technical-material sustainability competences

To further extend the concept of sustainability competences, we introduce the idea of technical-material competences. This refers to the role of tools, infrastructures, technologies and physical environments in enabling (or constraining) action. Competence, in this view, is not only a matter of human or collective abilities, but also of material conditions and capabilities.

Change (like sustainability action) depends not only on people's intentions but also on how materials and infrastructures enable or constrain those intentions[72]. Material conditions are not neutral backgrounds, but active components of what people and communities are able to do and become[73]. From the technical-material perspective humans can make arrangements, such as invent and use equipment or prevent pollution by using tools, but they cannot change the physical, chemical and biological laws of nature. For example, acids act in chemical reactions, potentially causing environmental problems, and machines are able to perform their tasks for the environment within the limits of their material constraints. The technical-material domain mediates the relationship between environmental challenges and human activity[74].

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[72] Based on sociomaterialist theories, e.g. Fenwick, T., Edwards, R. & Sawchuk, P. (2011). Emerging Approaches to Educational Research: Tracing the Socio-Material. United Kingdom: Routledge. https://doi.org/10.4324/9780203817582

[73] Based on capability theories, e.g. Nussbaum, M. C. (2011). Creating Capabilities: The Human Development Approach. Cambridge: Harvard University Press. https://doi.org/10.4159/harvard.9780674061200

[74] Mykrä (2021), building on Leontiev (1978) and Activity Theory, which describes one level of activity: operations, which are driven by conditions.

Drawing on this, we define technical-material competences in the following way:

Technical-material sustainability competences are defined as an institution's capability to avoid or minimise environmental load or improve the environment through technical means or infrastructure improvements. At the same time, these competences promote learning and support the development of an experiential learning environment.

A school may be highly competent pedagogically, but without sustainable infrastructure – heating, electricity, air quality, food services, waste management, transportation systems, green spaces, green procurement, etc. – its educational actions for sustainability are compromised.

Technical-material competences can be conceptualised through eight environmental areas and key performance indicators (KPIs), described in Chapter 2. Increasing technical-material sustainability competences often results in measurable changes in the environmental performance of schools and universities. Material upgrades and individual and collective competences reinforce one another in educational practice.

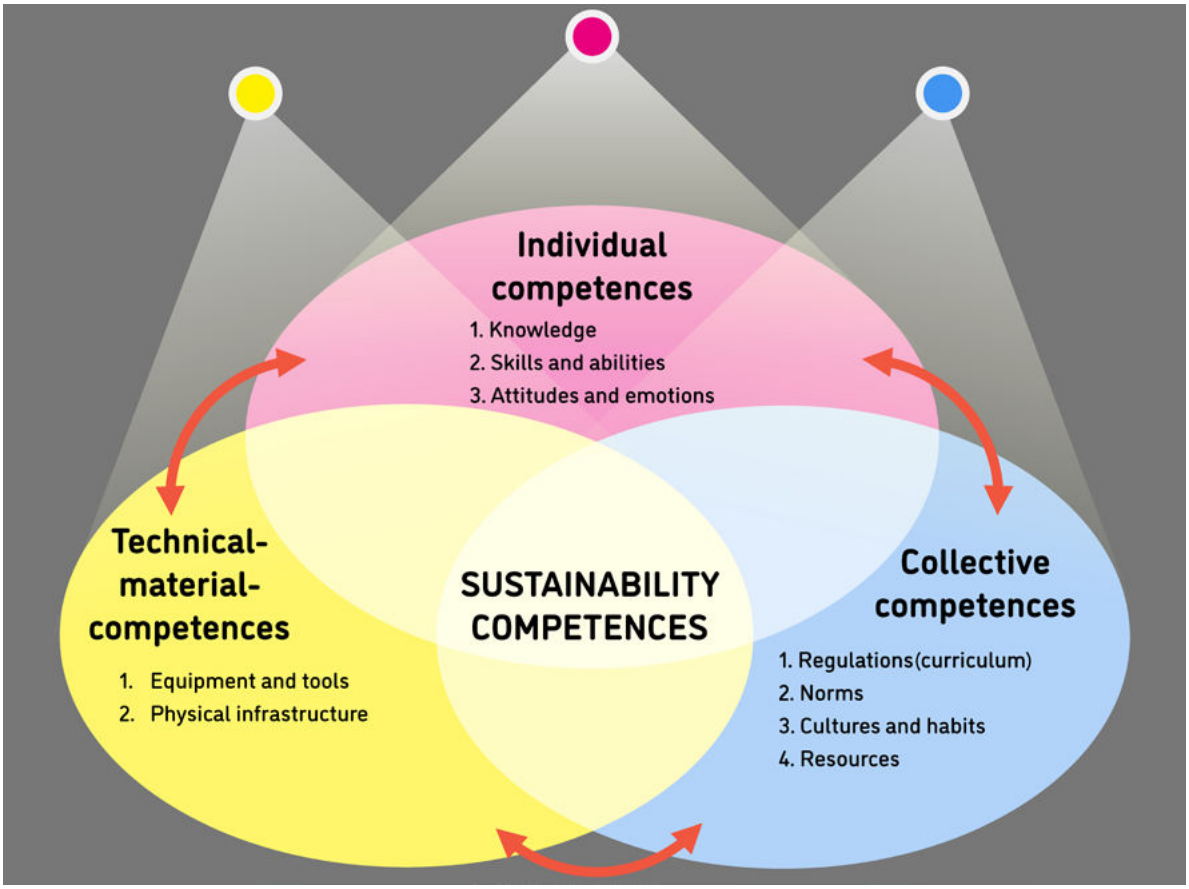
Intertwined sustainability competences

The three spheres of sustainability competence – individual, collective, and technical-material – are not isolated or hierarchical, but deeply intertwined and interdependent, overlapping like a trio of coloured spotlights illuminating the same phenomenon (Figure 8). Competences in educational practices rarely emerge from one of these domains alone, rather they are generated through their dynamic interaction.

Individual sustainability competences, that is, knowledge, skills and attitudes concerning sustainability, are needed when collective competences are being developed, or as the operational culture in a school or university evolves towards sustainability. Conversely, collective sustainability competences, such as regulations, curricula, norms and cultures that promote sustainability, guide individuals in making sustainable personal choices and adopting sustainable behaviours. Both individual and collective sustainability competences are prerequisites for improving technical-material sustainability competences. This is because individuals and communities need to understand how technical-material conditions must be improved for sustainability, but also because collective norms, regulations, cultures and resources are needed to support the implementation of new solutions. Equally, individuals and communities cannot act for sustainability without taking into account the laws of nature and the technical-material environment. If the technical-material conditions are poor, it becomes difficult for individuals or communities to make meaningful choices for sustainability. For example, if there is no infrastructure to enable sustainable choices, individual awareness alone cannot minimise environmental impact. Similarly, regardless of regulations, if there is no adequate equipment to measure environmental impact, it is difficult for organisations to identify the most effective ways to change their practices.

Increased individual responsibility fuels group success, collaborative problem-solving makes technical outcomes more robust and relevant, and hands-on sustainability practices enhance both personal learning and community impact. More examples of this intertwinement in practice are presented in the next chapter, especially the subsection **Practical examples of intertwined sustainability competences**.

Figure 8. The three intertwined spheres of sustainability competence



5. Four Practical Focus Areas related to Sustainability Competences Based on Interventions

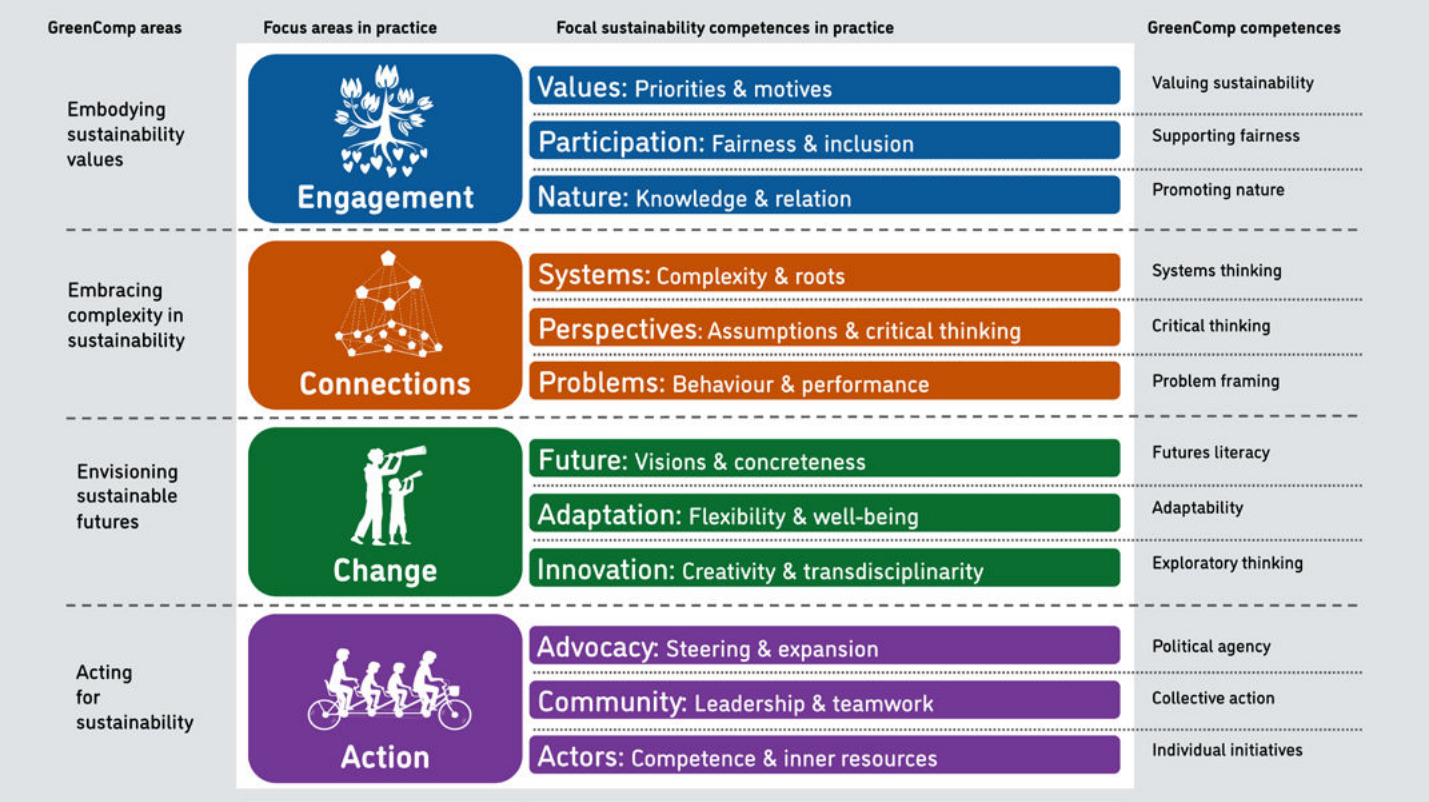
In this chapter, we present our Roadmap for Sustainability Competences in detail. The aim is to illustrate how sustainability competences can be applied and promoted in practice within educational settings. In addition to outlining the factors underlying sustainability competences, we elaborate on the enablers and constraints of sustainability, sustainability competences and the promotion of these competences in everyday life at schools and universities. One of the aims of this Roadmap is to challenge prevailing unsustainable practices and to develop more sustainable ones through different levels of competence. In doing so, the goal is to critically question both the current ways of acting and relating, as well as technical solutions that contribute to unsustainability

We use the European Sustainability Competence Framework GreenComp[75] as a springboard in this Roadmap for Sustainability Competences, expanding its scope beyond individual competences to include collective and technical-material competences. This broader perspective reflects the complexity of sustainability and incorporates its political dimension. This Roadmap has a strong practical aim: we hope that it will help schools and universities move from the conceptual level of GreenComp to practical implementation, as evidenced by intervention results from the ECF4CLIM project[76] and our insights from demonstration sites, which have deepened our understanding of sustainability competences in practice.

[75] European Commission, Joint Research Centre (2022). GreenComp, the European sustainability competence framework. Publications Office of the European Union. **https://data.europa.eu/doi/10.2760/13286**

[76] The contents of the roadmap have been formulated based on interventions at schools and universities and the other results of ECF4CLIM project. The findings are described more in detail in the ECF4CLIM project reports that can be found on the ECF4CLIM project site **https://ecf4clim.eu/project-reports/**

Figure 9. The four practical focus areas of the Roadmap for Sustainability Competences.



The four practical focus areas of this Roadmap for Sustainability Competences are Engagement, Connections, Change and Action (Figure 9). We structure each area around individual, collective and technical-material competences in educational practice, and also describe their intertwinedness. Some examples are also provided.

After presenting the four practical focus areas, we discuss the nature of this Roadmap for Sustainability Competences: on one hand, all areas of the Roadmap are simultaneously present at any given moment in schools and universities; on the other hand, the Roadmap can be seen as a process that gradually leads toward sustainability competences in educational settings.

Engagement

Working in a school or other educational institution necessitates balancing multiple – and sometimes mutually contradictory – values, objectives and understandings. As a result, translating values and ideals into pedagogical practice can be challenging, often leading to ongoing compromises and a continuation of business-as-usual. Successfully promoting sustainability requires prioritisation, inclusive collaboration and a solid foundation of knowledge about sustainability and nature. A core question for educators, therefore, is: How can we deepen our understanding and reflection on the meanings of sustainability, and how can we engage the whole community in promoting it together? This calls for organising time and space for collective reflection, even in the presence of differing value hierarchies. Acting in accordance with both individual and shared values and building a common knowledge base are essential for the well-being of all members of the community.

The Engagement competence area of the Roadmap for Sustainability Competences further elaborates in practice the GreenComp competence area **Embodying sustainability values**[77]. Through this area, GreenComp encourages individuals to reflect on values and worldviews from a sustainability perspective, to consider fairness when promoting sustainability, and to acknowledge the needs and rights of other species and nature as a whole. This Roadmap broadens the understanding of these competences: in addition to individual competences, collective and technical-material competences are also considered essential. The individual competences also expand on the competences in GreenComp as, on the one hand, we conceive them to be in interaction with collective and technical-material competences and, on the other, we define them based on practice rather than theory.

In practice, these competences are expressed and strengthened through **engagement** (Figure 10). Practitioners consider engagement to be one of the most important factors in promoting sustainability in education. Engagement with sustainability in schools and universities arises through values, participation and nature.

1) **Values** reflect **priorities and motives**. The intrinsic motivation of individuals, collective enthusiasm, and material practices – shaped by and shaping pro-sustainability values – enable engagement. The corresponding GreenComp competence, focused on individual competences, is Embodying sustainability values.

2) **Participation** includes the perspectives of **fairness and inclusion**. Participation that fosters engagement requires a personal sense of importance, inclusive critical reflection and a participatory approach within the educational community, and co-design of technical measures and environmental impact tracking. The corresponding GreenComp competence, focused on individual competences, is **Supporting fairness**.

3) **Nature** refers to **knowledge** based on ecology and sustainability sciences, and the relation between humans, nature and the human-made environment. Engagement grows from a personal connection with nature and a caring attitude, knowledge of nature and sustainability, a collective understanding of the basics of sustainability, and access to local, measurable data. The corresponding GreenComp competence, focused on individual competences, is **Promoting nature**.

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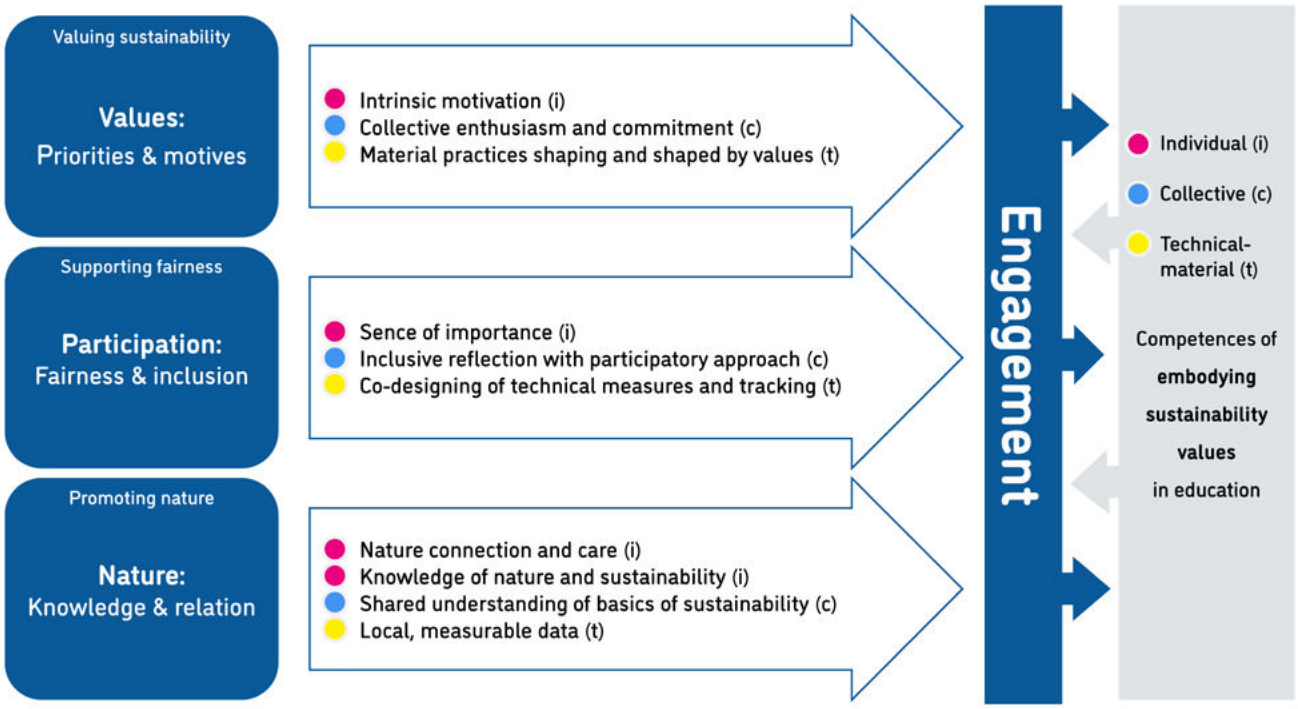
[77] Competence area 'Embodying sustainability values' in: European Commission, Joint Research Centre (2022, pp. 17-19). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

Figure 10. Engagement and GreenComp area 'Embodying sustainability values' in practice.



Next, we elaborate further on the engagement-related, intertwined competences in educational practice at the individual, collective and technical-material levels, and provide examples of their enablers and barriers. The Engagement section concludes with real-life stories and examples of engagement in the ECF4CLIM project.

Engagement and competences

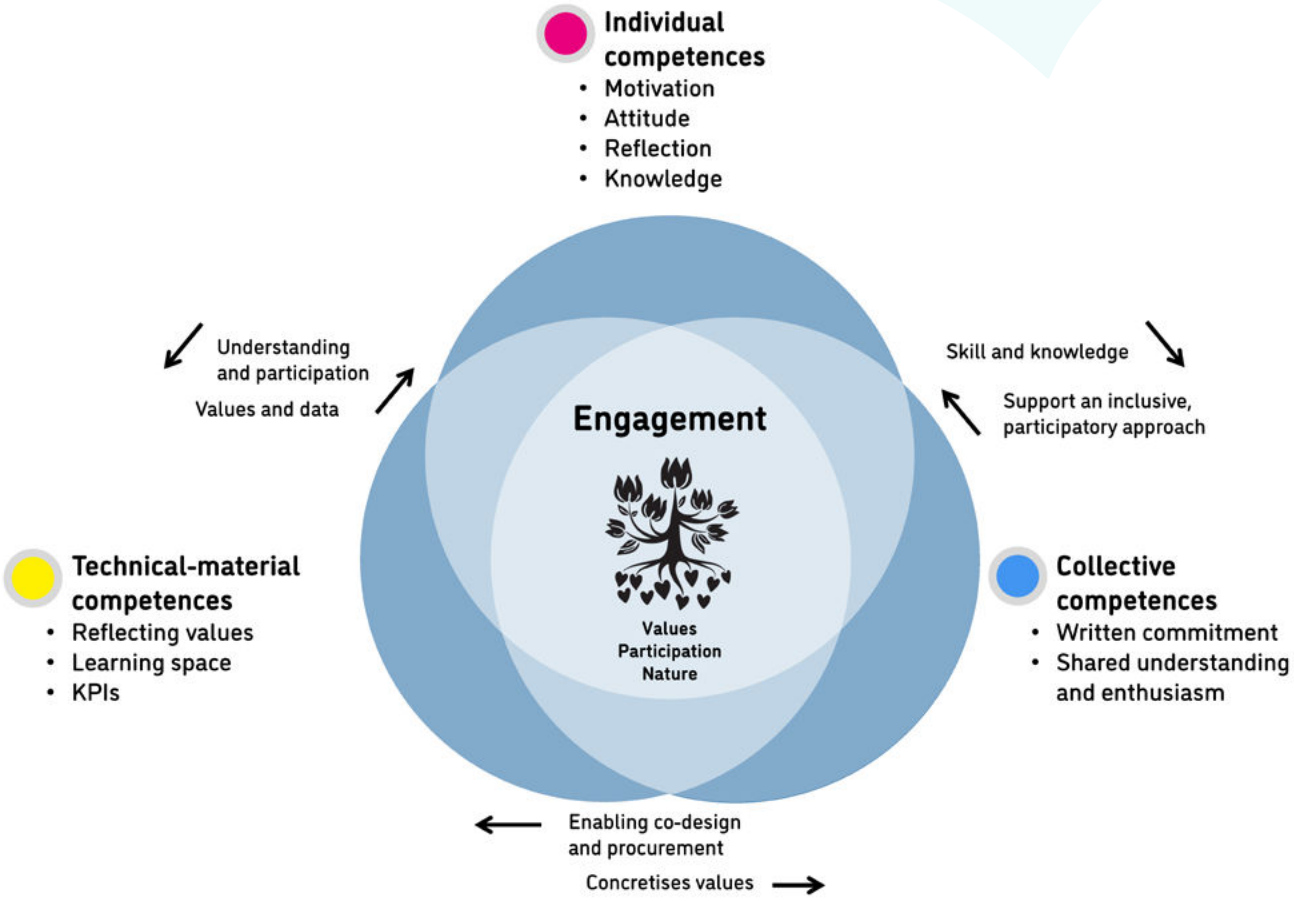
The main factors driving engagement in educational settings are values, participation, knowledge and relation to nature and sustainability, as described above. To translate these into practical actions, we should consider three spheres:

- Educating **individual** students, teachers, headmasters and other staff members to broaden their knowledge, skills and attitudes, enabling them to engage personally in sustainability efforts;
- Focusing on **collective** regulations, norms, practices and organisational culture to strengthen the engagement of the entire school or university; and
- Developing the **technical-material** environment to engage the institution in sustainable best practices.

The individual, collective and technical-material possibilities are intertwined, with each area enabled by the other two[78] (Figure 11).

[78] See also Chapter 4: Intertwined individual, collective and technical-material sustainability competences.

Figure 11. Intertwined competences promoting engagement.



Attitudes toward sustainability and nature constitute the main **individual competences** that drive engagement. The intrinsic motivation of students, teachers, managers, other staff and stakeholders facilitates engagement with sustainability efforts. A positive and caring attitude toward nature – including humans – can be fostered through experiences and knowledge about nature and sustainability. Reflecting on fairness and inclusiveness, both individually and in groups, is an effective way to go forward. Skills in self-examination and reflection on the potential of different value profiles[79] to support engagement with sustainability are also essential. The ability to question the system and to rethink our ways of being in the world are important competences; however, in educational practice, they may receive too little attention.

Collective competences reflect the engagement of the entire school or university with sustainability. Formal commitment to sustainability is embedded in regulations and norms. Despite the gap between bold ambitions and actual practice, legislation, plans and strategies provide support for local sustainability

[79] Motivation profiles of a sustainable lifestyle https://www.sitra.fi/en/publications/motivation-profiles-of-a-sustainable-lifestyle/

efforts. For shared engagement, the cultural-cognitive level is essential. Collective enthusiasm fosters the engagement of the whole school or university. Underpinning sustainability work is a shared understanding of the fundamentals of environmental science.

Sustainability values materialise in **technical-material competences** that reflect physical engagement in sustainability at schools and universities. These competences include infrastructure, equipment and learning environments. Improving technical-material competences leads to short-term environmental gains. Current technical-material practices should be critically assessed, and measurements can support this process. Measuring **water** and **energy use**, the amount of recycled **waste**, or calculating other key performance indicators that describe the environmental impact, provides concrete data on progress and the technical-material state of engagement within a school or university. Natural and built environments also serve as important learning spaces.

Individual, collective and technical-material competences related to engagement are deeply **intertwined**. For example, the technical-material environment offers local data for collective discussions and constructing practical knowledge – that is, individual competences. Easy-to-understand numbers foster a sense of achievement and show participants that their efforts pay off, which in turn increases motivation and broadens participation. Technical-material competences promote sustainability values among students and staff through their very existence. Individual competences, in turn, are essential for understanding the basics of environmental impact and for utilising participatory opportunities in technical-material design.

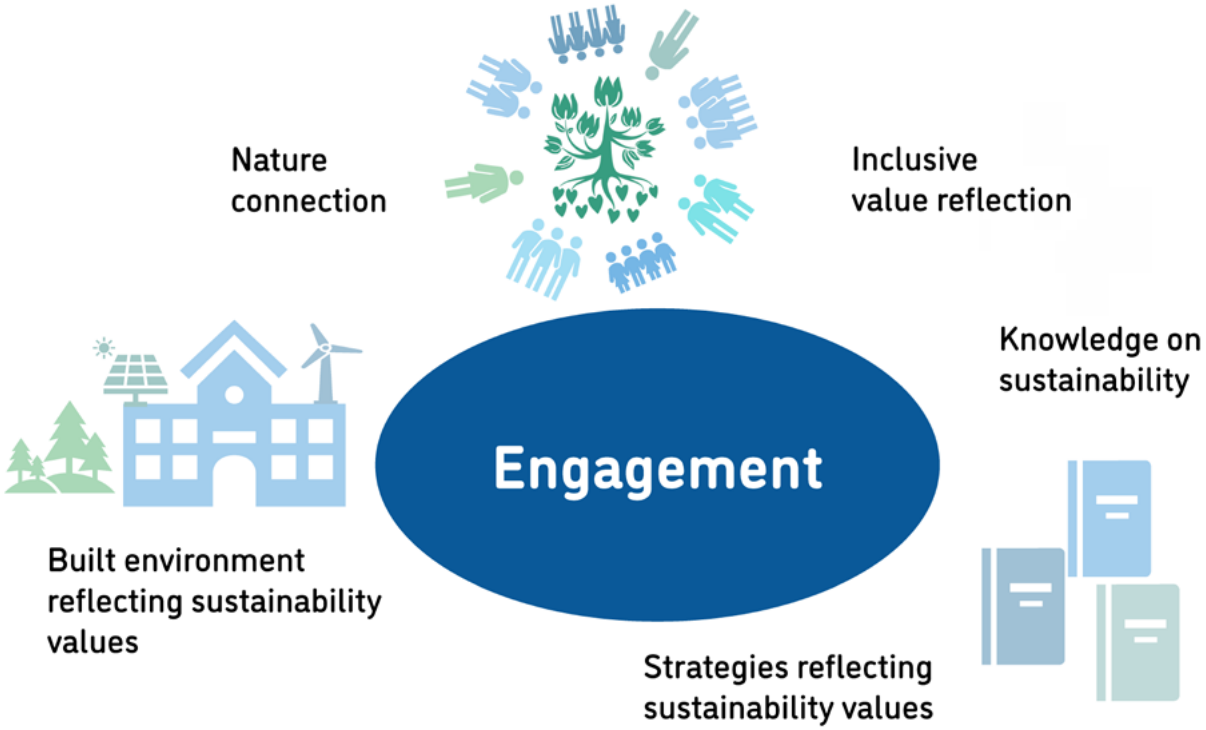
Collective competences such as regulations, practices and resources are essential enablers in co-designing technical-material environments and procurement. Procurement and technical-material competences, in turn, reveal the materialised values of the institution and offer a window into how written strategies are translated into reality. They can increase the enthusiasm and participation of the entire school or university in the development and promotion of sustainability.

Collective competences such as structures, decisions, plans and resources are also important for supporting an inclusive, participatory approach, which in turn helps develop individual competences. To promote these collective competences, principals and teachers should possess individual competences, such as sustainability knowledge and decision-making skills, as well as the ability to facilitate collective value reflection and foster inclusive dialogue. Engagement skills should range from cross-boundary teamwork to meticulous micro-planning and strong cooperation abilities for working with stakeholders.

Enablers and constraints in the area of engagement

The process towards engagement is not straightforward. Even if we know that value reflection, inclusive discussions, nature connection, knowledge about sustainability, and technical-material environments and strategies that reflect sustainability values enable engagement (Figure 12), it is important to understand how to promote these things in practice, and what kinds of constraints could be expected.

Figure 12. Enablers of engagement.



In this section, we present examples of how to enable engagement in educational institutions, along with the constraints that sustainability efforts and engagement may encounter. The examples are drawn from experiences from the ECF4CLIM project and its demonstration sites. The enablers and constraints are presented in table format (Table 2) and as lists to help readers more easily identify relevant viewpoints. We also provide pedagogical questions to support the development process in educational institutions toward deeper engagement with sustainability. The examples are organised according to three main factors underlying engagement: values, participation, and nature. Colours refer to **individual**, **collective** and **technical-material** competences.

Table 2. Enablers, constraints and pedagogical questions of engagement in educational settings.

Values: Priorities & Motive

Corresponding competence in GreenComp: Embodying sustainability values

How to enable?	Who?	Competence
Personal value reflection and self-examination, and willingness to open dialogue.	All actors	Individual
Acting as a role model and a peer influence.	All actors	Individual
Allocating time, space and other resources.	Managers	Collective
Respectful and inclusive value discussions in a safe space, collectively identifying the values underlying different conceptions of sustainability.	Managers, teachers, all actors	Collective
Recognising and reflecting the collective values embedded in regulations, curricula, material environment, decisions and practices.	Managers, teachers	Collective Technical-material
Mutually shared internal (students and staff) and external (stakeholders) rules for action.	Managers, teachers, all actors	Collective
Constraints	**Who?**	**Competence**
The organisational specificities and scarce resources limiting possibilities.	Administration, managers	Collective
Conflicting values, competing priorities (academic, consumerist, economic).	All actors	Individual
Inconsistency in examples and support provided by administration, teachers and parents.	Administration, manager, teachers, parents	Collective
Belonging to identity groups that are indifferent to sustainability.	All actors	Collective
Low motivation and personal commitment, and seeing sustainability activities as extra tasks.	All actors	Individual
Lack of competence and willingness to promote, facilitate and take part in value discussions.	All actors	Individual
Pedagogical Questions	**Who?**	
Where and when could meaningful discussions on sustainability values be organised? Who could be in charge of them?	Managers, teachers	
How can I help my team/students/staff feel safe to express differing views on sustainability topics? What norms or agreements help to maintain inclusivity in sustainability-related dialogue?	Teachers, managers	
How do you understand the meaning of sustainability? Are there diverse understandings in your class/ team/ group? How could each of these understandings promote sustainability?	Teachers, students	
What kind of role model are you for your peers, students or staff? To promote sustainability, how could you demonstrate sustainability values?	Managers, teachers	
Analyse in a group: What kinds of values are embedded in the technical-material environment, practices and documents of the school?	Managers, teachers, students, other staff	

Participation: Fairness & Inclusion

Corresponding competence in GreenComp: Supporting fairness

How to enable?	Who?	Competence
Well-designed, sufficiently resourced, inclusive participatory process with strong pedagogical leadership and shared decision making.	Managers, teachers	Collective
Creating collaborative, inclusive and accessible learning environments that make respectful dialogues possible.	Managers, teachers	Collective
Integrating sustainability in lesson plans and curricula, with interdisciplinary or transdisciplinary strategies.	Teachers	Collective
Clear communication and promotion of creative options to engage in sustainability efforts, making voluntary participation easy.	Managers, teachers	Collective
Giving an example of personal passion, taking advantage of peer influence.	Managers, teachers, students, other staff	Individual
Co-designing technical measures.	Managers, teachers, all actors	Technical-material
Assigning environmental responsibilities.	Managers, teachers	Collective

Constraints	Who?	Competence
Apathy and lack of incentives or recognition for participation, and limited possibilities, motivation or skills for cooperation.	All actors	Individual Collective
Limited time for engagement processes.	All actors	Collective
Hierarchical organisation.	Managers	Collective
Poor facilitation of participatory processes: limited competence and insufficient support.	Managers	Individual
Lack of integration into everyday practices or strategies.	Managers, teachers	Collective
Narrow understandings of sustainability, causing persistent disputes.	All actors	Individual

Pedagogical Questions	Who?
What kind of pedagogical leadership is needed from managers to guide sustainability efforts effectively and using a participatory approach?	Managers
Who are the key internal and external stakeholders that can support sustainability in our school? How to reach them and build partnerships that strengthen sustainability?	Managers, teachers
What kinds of environmental responsibilities can be meaningfully assigned to students or teachers in our school/university? How can these responsibilities be integrated into everyday learning and school culture?	Managers, teachers
What kinds of physical spaces or environments do we have that could help in participatory and hands-on learning?	Managers, teachers
Are there individuals or groups in our community whose voice is seldom heard? Who? How could we ensure that all feel heard and valued?	Managers, teachers
How can I embed sustainability themes across different subjects using interdisciplinary or transdisciplinary approaches, engaging all students?	Teachers

Nature: Knowledge & Relation

Corresponding competence in GreenComp: Promoting nature

How to enable?	Who?	Competence
Versatile learning methods.	Teachers	Individual
Incorporating sustainability in every discipline.	Teachers	Collective
Designing elective courses and multidisciplinary learning modules on sustainability.	Managers, teachers	Collective
Encouraging students towards sustainability and examining how everyday choices influence wider society (from curiosity to advocacy).	Teachers	Individual
Sharing systematic knowledge and a clear baseline of facts among students, teachers and technical staff.	Managers, teachers	Individual
Peers reminding each other to promote sustainability.	Teachers, students	Individual
Local technical solutions and environments used as teaching aids.	Teachers	Technical-material
Offering a solid grasp of environmental and systemic knowledge, for example for understanding how solar arrays interact with the grid or how municipal waste is handled after collection.	Teachers	Technical-material Individual
Constraints	**Who?**	**Competence**
Distrust of research.	All actors	Individual
Pedagogical incompetence.	Teachers	Individual
Teachers' inconsistent (weak) role-modelling.	Teachers	Individual
Other learning contents prioritised.	Teachers	Individual
Academic requirements focus on other things.	Managers, administration	Collective

Pedagogical Questions	Who?
What opportunities exist to co-create elective or multidisciplinary courses focused on sustainability? How can I collaborate with colleagues from other disciplines?	Teachers
What nearby technical-material resources (e.g. energy systems, water use, waste management) can serve as real-world teaching tools?	Managers, teachers
How can sustainability be meaningfully integrated into my subject area?	Teachers
Reflect in group: How are your everyday choices connected to broader sustainability issues?	Managers, teachers, students, all actors
How could you organise an awareness-raising campaign on the basics of sustainability in your school or university? In what course or situation? With whom?	Managers, teachers

Stories: How to engage teachers and the whole school in sustainability?

There are several alternative approaches that can engage students, teachers and the whole school. Personal experiences of concrete, visible sustainability issues often raise interest in taking action when they are addressed together with teachers and students.

The Danube River

Written by a teacher from Romania

Plastic pollution of the banks of the Danube. International Danube River Day, celebrated annually on June 29, is an opportunity to celebrate this important river and to promote its conservation and the environment. In 2023, we participated in a trip with primary school students to a bank of the Danube to spend time in nature. We found a lot of rubbish. The children exclaimed: We don't like it here? Why is it like this? Who should clean it? The general feeling was one of dissatisfaction. After this experience, in the classroom the teacher talked about many aspects of plastic pollution: causes, effects and solutions. In the following spring of 2024, the children happily participated in helping clean the Danube bank of plastic.

Enthusiasm spread from individual initiatives to collective action

In one Spanish school, the principal noticed and seized the opportunity to act as part of the Eco-Schools network and receive support from the ECF4CLIM project for the development of environmental activities. The school received help from many organisations. Together, with support from organisations like CIEMAT, ARBA, Ecoescuelas and CENEAM, they learned about clean energy, recycling, biodiversity conservation, how to save water, trees, forests and how nature is important. They understood better what and why actions for sustainability are important.

What helped them most in engagement was enthusiasm and effective planning. When everyone wanted to do something good for the planet, by working together, they achieved things. They also created a network of environmental friends and invited other schools to participate, and shared their ideas. To make it all work, it was important that the principal appointed one teacher as the official programme coordinator. Finding time for activities was challenging as it was difficult to fit ECF4CLIM activities into regular classes. They managed to use breaks for their activities and art classes to make posters, and included special time in the school schedule for project activities.

What can we learn from these experiences? Individual attitudes, emotions and initiatives are very important to succeed in engaging others in collective action. Intrinsic motivation, peer influence, and an emotional connection to nature are key drivers of engagement. Also, collaboration, planning and inclusive facilitation were key to sustaining participation. Students' commitment deepened when they felt their voices mattered. Hands-on learning and basic sustainability knowledge formed the foundation, while personal reflection and open dialogue enabled wider inclusion. However, sustainability values were not always prioritised, often being challenged by academic pressures and inconsistent role-modelling. Strong pedagogical leadership was essential for fostering meaningful whole-school engagement.

Headmasters and teachers as enablers of engagement

'A school is like its leaders.' – a Finnish principal's reflections:

An effective leader is key to making changes happen in a school. Regular reminders and interventions by the principal are crucial for ensuring sustainability issues remain active in the everyday life of the school. There will always be several important issues to address at any one time. You have to choose what to focus on. Focus on the **issues you can change**. It's important to have a good long-term plan as 'Well begun is half done'.

How to engage employees who do not find sustainability important or interesting? Don't let the critics take you down! It's a part of the process. Get and stay in touch with like-minded colleagues. Network!

Both headmasters and teachers play a key role in engaging the whole school, fostering students' interest and engagement in sustainability actions. This was noted in all the partner countries. But also students' initiatives and attitudes can inspire and strengthen motivation among teachers. The competences of communication, facilitation of discussions and dialogue with students were seen as important in all the interventions in demonstration sites.

Here is some advice from Finnish teachers to other teachers on how to proceed from interest and willingness to action:

Dear teacher, be brave! – Finnish Teachers' reflections:

There is a strong justification and clear reasoning for you to implement sustainability education in school. You are a wise, capable and experienced adult. Take **time** to get to know where you stand: How do you feel? What are you willing to do? What are you willing to give up? What do you want to learn, and what is important to you? You are allowed to disagree, but please acknowledge the facts, about, e.g., climate change. **Make time and opportunities for discussion with** students, both during lessons and breaks, and with colleagues, formally (planning and meetings) and informally (coffee breaks and lunches). Be positive! That in itself is valuable and will start moving mountains!

Portuguese schools and practical activities

At the Portuguese demonstration sites, engagement was achieved by actively involving students, teachers and the broader community in practical sustainability activities rather than focusing on theoretical discussions. At both the EB Bobadela and EB Camarate schools, engagement strategies relied on participatory actions that connected classroom learning with concrete environmental goals. For example, both schools organised waste separation **competitions** in which classes and groups were encouraged to reduce, reuse and recycle materials. These friendly contests motivated students while triggering deeper discussions on the environmental impacts of waste production. At EB Bobadela, the contests were supported by the installation of new recycling bins and awareness sessions, while at EB Camarate they were integrated into a broader set of activities on waste and circular economy. In both schools, **students acted as agents of change**, inspiring their peers and teachers to adopt more sustainable practices.

Beyond waste-related activities, engagement was also promoted through experiential learning and **partnerships** with external entities. At EB Bobadela, the 'Energy Route' initiative, developed in collaboration with ADENE, allowed students to explore practical aspects of energy efficiency through interactive sessions. Similarly, at EB Camarate, the same initiative promoted awareness of energy consumption and renewable energy sources, helping students to connect theoretical knowledge with real-world energy management. These experiences demonstrated how local partnerships can significantly strengthen engagement when sustainability topics are made visible and tangible in everyday school life.

At the higher education level, the Instituto Superior Técnico (IST) fostered engagement through initiatives such as 'Técnico Makes the Difference' and the 'Bio Técnico' project, which encouraged students and staff to reduce waste, improve recycling and promote sustainable food practices on campus. Through **contests, workshops and voluntary actions**, IST turned awareness into commitment, helping to build a shared culture of environmental responsibility within the academic community.

Collected short examples from all countries

- **Role-play** reflections stressed the importance of interpersonal and communication skills to involve others and spark interest early on.
- Participants also stressed that the ability to engage with others through clear **communication** and inclusive facilitation is essential.
- Participants' experiences showed that without good **facilitation**, initial engagement faltered.
- Students adopted proactive attitudes toward sustainable resource use, taking on classroom pledges to turn off lights and reduce water waste.
- Some schools reported increased positive awareness and behaviours toward resource saving and environmental responsibility, noting **frequent peer reminders** about turning off taps and collecting litter after breaks.
- Students appreciated **belonging** to the school's environmental team, which provided opportunities to discuss sensitive environmental issues comfortably. They described **lunchtime gatherings** where members exchanged personal stories about choosing vegetarian options or cycling to school.
- Interventions provided a replicable model aligned with the school's sustainability goals, outlining how technical staff, teachers and students jointly monitored electricity output and savings.
- **Creative promotion** of ideas, such as school radio segments and a mascot design, raised visibility and pride, detailing **weekly broadcasts** featuring interviews with gardeners and jingles about composting.
- An individual's **personal passion** and **example** could substitute to some degree for formal knowledge in sparking engagement. One participant with strong personal sustainable habits (but not an expert by training) inspired others by sharing practical examples, thereby expanding the roadmap assumption by showing passion and role-modelling as valuable engagement competences.

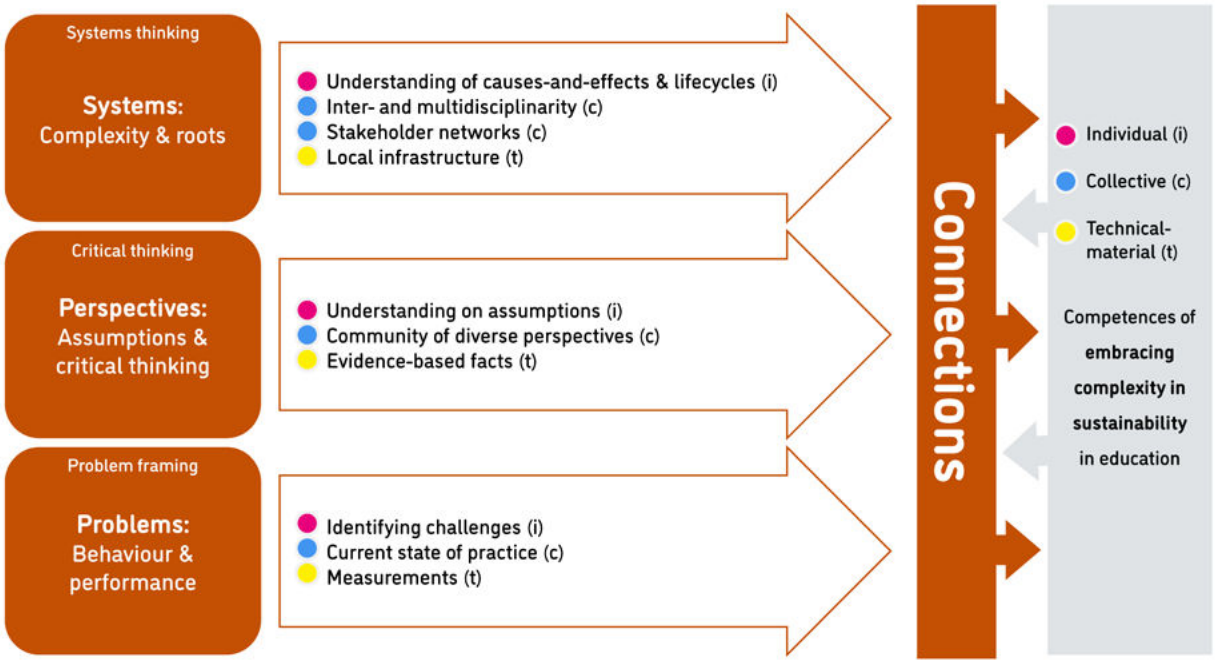
- **Effective cooperation and detailed planning** by the school leaders helped to rally the community. This cooperation was essential in driving engagement.
- In some cases, such as those of schools in Finland, Portugal and Romania, a new subject has not been created, but sustainability is discussed as part of teaching under other subjects (e.g. in English classes). As a result of our project's interventions, it seems that these topics are being addressed and discussed in class, albeit sporadically, in an increasing number of teaching subjects. This is the case even though the curricula often have not changed. The ECF4CLIM project's interventions also helped the schools and teachers **to translate into practice the theoretical lessons on sustainability** that they had been teaching already prior to the project. In this way, ECF4CLIM has helped to reinforce the content already included in the curriculum.
- Teachers sometimes claimed that students were not always willing to spend time learning more about sustainability, because the pressure to do well in final exams outweighed their interest in learning about these topics, especially outside of the classroom.

Connections

In schools and other educational institutions and in lifelong learning and non-formal education, everyday life unfolds through a variety of seemingly disconnected situations, making it challenging to grasp the holistic nature of sustainability. Without recognising the underlying interconnectedness of our activities, it becomes impossible to identify root causes or frame problems in a meaningful way. Connecting different subjects and disciplines with sustainability helps construct an understanding of its entirety. It is also important to scrutinise how our individual contexts and cultural backgrounds shape the way we perceive sustainability and the knowledge we hold about it. Through regular participatory and transdisciplinary discussions, schools and universities can identify the most pressing sustainability challenges within their own environments. In addition, technical measurements can assist in identifying key causes of environmental impacts in school activities, enabling institutions to take appropriate action.

The Connections competence area of the Roadmap for Sustainability Competences further elaborates, in practice, the GreenComp competence area **Embracing complexity in sustainability**[80]. Through this focus, GreenComp encourages learners to identify interdependencies, critically assess information and worldviews, and define sustainability challenges to strengthen their ability to question unsustainable practices. This Roadmap for Sustainability Competences expands the understanding offered by GreenComp from an individual perspective to the collective and technical-material spheres. In addition, the individual competences also expand on those of GreenComp as we conceive them to be in interaction with collective and technical-material competences and we define them from a practice- rather than theory-based perspective. This provides a practical lens for everyday life in schools and universities.

Figure 13. **Connections and GreenComp area 'Embracing complexity in sustainability' in practice.**



[80] Competence area 'Embracing complexity in sustainability' in: European Commission, Joint Research Centre (2022, pp. 19-22). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

In educational practice, these competences emerge through understanding connections (Figure 13). Many practitioners experience everyday life in schools and universities as highly complex, with numerous connections to manage and a variety of issues to take care of – such as collaboration with stakeholders and other disciplines, curriculum content, disciplinary boundaries, and environmental concerns. This complexity can make promoting sustainability a challenging task.

To address these challenges, attention should be focused on:

1) Systems: Exploring the complexity and roots of activities. Understanding cause-and-effect relationships and material life cycles enables students, teachers and administrators address key sustainability challenges. Inter- and multidisciplinary approaches reveal how different subjects and disciplines contribute to sustainability, supporting broad scientific, cultural, social and political perspectives. Mapping stakeholder networks and local infrastructure highlights key actors in sustainability efforts. The related GreenComp competence is **Systems thinking**, focused on individual capabilities.

2) Perspectives: Understanding assumptions and critically considering different viewpoints. Critically examining our individual and collective beliefs about how the Earth, people or societies function can reveal cultural biases that prevent us from recognising key sustainability factors. Tracking diverse perspectives within the educational community helps broaden our insights. A good way to avoid narrow-mindedness is to explore evidence-based facts – such as reviewing energy consumption data – or to gather stakeholder opinions through surveys and dialogues. The corresponding GreenComp competence, focused on individual capabilities, is **Critical thinking**.

3) Problems: Identifying current practices by scrutinising individual and collective behaviours and assessing the environmental performance and impact they produce. Students, teachers, administrators and practices are all part of both the sustainability problem and the solution within schools and universities. It is essential to identify and prioritise the most relevant challenges that can realistically be addressed. Participatory dialogues and scientific measurements, possibly supported by technical equipment, can assist institutions in this task. The corresponding GreenComp competence, focused on individual capabilities, is **Problem framing**.

Next, we elaborate further on the connections-related, intertwined competences in educational practice at the individual, collective and technical-material levels, and provide examples of their enablers and barriers. We also present some stories and examples from the ECF4CLIM demonstration sites regarding connections.

Connections and competences

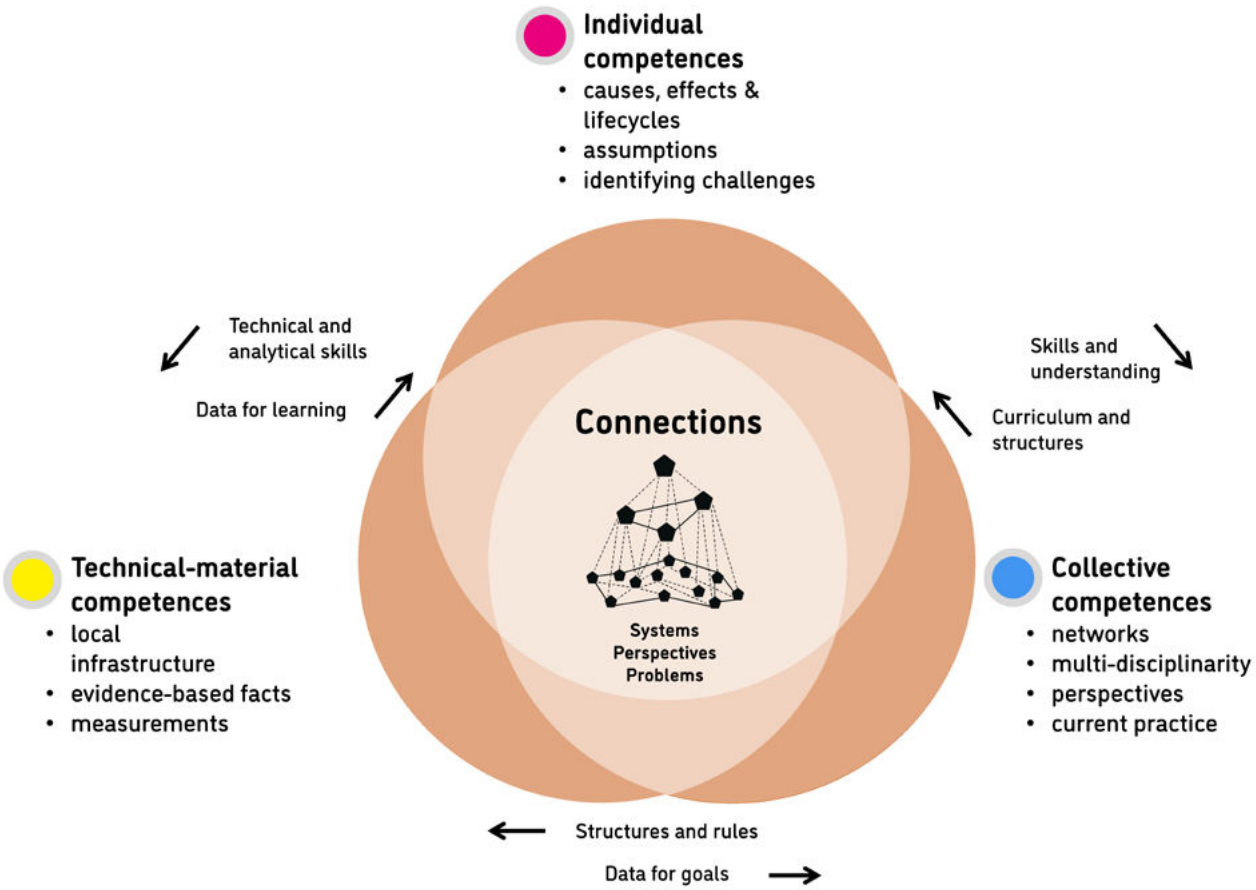
The main viewpoints in understanding connections are systems, perspectives, and problems, as described above. Different spheres of sustainability competence can contribute to understanding connections:

- Facilitating **individual** students, teachers, headmasters, or other staff members to learn systemic and critical thinking and problem framing;
- Focusing on understanding networks and **collective** regulations, norms, practices and organisational culture to figure out the relevant connections; and
- Developing the **technical-material** environment to have the equipment to provide evidence and measure the current state of practice.

The individual, collective and technical-material possibilities are intertwined, with each area enabled by the other two[81] (Figure 14).

Understanding causes and effects, life cycles, and underlying assumptions require **individual competences** – systems **knowledge**, creative **out-of-the-box thinking**, and analytical **skills** when identifying challenges. Positive attitudes toward reflecting on personal and cultural worldviews are also essential. Awareness of relevant actors and diverse perspectives – such as disciplinary, cultural, technical, environmental, social and political – is necessary, along with an understanding of how these elements are interconnected. These competences are important for all actors in educational settings. Participants in diverse networks working toward sustainability efforts benefit from cooperation skills, commitment to transdisciplinary work, and social influence competences. Leaders can gain advantage from project management competences when guiding collaborative groups that promote sustainability. In this complex system, the ability to accept the complexity of the world is vital.

Figure 14. **Intertwined competences for understanding connections.**



[81] See also Chapter 4: Intertwined individual, collective and technical-material sustainability competences.

Structures and networks for cooperation are essential **collective competences** in navigating interconnected systems. **Regulations and norms** that maintain or advance sustainable practices are notable competences for promoting sustainability. An organisational culture that brings diverse perspectives to the forefront helps construct sustainability in schools and universities. Sustainability is supported by curricula that integrate sustainability perspectives across all subjects and disciplines, as well as by multidisciplinary practices that draw connections between them. A collective understanding of the key factors behind unsustainability is valuable in sustainability efforts.

Technical-material competences enable schools and universities to gain access to evidence-based facts – for example, through measurements of **water** and **energy** consumption or the amount of waste. This data can evolve into new technical-material competences when it highlights the need for new procurements that reduce environmental impact. Local infrastructure constitutes an essential part of technical-material competence: for instance, functioning energy, transport and waste collection systems in the municipality are crucial for the local operations of schools and universities.

Individual, collective and technical-material competences related to connections are deeply **intertwined**. For example, when developing strategies and cooperation plans for sustainability, individual competences in collaboration and management are essential. In turn, a curriculum that includes sustainability as a norm can guide individual teachers to address environmental or social issues and facilitate multidisciplinary teamwork in their lessons.

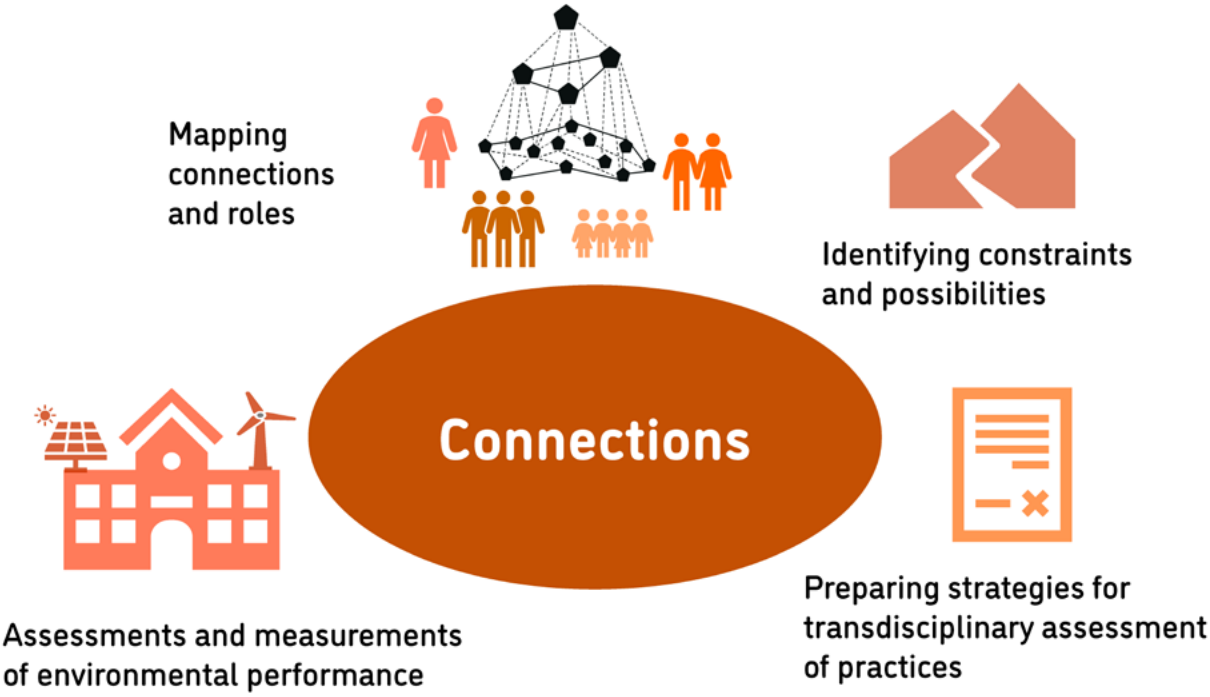
Many improvements in the technical-material environment require collective competences, such as communication structures across organisations and established practices and rules for procurement. Additionally, an organisational culture that promotes sustainability can lead to enhancements in material-technical infrastructure.

Technical-material competences can generate data that individuals use to build knowledge on sustainability. Conversely, individual competences – such as technical skills and the ability to analyse and interpret data – are needed to install and maintain technical infrastructure and to utilise data from technical equipment.

Enablers and constraints in the area of connections

Understanding connections is a demanding process (Figure 15), but some practical procedures can enable these in practice. It is also beneficial to know what kinds of constraints could be expected.

Figure 15. Enablers of understanding connections.



In this section, we present examples of how to enable understanding of connections in educational institutions, along with the constraints that sustainability efforts and connections may encounter. The enablers and constraints are presented in table format (Table 3) and as lists to help readers more easily identify relevant viewpoints. We also provide pedagogical questions for different audiences to support the development process in educational institutions toward a deeper understanding of connections. The examples are organised according to three main factors underlying connections: systems, perspectives and problems.

Table 3. **Enablers, constraints and pedagogical questions of understanding connections in educational settings.**

Systems: Complexity & Roots

Corresponding GreenComp competence: Systems thinking

How to enable?	Who?	Competence
Critical analysis and mind maps of complex situations from diverse perspectives (environmental, social, economic, cultural, policies, networks).	Managers, teachers, students, other staff	Collective
Mapping the roles of actors in the system (agreements on responsibilities, including external stakeholders such as service providers, municipalities, NGOs).	Managers, teachers	Collective
Participatory audits with stakeholders to identify constraints and propose solutions.	Managers, teachers, other staff, external stakeholders	Technical-material
Tracking environmental impact.	Managers, other staff, school owners	Technical-material
Life cycle studies (root causes, end result, rebound effects, post-school chain) on personal, community and cultural levels.	Managers, teachers, students, other staff	Individual
Critical reflection to understand the connections to sustainability in and between different disciplines and subjects.	Teachers, students	Individual
Constraints	**Who?**	**Competence**
Limited institutional support for the integration of environmental, economic and policy dimensions.	Administration and management	Collective
Inconsistent community and individual engagement.	See enablers of Engagement	Collective Individual
Rigid academic structures.	Cultural traditions	Collective
Fragmented curricula.	National and local administration	Collective
Outsourcing services such as catering, cleaning and procurement, moving power from schools to external actors.	School owners, municipalities	Collective
Fragmented, insufficient and complicated decision structures, rules for action, and legislation.	Policymakers, service providers	Collective
Infrastructural constraints (poor energy, food, waste management, transport services, municipality infrastructure).	Service providers	Technical-material
Pedagogical Questions	**Who?**	
How are different aspects of sustainability (e.g., waste, energy, procurements, equity) connected in your daily school life? Create a mind map.	Students	
Who are the people and organisations involved in making your school more sustainable? How can we clarify and agree on responsibilities among staff, service providers and municipalities?	Teachers and managers, students	
What are the interconnections between environmental, social, economic, cultural and governance factors in our school's sustainability practices?	Teachers and managers	
How do different subjects (e.g., science, history, arts) contribute to sustainability education?	Teachers	
What is the life cycle of (a certain) procurement and equipment in your school?	Teachers, managers, students, other staff, service providers	

Perspectives: Assumptions & Critical Thinking

Corresponding GreenComp competence: Critical thinking

How to enable?	Who?	Competence
Influencing attitudes, such as being open to change and seeing sustainability challenges in flexible ways.	Teachers and managers	Individual
Looking at problems from different angles in participatory activities.	Teachers	Collective
Being critical when scrutinising technical-material practices and possibilities.	Teachers and managers	Technical-material

Constraints	Who?	Competence
Techno-optimism or pessimism constraining realistic plans.	Teachers, managers, other staff, service providers	Individual
A high level of 'meta-reflexivity' is needed for structured reflection on cultural assumptions; no expert support for facilitators.	Administration and management	Collective
Unexamined assumptions, like 'students don't care'.	Teachers and managers	Individual

Pedagogical Questions	Who?
What sustainability challenges do you notice in your school environment?	Teachers, managers, students, other staff, stakeholders
What different viewpoints do different actors have about a sustainability issue chosen for inspection (like waste, energy, food)?	Teachers, managers, other staff, service providers, students
What perspectives (e.g. cultural, economic) influence how people view sustainability?	Students, teachers
What current practices in our school might unintentionally hinder sustainability?	Teachers and managers
Are we relying too much – or too little – on technology to solve sustainability problems?	Teachers, managers, students
What cultural assumptions might influence how we teach sustainability?	Teachers

Problems: Behaviour & Performance

Corresponding GreenComp competence: Problem framing

How to enable?	Who?	Competence
Mapping individual and contextual unsustainable behaviours and sustainability problems in everyday life.	Teachers, managers, other staff, service providers, students	Collective
Regular assessments of environmental, social and economic systems (data on electricity and water consumption, air quality, waste, individual pro-environmental behaviour).	Teachers, managers, other staff, service providers (students)	Technical-material
Framing priority problems, e.g. by using baseline KPIs to find enablers and opportunities that have the greatest potential: pinpointed leverage points.	Teachers and managers	Technical-material
Acquiring knowledge about possible solutions and the impact of potential changes and facts to avoid relying too much or too little on technical solutions.	All actors	Individual
Allocating sufficient financial resources, including systematic and regular monitoring and revision of equipment.	Managers	Collective
Using AT and digital platforms (energy-use curves, water-flow graphs and CO_2 levels) to help observe the effects of actions and to set reduction goals.	Teachers, students	Technical-material Individual
Using storytelling, peer modelling and persuasive communication to spread practices beyond core groups.	Teachers and managers	Individual

Constraints	Who?	Competence
Simplistic framings of the problem.	All actors	Individual
Individual, collective and technical-material factors that reduce motivation to participate in environmental activities.	See enablers of Engagement	Individual Collective Technical-material
Poor local infrastructure, e.g. insufficient or poorly placed bins and unclear signage.	Administration and management	Technical-material
Interventions requiring the installation of equipment or devices: no provisions made for repair and maintenance, lack of on-site maintenance skills.	Managers, administration	Technical-material Collective Individual
Challenges of assessing the environmental benefits of classroom content and debates.	Teachers	Collective
Missing skills and knowledge for the assessment of environmental performance.	Teachers, managers, other staff, service providers	Individual Technical-material
Budgetary limitations.	School owners, administration	Collective

Pedagogical Questions	Who?
What are the sustainability challenges in this context? What are the most impactful changes to be made in our institution with limited resources?	Teachers, managers
How can we improve our skills in evaluating environmental performance?	Teachers, managers, other staff, service providers, and students
What knowledge or data can be collected to critically assess sustainability in our school or university?	Teachers, managers, other staff, service providers
How to make environmental data visible and meaningful for students?	Teachers, managers
How to ensure that sustainability equipment is maintained and monitored effectively, and how can we allocate resources for repairs and upkeep?	Managers, other staff, service providers

Stories and examples from ECF4CLIM demonstration sites

Stories: Connections through multidisciplinary studies at the university level

Interdisciplinarity is central to facing the challenges of sustainability transitions. Universities in Finland, Romania and Spain developed multidisciplinary sustainability courses as part of the ECF4CLIM project.

Planning a multidisciplinary Sustainability Transitions Study Module at the University of Jyväskylä

At the University of Jyväskylä, Finland, ECF4CLIM supported the interdisciplinary collaborative development process of a 25 credit study module called 'Basic Multidisciplinary Studies in Sustainability Transitions'. The study module introduces students to the needs, barriers and opportunities of sustainability transitions from a multidisciplinary perspective of technological solutions, social governance systems, cultures, and behaviours.

The interdisciplinary planning proved fruitful, but challenging. University regulations for promoting sustainability and **JYU.Wisdom**, an open and **transdisciplinary community** of the University of Jyväskylä, were good starting points for the development. Despite the university's favourable regulations, the first attempt to begin the planning process did not succeed. Leaders' decisions were needed to designate an **official planning group e**nabling all the faculties to participate in its development. However, **allocation of resources** and academic credits among faculties occasionally revealed underlying tensions and the defence of **institutional interests**.

Successful interdisciplinary planning demanded genuine commitment to understanding colleagues from other disciplines, contributing to the common good and dedicating personal time or reallocating effort from other responsibilities. Engaging with **diverse viewpoints** during the planning process helped **broaden participants' perspectives** on sustainability. Multidisciplinary planning was considered a valuable opportunity to **step outside disciplinary** silos and gain insight into other fields' perspectives as well as for identifying issues that often remain unaddressed – those residing in conceptual 'no man's land'. **Dialogue was** considered essential for enabling the emergence of new perspectives.

Different cross-curricular approaches in Romania and Spain

At the University of Pitești, engineering students applied sustainability principles in technical projects supported by a co-designed curriculum. Teachers observed that the students developed the ability to **link engineering outcomes with ecological impacts** and to integrate individual, collective and technical competences. **Teamwork, respectful dialogue and shared responsibility** were also raised as important among the participants. Through collaborative projects, the students learned to **distribute roles, engage in democratic decision making**, and build a **common vision** for a more sustainable future. This cooperative culture fostered mutual learning and a deeper understanding of complex sustainability issues

At UAB (Spain), one of the interventions was the design and implementation of an open two-credit course on critical analysis of the eco-social crisis, available for students from any study programme offered by the university. The focus of these studies ranges from technical and corporate-management-oriented teaching to highly philosophical courses questioning the **hegemonic socioeconomic model**.

Stories: Understanding connections when improving the sustainability of school meals in Finland

Improving the quality and sustainability of school meals served in schools was considered the **most relevant issue among students** and personnel of both demonstration sites located in Tampere, Finland. Also, fostering positive attitudes towards vegetarian food was another common goal for the interventions in both schools. These issues are very relevant as schools have a key role in sustainable food transitions, especially in Finland, where there is a long tradition of free school meals. However, these are very complex issues with many influencing factors. Mapping and understanding systemic, regulative, normative, social and practical constraints and possible solutions was therefore essential. Moreover, influencing these issues necessitates collaboration not only with personnel within the school but also with other stakeholders.

Municipal decision makers and experts were invited to ECF4CLIM sustainability committee meetings, where students, teachers and headmasters **discussed together** how to improve the quality and sustainability of Finnish school meals. **Surveys mapping general attitudes** and behavioural choices were conducted in both schools. Vegetarian food cooking events, a **tasting day** and recipe contest were organised as interventions in the comprehensive school to foster positive attitudes not only among students but also among teachers and families. In upper secondary school, a **digital food scale** was procured in order to obtain data to be able to give accurate feedback on the quality and amount of food that students eat and of leftover food in school. All the food interventions were experienced positively. The meetings were interesting but also partly frustrating, especially for students, on learning how systems and scarce resources restrict possibilities to improve school meals.

Stories: Understanding connections when changing things by changing things (CO2 and water market)

In CEIP Mozart, students, teachers and parents engaged in the organisation of a local market within the school community for the exchange of good-condition T-shirts. They could **calculate the CO_2 and water savings** associated with wearing a second-hand T-shirt using a weighing scale and a carbon and water footprint calculator (taking into account the weight and type of textile). Participants received CO_2 and **water vouchers** reflecting the savings compared to buying a new T-shirt and signed a commitment agreement not to buy a new T-shirt. At the end of the activity, the total savings made by the school through this intervention were calculated, after which participants engaged in a deliberative workshop to reflect on their experience.

The market helped to understand the links between environmental challenges and consumption patterns. It also promoted **life cycle thinking, identifying the root causes** of environmental impacts at a personal level and encouraging a critical re-evaluation of previous assumptions. For example, the idea that a single T-shirt is insignificant was challenged. Students became aware of the various environmental impacts of different types of textiles, such as water consumption and CO_2 emissions, and possible simple solutions, such as reusing T-shirts.

Stories: Understanding connections in Portugal and cross-sectoral collaboration

In Portugal, the ECF4CLIM interventions helped to strengthen connections between schools, universities, municipalities and local communities. Collaboration between the Instituto Superior Técnico (IST) and EB Camarate created a two-way exchange of knowledge: university researchers and students provided technical and scientific support, while the school offered real contexts for collaborative sustainability learning.

One of the most successful examples of these connections was the Quinta do Charco project in Camarate. A team of researchers from IST worked closely with teachers, students, parents and school staff to redesign and reactivate the school's biological garden. Through classroom and outdoor sessions, participants shared ideas, discussed priorities and co-created the architectural plan for the new space. The process was iterative and dialogical, combining technical design with collective reflection and decision making. The final plan represented not only a physical transformation, but also a **shared vision of sustainability, belonging, and community empowerment.**

At the higher education level, sustainability became a common theme connecting different departments and functions at IST. In the Communication and Community Involvement project, architecture students and professors co-designed new green areas on campus, integrating creativity, environmental design and participatory planning. The Technical + Green initiative linked researchers, technical staff and maintenance teams to jointly develop biodiversity and permaculture areas, while the Bio Técnico project extended this network to external companies promoting sustainable food systems and circular economy practices.

Together, these experiences demonstrate how cross-sectoral collaboration – between schools, universities, local authorities and private partners – can transform sustainability from a theoretical concept into a practical, relational and community-driven learning process.

Collected short examples from all countries

- There were many examples of **cooperation with stakeholders from outside of the school**, as these stakeholders are often necessary for the proper functioning of the school itself. This was the case in Finland, for example, where collaboration with town councils was vital, given that the schools are owned and operated by the municipalities. Collaboration with private companies was important, for instance, in the Portuguese case, where the contribution of the waste collection company was necessary for the establishment of new mutually shared rules.
- The iterative deliberative processes implemented throughout the project allowed students and teachers to collectively reflect on the relevant stakeholders in carrying out sustainability projects. In the course of this process, participants repeatedly mentioned internal entities (offices, departments, etc.), external bodies (municipalities, companies, etc.) and intermediaries (families) to whom specific responsibilities are assigned and with whom specific types of relationships are required.
- Several of the project's interventions have generated data on electricity and water consumption, air quality, waste generation, and more. This has allowed schools and universities to estimate certain environmental impacts and assess the effectiveness of the interventions. These **data** can thereby **constitute a powerful means of awareness-raising**, which can, in turn, foster change in behaviours and practices. **Making data**

- **on environmental impacts visible** can guide future action, for example by motivating the involved actors to improve or at least maintain the improvements achieved.
- Some schools have strengthened their environmental commitment by increasing their participation in 'green-school' or 'eco-school' programmes. This fosters greater involvement among the school's various stakeholders, as well as stronger ties with external stakeholders (municipalities, etc.).
- Schools and universities often have **limited possibilities** to improve their environmental performance through better management of facilities and services **due to the prominent role of municipal authorities** (in Spain, also regional) in decisions concerning services such as energy and water supply, waste collection and recycling, as well as the common practice of outsourcing services such as catering, cleaning and procurement.

Change

Amid the current deepening ecological and sustainability crises, educating future generations to take responsibility for change is a complex task – especially when no one has precise knowledge of the solutions. In schools and universities, collective discussions and decisions based on scientific future scenarios are essential for identifying the most effective paths toward sustainability. Once the collective and technical-material conditions and possibilities within a specific institution are understood, meaningful and achievable goals can be defined through creativity, adaptability and a willingness to learn things that do not yet even exist.

The Change competence area of the Roadmap for Sustainability Competences further elaborates, in practice, the GreenComp competence area **Envisioning sustainable futures**[82]. These competences involve exploring alternative future scenarios and identifying the actions needed to achieve a sustainable future. Coping with uncertainty about the future and navigating trade-offs in sustainability require adaptability. Exploratory thinking connects different disciplines, encourages creativity, and supports experimentation with novel ideas and methods. This Roadmap for Sustainability Competences expands the understanding offered by GreenComp from an individual perspective to the collective and technical-material spheres, providing a practical lens for everyday life in schools and universities. In this Roadmap, individual competences also expand upon the competences of GreenComp, firstly, because we conceive of them as being in interaction with collective and technical-material competences and, secondly, because we define them based on practice, rather than on theory.

In educational practice, these competences are expressed through addressing change (Figure 16) in schools and universities. For practitioners, it is often easier to focus on concrete ways to improve sustainability and reduce environmental impact within their own institutions, rather than relying on abstract visions. They are interested in what concrete options are available to them and what specific changes are needed. Uncertainty and eco-anxiety can make the process burdensome.

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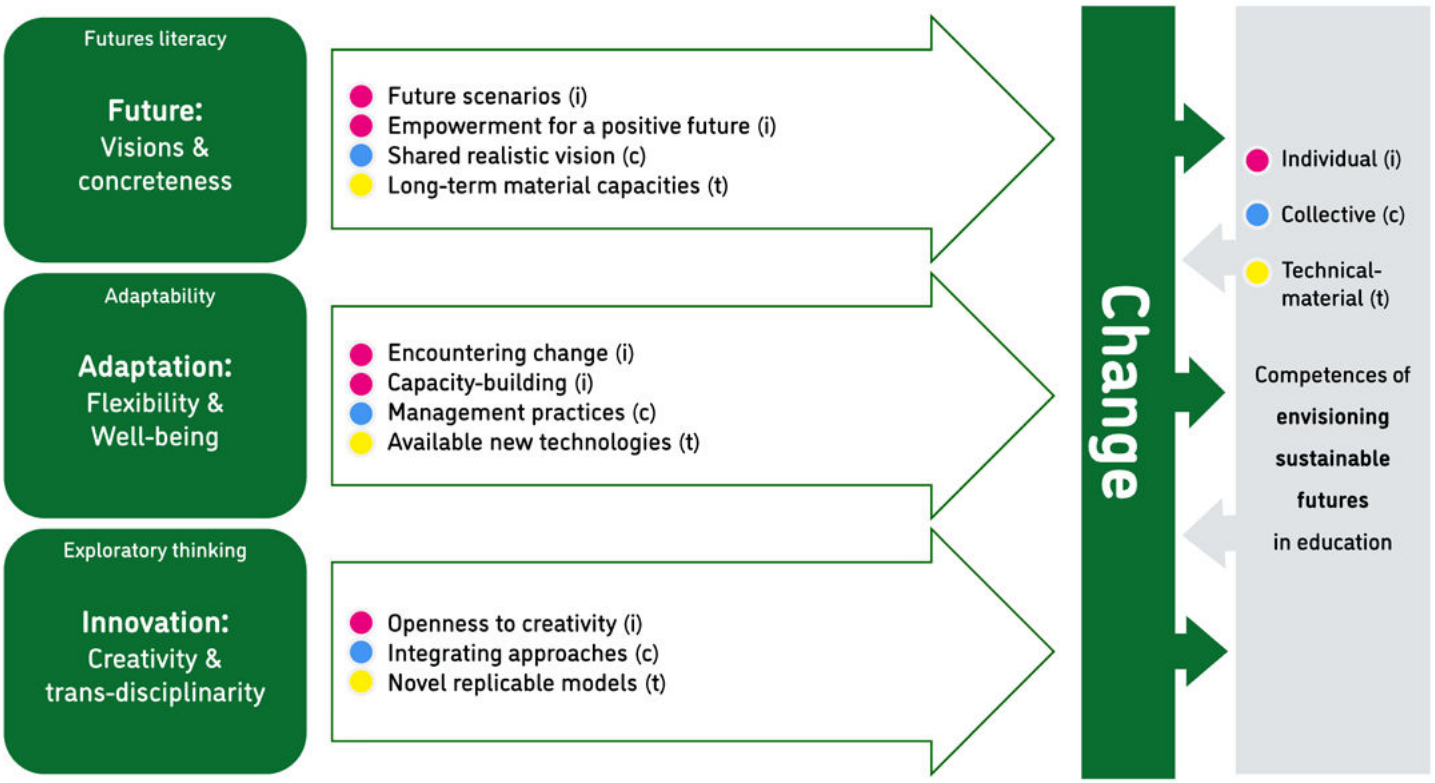
[82] Competence area 'Envisioning sustainable futures' in: European Commission, Joint Research Centre (2022, pp. 23-25). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

Figure 16. Change and GreenComp area 'Envisioning sustainable futures' in practice.



To address these challenges, attention should be directed to:

1) Future: Outlining possible future visions and how they can be translated into concrete goals within the school or university. Studying undesirable, probable and preferable futures can sometimes lead students and even adults to apathy and despair, so it is important to empower the community with belief in the possibility of a sustainable future. Designing a shared, realistic vision of the steps the institution can take helps the vision of the preferred future to become concrete. If the institution decides to improve its technical-material capacities (Table 4), it is also important to consider long-term procurement and to think critically about future maintenance, durability and the life cycle of the equipment. The corresponding GreenComp competence, focused on individual capabilities, is **Futures literacy**.

2) Adaptation: Being flexible in the face of change without compromising well-being. Encountering change is always a personally burdensome experience, even when it leads to a better future. The school or university can support the entire community – including students, teachers and maintenance staff – by providing opportunities to build their capacities and avoiding know-how gaps through learning. Management practices play a crucial role in the adaptation process and steering the development of concrete, shared, preferably written action plans. Possible new technologies require flexibility from the whole community: maintaining a critical attitude, accepting uncertainty, and believing in the power of learning. The corresponding GreenComp competence, focused on individual capabilities, is **Adaptability**.

3) Innovation: Creatively designing novel solutions by leveraging transdisciplinary networks as a strength. Sustainability challenges cannot be addressed using the old means. Personal openness to creativity and new solutions is essential. In this work, both internal and external cooperation are vital, as transdisciplinary insights can lead to the creation of something truly novel. Ideally, the school or university can innovate replicable models that can be shared beyond the institution. A prerequisite for innovation is critical assessment of the need for change. The corresponding GreenComp competence, focused on individual capabilities, is **Exploratory thinking**.

Table 4. Examples of technical-material solutions

Examples of technical-material solutions in schools and universities

Renewable Energy Installations: Rooftop photovoltaic panel arrays to generate on-site green electricity, reducing grid dependency and carbon emissions.

Recycling Infrastructure: Classroom and common-area eco-points or colour-coded recycling stations, in collaboration with local waste management partners, to increase separation rates of paper, plastic and metal.

Garden and Green Space Reactivation: Transforming abandoned plots into living laboratories, biotic gardens and educational vegetable beds, and carrying out tree-planting projects, adding native shrubs and trees to enhance biodiversity and microclimate regulation.

Sensor Deployments: Enabling real-time monitoring and data-driven decision making (temperature, humidity, PM2.5, CO_2 and energy-use sensors)

Water Flow Reduction Measures: Flow restrictors and low-flow fixtures on taps and showers

Active Mobility Infrastructure: Bicycle racks to promote cycling to school

Food Quality Initiatives: Introducing vegetarian cooking recipes along with quality improvements in school canteens to reduce food-related emissions and engage students in sustainable dietary choices.

Smart Building Controls: Implementing HVAC (Heating, Ventilation and Air Conditioning) controls and smart lighting systems with motion and daylight sensors to optimise energy use dynamically.

Low-Flow Fixtures: Installation of flow restrictors and dual-flush toilets to reduce potable water use

Advanced Water Management: Installing greywater recycling loops and sub-metering for hot and cold water, coupled with leak detection sensors to further reduce consumption.

Integrated Waste Tracking: Deploying sensor-equipped 'smart bins' that monitor waste volumes and contamination levels, feeding data to classroom dashboards to gamify recycling.

Green Roofs and Facades: Expanding green infrastructure by adding vegetated roofs and living walls, improving insulation, stormwater retention and urban biodiversity.

Heat Pump Upgrades: Replace traditional heating systems with air- or ground-source heat pumps to enhance energy efficiency and reduce emissions.

Microgrid and Energy Storage: Incorporating battery storage systems to pair with PV arrays, enabling load shifting and resilience during peak demand or outages.

IoT Maintenance Platforms: Developing mobile apps for facility staff and 'green brigades' to schedule, log and track routine maintenance of technical systems, ensuring sustained performance.

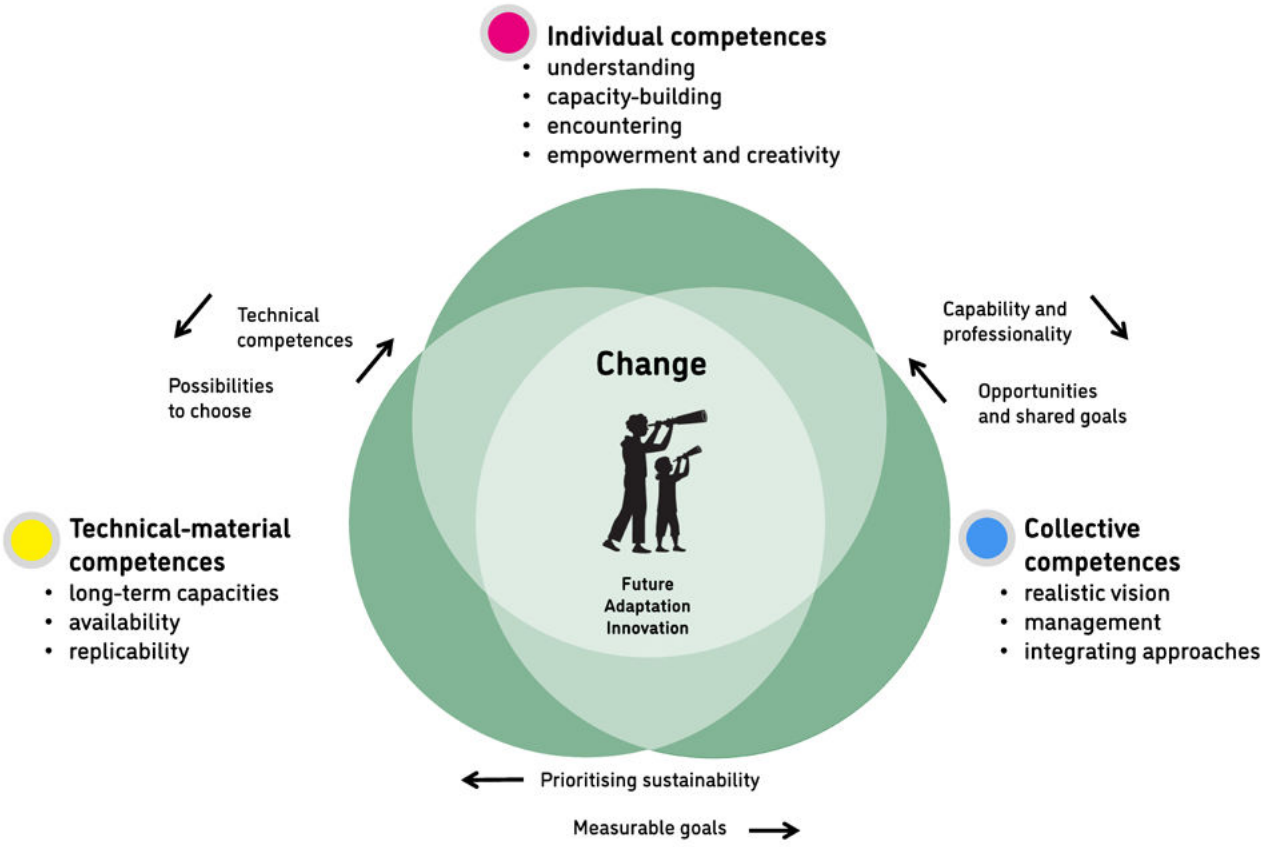
Change and competences

The main perspectives in promoting change in educational settings are future, adaptation and innovation, as described above. Different dimensions of competences are simultaneously needed for tackling this change, and we should ponder how we can promote these different competences:

- Preparing **individual** students, teachers, headmasters, and other staff to understand future scenarios, develop their creativity, and remain resilient;
- Supporting **collective structures, norms, and an organisational culture that fosters change;**
- Making changes in the **technical-material** environment that enable sustainability transformation in schools and universities.

The individual, collective and technical-material possibilities are intertwined, with each sphere enabled by the other two[83] (Figure 17).

Figure 17. Intertwined competences driving change.



[83] See also Chapter 4: Intertwined individual, collective and technical-material sustainability competences.

Coping with uncertainty, new circumstances, and the development of new solutions requires **individual competences**. Understanding future scenarios and new approaches require basic **knowledge** of ecology, society and science. Planning and using new equipment is not possible without creative and technological **skills** and understanding. The emotional load is also significant when encountering change, and personal flexibility, creativity and a positive **attitude** toward learning are essential. Additionally, working in transdisciplinary networks requires strong intrapersonal and collaboration skills. Leaders and teachers also need facilitation skills to guide the transformation toward sustainability. Beyond adaptation and the search for creative alternatives, resistance to unwanted changes and critical questioning are essential. However, in educational practice, teachers often find these approaches challenging.

The readiness of a school or university to change is embedded in its institutional structures. The ability to create a shared vision depends on **collective competences** and a cultural-cognitive atmosphere that supports development work. **Regulations**, such as collective labour contracts, can sometimes hinder flexible cooperation or limit opportunities for technical development. Transdisciplinary networks (including teachers, students, staff, families, service providers, municipalities, local associations, and businesses) create possibilities to integrate competences from diverse backgrounds into something new. Turning plans into written **norms** and strategies helps schools and universities, along with their stakeholders, work toward a common goal.

New **technical-material** competences are developed during the transition toward sustainability. How these competences evolve depends on the availability of technologies and resources within the school or university. Technical-material improvements can be considered for energy, water, waste, air quality, green procurement, transport, and green spaces. To avoid resource misuse, procurement should be critically assessed from a long-term perspective, considering life-cycles and maintenance possibilities. Ideally, the school or institution is able to innovate replicable technical-material changes that promote sustainability within the institution and serve as examples for others.

Individual, collective and technical-material competences related to change are deeply **intertwined**. For example, technical-material improvements are not possible without the competences, knowledge and skills of individuals. Conversely, if technical-material competences are lacking, and the change is needed, for example in waste management, individual attitudes or decisions do not help if recycling possibilities are unavailable.

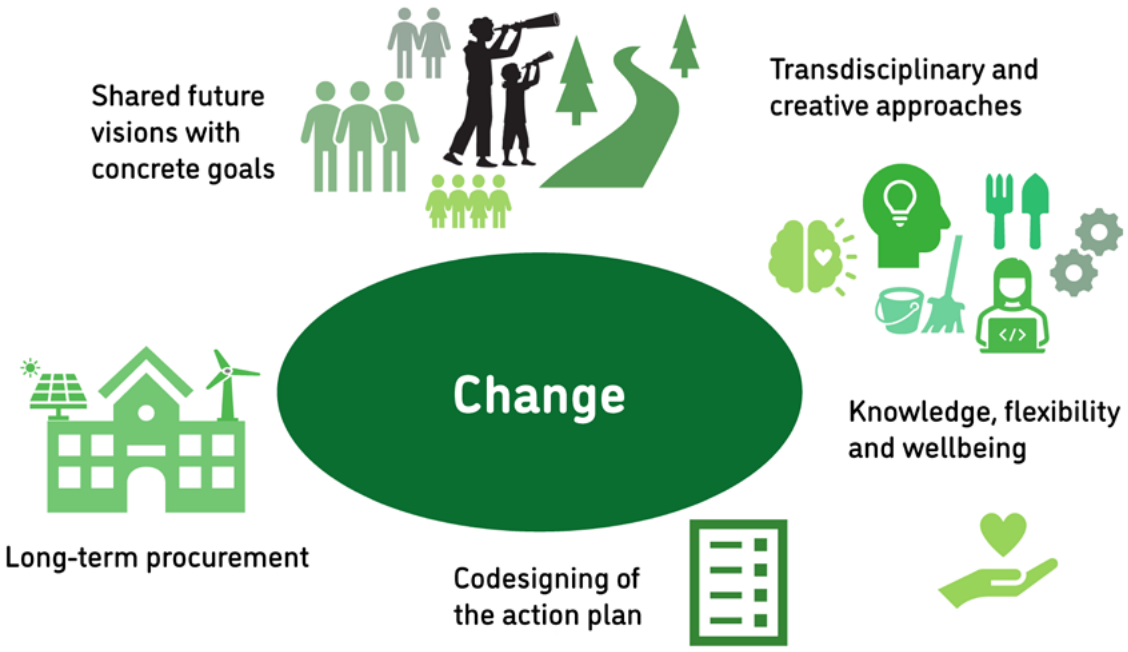
The aspiration for technical-material changes toward sustainability can falter amid scarce resources, especially if the collective competences – such as the strategies of the school or university – prioritise other goals over sustainability. On the other hand, technical-material possibilities can support collective competences by offering concrete, measurable goals for institutions, goals that can be written in action plans.

Collective efforts and strategies can promote individual competences by providing opportunities for capacity-building for all members of the community. Plans and strategies also help individuals work toward shared collective goals. In turn, these plans, strategies, and goals do not develop without the contributions of capable individuals and the professional facilitation of the process by competent leaders.

Enablers and constraints in the area of change

Making and adapting to change (Figure 18) is challenging, but some practical procedures can enable this in practice. It is also beneficial to know what kind of constraints could be expected.

Figure 18. Enablers for driving change.



In this section, we present examples of how to drive for change in educational institutions, along with the constraints that sustainability efforts and change processes may encounter. The enablers and constraints are presented in table format and as lists to help readers more easily identify relevant viewpoints (Table 5). We also provide pedagogical questions for different audiences to support the development process in educational institutions toward understanding change in sustainability. The examples are organised according to three main areas underlying change: future, adaptation, and innovation.

Table 5. Enablers, constraints and pedagogical questions of change in educational settings.

Future: Visions & Concreteness

Corresponding GreenComp competence: Futures literacy

How to enable?	Who?	Competence
Using simple planning exercises – like basic future-scenario sessions and working backwards from key goals.	Managers, teachers, students, other staff	Collective
Empowering students to take on the role of community ambassadors and believing that they could shape the future.	Teachers, students	Collective
Hands-on activities to try out new tools and think about reusing materials can turn big sustainability ideas into small, projects of change that give hope and help the school learn and grow.	Managers, teachers	Collective
Critical reflection on how to realise the visions of a sustainable future in one's own life and in the community.	Managers, teachers, other staff, external stakeholders	Individual
Vision promoted by leaders who prioritise sustainability in their daily decision-making processes and encourage everyone to envisage preferred and feasible futures.	Managers	Individual
From ambition to action by testing plans against real-world constraints.	Teachers, managers	Individual
Strengthening institutional material capacities, while empowering school communities to manage and maintain sustainable infrastructures over the long term.	Managers, maintenance staff, service providers	Technical-material
Easy-to-update equipment makes it easier to keep long term plans realistic and flexible.	Managers, maintenance staff	Technical-material
Constraints	**Who?**	**Competence**
Lack of understanding the meaning and value of visioning.	Managers, teachers, other staff, external stakeholders	Individual
Indifferent leadership and fragmented communication result in hesitation and cynicism among students, who then doubt the impact of their efforts.	Managers	Individual
Contradiction between what is recommended at school and the dynamics that govern today's consumer society.	Society and culture	Collective
Demands for a less consumerist future remain vague, as it is difficult to imagine such a future in the current context.	Managers, teachers, other staff, external	Collective Individual
Pedagogical Questions	**Who?**	
How can we integrate sustainability into our daily decision making and long-term planning?	Teachers and managers	
How can we empower students to take leadership roles in sustainability efforts within the school and the wider community?	Teachers and managers	
Are our current strategies and resource allocations aligned with our sustainability goals? If not, what needs to change?	Managers	
How can I incorporate hands-on, hopeful sustainability projects into my teaching to make abstract ideas tangible?	Teachers	
How can I support students in navigating the contradictions between sustainability education and consumer culture?	Teachers	
How do I feel when thinking about the future, and how can I turn those feelings into motivation for change?	Students, teachers and managers	

Adaptation: Flexibility & Well-Being

Corresponding GreenComp competence: Adaptability

How to enable?	Who?	Competence
Boundary-spanning leadership, uniting students, staff, parents and authorities.	Managers	Individual
Capacity-building culture broadening the circle of vision carriers: Caretakers are trained in waste handling, technicians in sensor maintenance, and teachers in new pedagogical approaches -> opportunities for growth.	Managers, teachers, other staff	Collective
Deliberative workshops foster a climate conducive to the expression of emotions and creativity. Deliberations allowing for collective diagnoses and the development of creative proposals.	Managers, teachers, other staff, service providers, external stakeholders	Collective
Keeping long-term plans realistic and flexible.	Managers	Collective
Assimilating novel technologies or approaches, flexibility in adopting unknown tools (e.g. sensors, applications, innovative materials).	Teachers, managers, other staff, service providers	Technical-material
Purchasing easy-to-update equipment.	Managers, maintenance personnel, service providers	Technical-material

Constraints	Who?	Competence
Denial of personal responsibility and relevance, and narrow ownership.	Teachers, managers, other staff, service providers	Individual
Creativity blocks.	Teachers, managers, other staff, service providers, students	Individual
When people see actions as unimportant, interest fades quickly.	Teachers, managers, other staff, service providers, students	Individual
Lack of financial resources and time.	Administration, managers	Collective
The hierarchical relationships typical of schools and universities seldom allow the opportunity for students to express themselves and teachers to be heard.	Administration, managers	Collective
Inconsistencies between what is taught about sustainability and the actual practices within the educational institutions.	Culture, administration, managers	Collective

Pedagogical Questions	Who?
How can we integrate sustainability into our daily decision making and long-term planning?	Teachers and managers
How can we empower students to take leadership roles in sustainability efforts within the school and the wider community?	Teachers and managers
Are our current strategies and resource allocations aligned with our sustainability goals? If not, what needs to change?	Managers
How can I incorporate hands-on, hopeful sustainability projects into my teaching to make abstract ideas tangible?	Teachers
How can I support students in navigating the contradictions between sustainability education and consumer culture?	Teachers

Innovation: Creativity & Transdisciplinarity

Corresponding GreenComp competence: Exploratory thinking

How to enable?	Who?	Competence
Designing projects that encourage participants to analyse problems and come up with their own ideas: real change requires more than just following instructions – thoughtful, imaginative solutions.	Teachers and managers, and students	Individual
Deliberative workshops foster a climate conducive to the expression of emotions and creativity. The deliberation allows for collective diagnoses and the development of creative proposals.	Managers, teachers, other staff, external stakeholders, and students	Collective
Networking among stakeholders, both those internal to the institution (teachers, students, staff, families, service providers, etc.) and external (municipalities, local associations, businesses, etc.). The desire and readiness to listen to other stakeholders who hold different interests and ways of thinking.	Teachers, managers, other staff, service providers, students	Collective Individual
Using creativity and transdisciplinary approaches, integrating technical knowledge, behavioural change and community involvement for developing innovative and practical solutions to complex sustainability challenges.	Teachers and managers	Collective
Capacity-building for all actors to prevent collapse due to know-how gaps.	Teachers, managers, other staff, service providers, students	Collective
Emphasising replicable models, showing the movement from ambition to action by testing the plans against real-world constraints.	Managers, service providers	Technical-material
Constraints	**Who?**	**Competence**
Institutional barriers, such as the roles of faculty members, valuing above all autonomy and the possibility to freely organise their own teaching and other professional activities, and reluctance to listen to advice or receive support offered by colleagues, especially those from other disciplines than their own.	University/ faculty members	Collective Individual
Resistance towards creative practices.	Teachers, managers, other staff, service providers and students	Individual
Pedagogical Questions	**Who?**	
What strategies can we use to build networks with external stakeholders (e.g., municipalities, businesses, associations) to co-create sustainable solutions?	Managers	
How can we create a school culture that values creativity and transdisciplinary collaboration across all roles and departments?	Managers and teachers	
What kind of project would we like to design that could make a real difference in our school or community?	Students and teachers, and managers	
How can I design learning experiences that encourage students to analyse sustainability challenges and develop together their own creative solutions?	Teachers	
How can I foster a classroom climate that supports emotional expression and creativity, especially when tackling complex issues?	Teachers	

Stories: Change!

Co-creating sustainability with busy upper secondary students

At a Finnish upper secondary school, teachers were determined to engage students in environmental and sustainability issues, but they faced a common challenge: upper secondary students have **very tight schedules and little time or interest in extracurricular activities**. Despite challenges in raising interest among students in climate action, teachers established their own team. **Collegial support** among teachers and administration and **sharing responsibilities** helped teachers to remain active and committed. They defined a **collective mission** of making sustainability more visible and integrated into everyday school life activities in order to shift students' attitudes toward a more sustainable future and to reduce the school's environmental footprint.

Through several **years of the process of trying out** different activities and time-slots, and learning from experiences, teachers managed to find motivated students and create a student group. Face-to-face contacts, surveys and interviews were conducted to map students' interests and possible motives to sustainability action. **Understanding of various potential interests** people may have in sustainable life-choices through motivation profiles helped to acknowledge how teachers' values differed from the students and to consider issues and activities that appeal to students. Currently, students and teachers have planned together yearly activities and a credit system.

The group has organised a variety of initiatives, such as:

- A **'Green Career' panel discussion** featuring representatives from sustainability-oriented companies.
- Recycling stations and collection boxes for refundable bottles and cans to collect money for excursions.
- A Preloved Ball Gown Sale, promoting reuse and circular economy thinking.
- Visits to elementary schools to talk and hold workshops about fast fashion for younger students
- Campaigns to promote vegetarian lunch options and reduce biowaste, in cooperation with the school's lunch provider.

In addition, the school's **digital information board has been actively used to share environmental data, spark reflection, and communicate sustainability** messages.

The success of these activities has been made possible by the school **administration's support** – especially the headmaster's positive and encouraging attitude, and the **allocation of resources** to sustainability work. It has been important to understand that developing a school's culture, system, and practices is a slow, time-taking process, but not impossible. It is advisable to set goals with a 10-year perspective, try things out, and learn from experiences.

Changing abandoned gardens and green spaces into living laboratories

Abandoned garden and green space reactivation plots were transformed into living laboratories with biotic gardens and educational vegetable beds. Installing new systems alone was not enough – the school community had to learn **how to use, monitor, and maintain** them. Teachers, students, and facility staff worked together and shared responsibility.

In Spain, a tree-planting project introduced native shrubs and trees to enhance biodiversity and regulate the microclimate. Meanwhile, in Portugal, the Quinta do Charco Biological Garden at Camarate Elementary School turned an abandoned plot into a vibrant learning space. It featured **outdoor classrooms**, a pond with ducks and chickens, native plant beds, and a vegetable garden irrigated by a planned rainwater harvesting system.

Through **terrain analysis, participatory mapping, and prototype sketching** – coordinated by architecture students from Instituto Superior Técnico and involving families, pupils and municipal stakeholders – the school community developed new technical and design skills. **Community workshops** further strengthened engagement, fostering collective ownership and long-term commitment to maintaining the garden.

Identifying and **addressing individual, collective and technical-material challenges that hindered participation** was essential for enabling change. Suggested actions included drafting written agreements to clarify responsibilities, ensuring accessibility, and sharing the project with other schools to broaden its impact.

Organisational and project management skills helped turn ideas into reality. Realising sustainability goals required **planning, scheduling, delegation, and coordination**. Teachers who encouraged students to take the lead not only empowered the students but also learned to assess project management. Designated committees played a key role in overseeing garden planning and implementation. Integrated planning with clearly aligned roles and responsibilities enabled faculty and staff to actively engage in green initiatives. Lasting solutions depended on structure, inclusion, and collaboration.

Portugal and the change in demonstration sites

In Portugal, the ECF4CLIM interventions demonstrated that change often begins with small, practical actions that gradually reshape school culture and daily routines. At EB Bobadela and EB Camarate, introducing sustainability topics into regular subjects – such as energy efficiency, waste management and water conservation – encouraged teachers to rethink their pedagogical approaches. Activities like the Energy Route and classroom assessments of energy consumption turned abstract environmental issues into measurable and visible realities. Over time, students began to associate **learning outcomes with real-life improvements in their schools**, while teachers reported greater motivation to integrate sustainability themes into their lessons.

Behavioural and organisational change also emerged from collective initiatives. The waste separation competitions in both schools proved to be effective tools for improving everyday habits among students and staff, leading to better recycling practices and **stronger ownership** of environmental results. These **contests and awareness campaigns** were particularly successful because they were **co-created with teachers and pupils**, ensuring that goals and rules reflected their own priorities. In EB Bobadela, for instance, improvements in the waste KPI were discussed openly during school meetings, reinforcing a shared sense of progress and accountability.

At the Instituto Superior Técnico (IST), change took a more structural form. The introduction of the Climate Crisis and Fair Transition curricular unit marked a step towards embedding sustainability in higher education, reaching students from diverse disciplines and research areas. In parallel, initiatives such as Técnico Makes the Difference and Bio Técnico translated sustainability commitments into everyday campus practices – from waste reduction and recycling to sustainable food systems. These initiatives not only improved environmental performance but also helped normalise sustainability as a shared and continuous responsibility within the institution.

Together, these experiences show how educational, behavioural and operational changes can reinforce one another, helping schools and universities evolve from isolated initiatives into continuous and self-sustaining transformation processes.

Collected short examples from all countries

- Effective sustainability actors must cope with evolving circumstances – staff departures, shifting tools, or unpredictable regulations. The capacity to re-plan, troubleshoot, and learn in real time underpins the durability of interventions. This adaptability surfaced in multiple statements: 'changes in personnel, one active teacher has left' or 'technical infrastructure ... can be planned so that it works and is adaptable'.
- In some interventions, participants had to assimilate novel technologies or approaches. It was mentioned that those involved should be able to 'handle new technology or methods, [and] creatively address challenges', which implies flexibility in adopting unknown tools (e.g. sensors, applications, innovative materials) and in overcoming unexpected challenges in creative ways. This technical adaptability goes hand in hand with critical thinking: whoever can continuously learn and reinvent their approach will contribute to smoother execution of the intervention. Conversely, although it is not frequently stated, lack of adaptability underlies many failures – as mentioned, resistance to change is a symptom of the absence of this competency.
- Our pilot sites showed that using simple planning exercises – like basic future-scenario sessions and working backwards from key goals – along with easy-to-update equipment makes it easier to keep long-term plans realistic and flexible. When schools add hands-on activities to try out new tools and think about reusing materials cyclically (so nothing goes to waste), they can turn big sustainability ideas into small projects of change that give everyone hope and help the school learn and grow.
- Participants at one demonstration site saw the arrival of multi-fraction recycling bins as an 'important first step'. Both students and university leaders in the role-play recognised that even a modest intervention can unlock our capacity to shape the future: while the rector role-player framed the bins as part of a broader ambition to become a 'green university', classroom conversations echoed the very same goal. A comparable understanding of our capacity to act emerged in another school. After installing smart taps, students affirmed that now 'we say no' to excessive consumption, signalling that small, tangible changes can spark change towards a more sustainable future.

- Some participants critically debated how to turn sustainability visions into reality in daily life. They discussed linking school and home habits, with some arguing that students should bring lessons home and become change agents, while others felt habits must start at home with municipal support (e.g. distributing recycling bags to residents). Additionally, participants identified structural challenges such as student turnover – each year new pupils arrive as others leave – which disrupt continuity. This led to a new insight that long-term engagement requires embedding projects into the school's curriculum and culture, rather than relying on one-off enthusiasm.
- One group emphasised clear, long-term planning: they insisted on well-defined responsibilities, schedules for monitoring, and realistic budgeting to ensure their sustainability vision would materialise and last.
- Some schools noted that their solar panel and recycling projects succeeded in part because they provided replicable models aligned with school sustainability goals, showing administrators and students exactly how to implement the change step-by-step. On the other hand, several groups encountered setbacks. For example, lack of a clear maintenance plan for newly installed solar panels was flagged as a major oversight, leading to confusion over responsibilities and safety concerns.

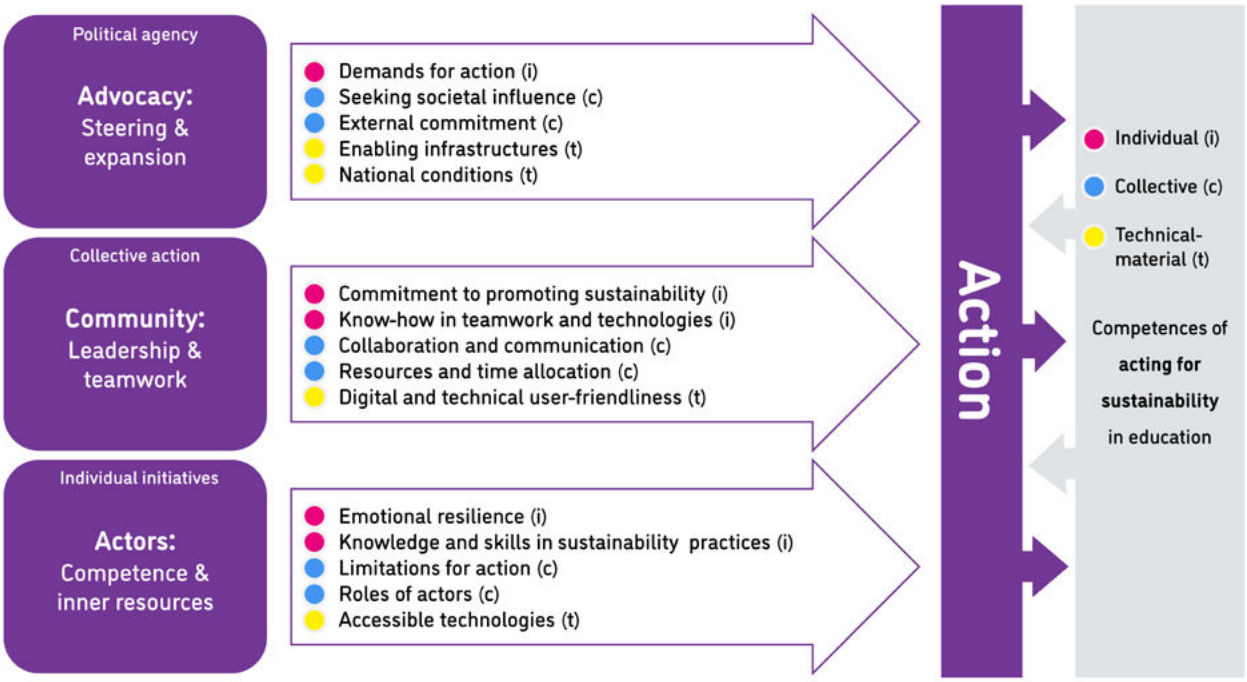
Action

Our success in promoting sustainability depends on our ability to 'walk the talk'. Schools and universities travel the sustainability path in many ways: they educate students to confront and address sustainability challenges, reduce the environmental impact of human activities in society by improving their own practices, and innovate novel solutions to sustainability problems. In practice, turning good intentions and shared goals into concrete action requires diverse competences from all members of the community, shared decision making, and support from both the social and material environment.

The Action competence area of the Roadmap for Sustainability Competences further elaborates, in practice, the GreenComp competence area **Acting for sustainability**[84]. The competences in this area enable both individuals and communities to take action toward a sustainable way of life. The area is also strongly connected to democracy, as it calls for action from those in positions of responsibility to drive change and emphasises the importance of civic engagement. The area is also strongly connected to democracy, as it calls for action from those in positions of responsibility to drive change and emphasises the importance of civic engagement.

In practice, these competences are realised through action (Figure 19). Practitioners frequently discuss both the barriers and enablers that either hinder or support concrete action for sustainability. If concrete action plans, structures for cooperation, infrastructure and adequate resources are missing, progress toward sustainability becomes difficult. Additionally, those most interested in sustainability often feel that they alone are responsible for the efforts, even though all levels and actors are needed to work toward common sustainability goals in practice – policymakers and administrators, school leaders, teachers, other staff members, service providers, students, and parents. In the midst of global sustainability crises, doubts also arise about the relevance of local action in the broader picture.

Figure 19. Action and the GreenComp area 'Acting for sustainability' in practice.



[84] European Commission, Joint Research Centre (2022, pp. 25-28). GreenComp, the European sustainability competence framework. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

To address these challenges related to concrete action, attention should be directed to:

1) Advocacy: Steering education towards sustainability and expansion of activities outside the school or university. Society outside of schools is increasingly interested in steering schools and universities towards sustainability, as education touches everyone at some point in their lives, and educational institutions are major public actors capable of promoting sustainability. External commitments – such as joining the Eco School programme or aligning with municipal strategies – connect the work of schools and universities to broader advocacy efforts, making their activities more effective. Often, when students learn about sustainability challenges and ways to promote sustainability, they begin to demand action from their school, university, or even from society at large. It is essential to link the activities of schools and universities to concrete actions that reduce environmental burdens. However, local infrastructure may not always support change, and national conditions – such as legislation, policies, trust in administration, bureaucracy, or corruption – can hinder progress. Sometimes, the attitude toward political action in schools is negative, even though political action refers to the widely approved promotion of sustainability, but at the societal level. Seeking societal influence, for example by serving as role models, can expand efforts and position schools and universities as agents of change. The corresponding GreenComp competence, focused on individual capabilities, is **Political agency**.

2) Community: Leadership and teamwork facilitating action. Promoting sustainability in schools requires the personal commitment of all community members, especially leaders such as headmasters and teacher facilitators of sustainability education. Teamwork and the use of new technical equipment also demand specialised knowledge and skills. Curricula with a strong sustainability initiative help actors to include sustainability efforts in everyday life. Additionally, clear and consistent communication of the course of action to all members is crucial. Transdisciplinary collaboration among different stakeholders remains essential even after shared goals have been established, particularly for reviewing the course and assessing the outcomes of sustainability efforts. Sufficient financial and human resources, as well as time, should be allocated to ensure progress. The digital and technical environment should be seamlessly integrated into the community's activities to make the best use of available opportunities. The corresponding GreenComp competence, focused on individual capabilities, is **Collective action**.

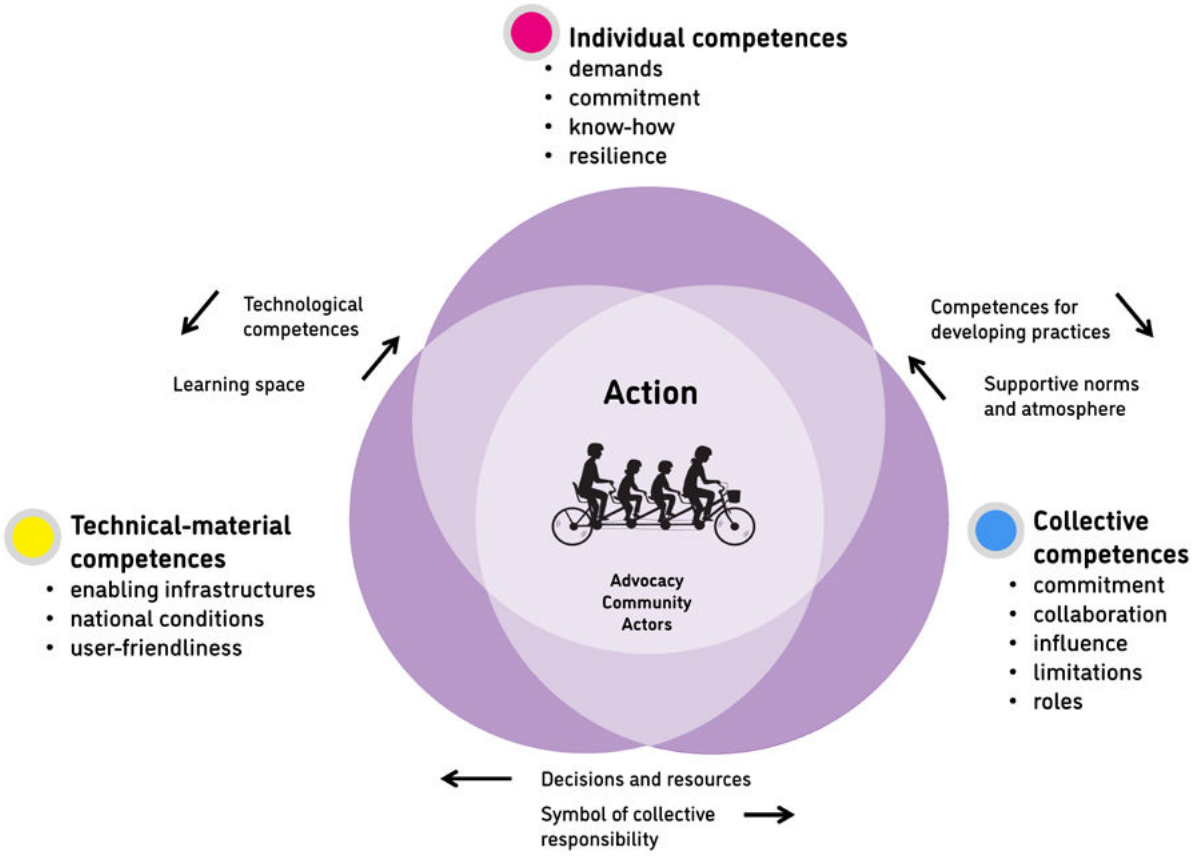
3) Actors: Competence and inner resources of individuals. Taking action toward sustainability in schools can be emotionally challenging due to numerous barriers and lack of clear solutions to global problems. Therefore, resilience, sustainability knowledge, and practical personal skills are essential. Understanding limitations helps individuals navigate obstacles and continue progressing. One person does not have to manage everything – different actors can take on different roles in promoting sustainability. One helpful tip is to choose accessible technologies that are easy to use and maintain. The corresponding GreenComp competence, focused on individual capabilities, is **Individual Initiative**.

Action and competences

- In educational settings, it is useful to scrutinise action from perspectives of advocacy, community and actors, as described above. Competences at different levels are simultaneously needed for successful action. We should reflect on how we can promote these competences:
- Supporting all individual actors in schools and universities and strengthening their competences in advocacy, cooperation and understanding best practices;

- Supporting collective practices – such as norms, rules and established practices – to promote a school's or university's ability to implement its sustainability goals;
- Supporting technical and material solutions to promote sustainability actions in education and to help minimise the environmental impact of schools and universities.
- The individual, collective and technical-material possibilities are intertwined, with each area enabled by the other two[85] (Figure 20).

Figure 20. **Intertwined competences promoting action.**



Action requires **individual competences** – practical knowledge on sustainability and how to translate goals into concrete actions, skills to carry out planned activities, and a positive attitude and commitment to sustainability efforts and proactive advocacy. Leaders, in particular, need competences to guide and facilitate the process, support others, communicate the goals, collaborate with community members in different roles, and make pro-environmental suggestions and decisions while negotiating with external actors. The ability to flatten hierarchies and invite diverse community members to participate in sustainability efforts – from their own starting points – is crucial. When technical equipment is used, individuals must have the ability to operate and maintain it over the long term. Ideally, the technical-material environment also serves as a tool for learning.

[85] See also Chapter 4: Intertwined individual, collective and technical-material sustainability competences.

Action is not possible without **collective competences.** The main barrier to sustainability efforts is lack of resources: general plans and norms do not automatically translate into concrete actions. Even detailed action plans with clearly defined responsibilities and corresponding decisions are necessary. In promoting sustainability, time is the scarcest resource. Without sufficient time, cooperation becomes impossible and the implementation of actions remains incomplete. Competent personnel are also essential. Allocating working hours for sustainability efforts, creating local sustainability policies and making technical improvements all require financial resources. Often, in addition to internal development, changes in external systems are needed – making functional cooperation networks crucial. Designing long-lasting, well-organised and well-resourced sustainability practices reduces the need for resources in the long run. Additionally, a collective, positive spirit of action for sustainability is a valuable asset in schools and universities. These barriers to action reflect the dimensions described in the Theory of Practice Architectures: cultural-discursive, material-economic and social-political arrangements. Critically exploring actions through these dimensions may help educational institutions identify solutions for more sustainable practices and action.

Technical-material competences, such as equipment that restricts the use of **water or energy**, adequate **infrastructure**, usable green spaces, and a functioning recycling system, are part of sustainable action. In reality, utilising technical solutions requires resources and good enough infrastructure, and the possibilities for improving the technical-material environment in practice vary across countries. When it comes to technical equipment, user-friendliness and accessibility are the key considerations. If the life cycle is not taken into account, maintenance is difficult, or teachers require advanced skills or knowledge to use the equipment in teaching, then expensive procurements may shift from being competences to becoming environmental burdens.

Individual, collective and technical-material competences related to action are deeply **intertwined**. For example, using technical-material systems requires individual competences from the users. In turn, the technical-material environment provides a learning space that enables hands-on, experiential learning for individual students – proven to be effective in sustainability education.

Technical-material environments serve as a showcase and a concrete field for collective action, being a symbol of collective responsibility and awareness. Conversely, without collective decisions and resources, the development of technical-material competences is not possible.

Individual competences are essential for developing collective practices and action within schools and universities. However, restrictive collective norms can hinder individual initiatives, while positive practices and a supportive atmosphere foster individual learning, advocacy and action.

Enablers and constraints in the area of action

There are both barriers and enablers to sustainability action in educational practice (Figure 21). Resources are a crucial factor, and support from administration and management is also essential. Committed leaders, teachers and students are the main enablers of sustainability action. In this work, the action plan and training sessions have proven helpful. Schools and universities can be valuable actors in the sustainability transition, opening themselves to the external world.

Figure 21. Enablers of action.

In this section, we present examples of successful action in educational institutions, along with the constraints that action may encounter. The enablers and constraints are presented in table format and as lists to help readers more easily identify relevant viewpoints (Table 6). We also provide pedagogical questions for different audiences to support the development process in educational institutions toward understanding action for sustainability. The examples are organised according to three areas presented: advocacy, community, and actors. Colours refer to **individual**, collective and **technical-material** competences.

Table 6. Enablers, constraints and pedagogical questions of action in educational settings

Advocacy: Steering & Expansion

Corresponding GreenComp competence: Political agency

How to enable?	Who?	Competence
Steering of schools and universities toward sustainability and including sustainability in their curricula.	Administration, policymakers, NGOs	Collective
Increasing resources for sustainability in education.	Policymakers	Collective
Sharing projects with other schools or universities to increase impact.	Managers, teachers	Collective
Joining eco-school or green school networks.	Managers, teacher	Collective
Mapping the possibilities to participate in societal transformations.	Managers, teachers, students	Individual
Sharing knowledge, information and practices with families and local communities; taking action in neighbourhoods or the municipality.	Teachers, managers, students	Individual
Discussions on how to positively address sustainability challenges.	Teachers, students	Individual
Developing resilience and questioning normal ways of doing things.	Managers, teachers	Individual
Collaborating beyond one's own school or university, e.g. municipality, city transport agency, external contractors, private companies, NGOs.	Managers, teacher	Individual
Making initiatives for better infrastructure or national policies.	Teachers, managers, students	Technical-material Collective

Constraints	Who?	Competence
National or local administration does not support sustainability efforts.	Policymakers, administration	Collective
Poor competences in communicating the goals, action plan and advantages clearly to external actors.	Managers, teachers	Individual
Lacking resources for sustainability efforts.	Society and policymakers	Collective
Scarcity of connections with families.	Managers, teachers	Collective
Educational institutions resistant to questioning normal ways of doing things.	Managers	Collective
Discrepancy between what the curriculum says and what teachers teach in the classroom.	Teachers	Individual

Pedagogical Questions	Who?
How do you foster a school culture that encourages questioning the status quo and embracing sustainability? What is your influence?	Managers, teachers and students
What role can your school play in broader societal transformations?	Managers
How could you collaborate with other schools or external actors (e.g., NGOs, municipalities) to amplify sustainability efforts?	Managers, teachers and students
How can you support students in developing political agency for sustainability?	Teachers
What kinds of activities would you like to take part in to influence change in your neighbourhood or municipality?	Students

Community: Leadership & Teamwork

Corresponding GreenComp competence: Collective action

How to enable?	Who?	Competence
Adding sustainability to the school's plans, as a visible part of them, to gain legitimacy, resources and morale.	Managers, Administration	Collective
Providing tools, materials, guides, templates, training and practical support for planning, implementing and assessing individual actions or interventions.	Managers, maintenance personnel	Collective
Designing a clear schedule and teamwork and allocating financial and time resources to design, coordinate and implement sustainability interventions.	Managers, administration, teachers	Collective
Using projects to strengthen strategic orientations.	Managers, administration	Collective
Making a system of rotating roles (e.g., monthly 'eco-officer') to distribute the maintenance burden without creating ongoing extra work.	Managers, teachers	Collective
Designing training activities/seminars for teachers and the entire organisation to discuss the role of sustainability in education.	Managers, teachers	Collective
Committed, clear and value-driven, distributed leadership, teachers and students.	Managers, teachers, students	Individual
Relating activities to subject matter across different subjects and courses.	Teachers	Individual
Finding and using the most effective internal communication channels, and through it, engaging the whole community.	Managers, teachers, students	Individual
Assessing the results.	Managers, teachers, students	Individual
Well-being and emotional climate are as important as technical planning.	Managers, teachers	Individual
Using KPIs to help translate abstract sustainability concepts into tangible, local actions and to offer concrete anchors for activities.	Managers, teachers	Technical-material
Purchasing digital and technical solutions to secure operational capacity.	Managers, administration maintenance staff	Technical-material

Constraints	Who?	Competence
Scarcity or complete lack of financing. For less-resourced schools, even small improvements might be difficult to sustain or replicate.	Managers, administration	Collective
Hurry, lack of time, or too much time between team meetings: without time management competences and scheduling, even well-resourced projects stall.	All actors	Collective
Everything on the same shoulders – many activities carried out thanks to the voluntary initiative of a few actors committed to sustainability.	Teachers, managers	Collective
Lacking technical user-friendliness and competence: lack of installations and ongoing maintenance to ensure equipment is functional and educationally useful.	Managers, maintenance staff	Technical-material Individual
Poor information, communication or advertising of sustainability action.	Teachers, managers	Individual
Missing municipal approvals for installations.	Administration	Collective
Leadership remains absent, passive or personal rather than distributed.	Administration	Individual
Poor usability and accessibility of technical equipment.	Administration, other staff	Technical-material

Pedagogical Questions	Who?
What would help you dedicate more time to sustainability work without overburdening your schedule?	Teachers
What structures are in place to ensure leadership is distributed?	Managers
How do you engage families, external experts and municipal actors?	Managers
How would you improve communication about your school's sustainability work in ways that would spark your interest?	Students and teachers

Actors: Competence & Inner Resources

Corresponding GreenComp competence: Individual Initiative

How to enable?	Who?	Competence
Leadership by principals and senior staff alone is insufficient; the skills and commitment of teachers and students are equally vital.	See engagement	Individual
Context-specific know-how matters, and targeted skills training is mandatory (e.g. staff able to manage or instruct advanced systems).	Managers, teachers, other staff	Collective Individual
Treating digital proficiency as a distinct competence rather than a background condition ensures that actors are not only users but also capable maintainers and adaptors of the tools.	Teachers, managers, other staff, service providers	Collective
Knowledge about the environment and systems to create suitable strategies.	Teachers and managers	Individual
Projects thrive when a head teacher, university administrator, or student champion embodies committed and informed environmental leadership, secures resources, and keeps momentum alive.	Managers, teachers, students	Individual
Transforming sustainability ideas into tangible outcomes requires competence in planning, scheduling, delegation, and coordination.	Managers, service providers	Individual
Knowing one's own potential, limits and resources – such as juggling exams, heavy timetables or shift work – enables interventions and prevents burnout.	Teachers, students	Individual

Constraints	Who?	Competence
Inconsistencies of leaders reduce students' and teachers' efforts.	Managers	Individual
Limited time, academic pressures, and emotional fatigue pose constraints for all members of the community.	All actors	Collective
Technical fears, resistance or hesitation towards unfamiliar technologies and interacting with systems, due to a lack of confidence, limited prior exposure, or concerns about handling complex systems.	Teachers, managers, other staff, service providers, students	Collective
Complicated systems that are difficult to use.	Managers, maintenance staff	Technical-material
Communication breakdowns undermining impact.	Teachers, managers	Collective

Pedagogical Questions	Who?
How do you ensure that sustainability leadership is shared among staff and students, not concentrated on a few individuals?	Managers
How do you support emotional resilience and well-being in your school community during sustainability transitions?	Managers
What strategies help you recognise and respect your own limits while staying engaged in sustainability efforts?	Teachers
How can you take initiative in sustainability projects even when leadership is inconsistent or passive?	Teachers
How do you embody environmental leadership in your role?	Managers
What are the best ways to communicate ideas and actions to students in your school?	Students

Stories from demonstration sites

Action! Learning through Establishing Solar Panels

Across several ECF4CLIM demonstration sites, solar panels have been installed – not just as technical upgrades, but as learning opportunities. These structural interventions required collaboration both within schools and universities, and also with municipalities. While the processes were often slowed by bureaucracy, the results have been impressive: significant energy savings, reduced emissions, and increased awareness of sustainability.

Students and staff alike gained **technical literacy**, learning how solar panels function and how to interpret energy consumption data. At the university level, engineering students noted that understanding the real-world impact of technology helped them design with sustainability in mind. The interest in solar energy extended beyond the classroom to families and communities. Students moved from curiosity to advocacy, especially when they understood how a solar panel works. But knowledge alone was not enough. Real change happened when **students had an active role**. In some schools, students took the lead in planning solar panel installations. Supported by peer **dialogue and consensus-building**, they created tangible environmental benefits and a stronger sense of ownership. Through hands-on experience with solar energy, energy monitoring systems, and resource tracking, students developed not only technical skills but also systems thinking – reflecting on the social and ecological implications of technological decisions.

Learning from experiences: despite the benefits, there are practical and strategic challenges that need to be considered when planning this kind of intervention.

- Technical fears or resistance to unfamiliar technologies: a number of students and the majority of staff expressed initial hesitation toward interacting with systems such as solar PV installations or water sensors due to lack of confidence, limited prior exposure, or concerns about handling complex systems.
- Resource limitations: all schools faced limitations in funding and technical capacity. For less-resourced schools, even small improvements might be difficult to sustain or replicate without targeted investment.
- Maintenance and technical support: once installed, systems require ongoing maintenance, which can be a burden if schools lack dedicated personnel or training. Ensuring that equipment remains functional and educationally useful is a long-term challenge.
- Integration into daily practice: while the interventions were successful, their long-term effectiveness depends on whether they are integrated into teaching and school operations. If treated as one-off projects, the impact may fade over time. Sustainability must be embedded into routines, curricula, and institutional planning to ensure enduring benefits.
- Scalability: teachers and administrators in the schools noted the importance of scaling such interventions to reach all students and involve more stakeholders. This requires time, leadership support, and cross-sector collaboration.

Action despite the constraints in Portugal – Bobadela School

At Bobadela School, located northeast of the capital city of Portugal, Lisbon, the project started with the headmaster's proposal. In order to engage the **entire community** and establish a participatory approach, the school decided to conduct surveys and quizzes about sustainability with the entire community. It was important for everyone to give their opinion and thus take part in the project.

Several topics were raised and taken into account. Installation of solar panels was most voted for, as the community was very concerned about reducing its energy consumption. The installation of tap fittings to reduce water consumption and materials recycling were also voted on and considered important.

A recycling contest was successful, with students and families contributing by bringing rubbish for recycling. The class that achieved the highest recycling result received a prize – a class camping trip to a nature spot with several activities organised for the students. Workshops on energy saving and recycling for our staff and students provided by external stakeholders also engaged the whole community.

However, planned interventions were difficult to implement because the school, as with many others in Portugal, depends financially on local and central funds, and curricular constraints are rigid. However, in Bobadela, sustainability content was **integrated into classes and activities** with students producing reports on their sustainability actions. There is still resistance to change within the school, but **campaigns, contests and workshops involving all stakeholders** are helpful.

Portugal and technical solutions

In Portugal several interventions illustrated how concrete actions can serve as powerful drivers of environmental learning and institutional change. The schools of EB Bobadela and EB Camarate, together with the Instituto Superior Técnico (IST) implemented a range of measures that combined technical improvements with educational value, making sustainability visible in the everyday life of their communities.

At the school level, EB Bobadela focused on tangible infrastructure upgrades, such as the installation of solar panels and double-glazed windows, improving the school's energy efficiency and comfort while providing real examples for classroom discussions. The introduction of new recycling bins and the organisation of waste separation competitions transformed waste management into a learning opportunity. Students and teachers monitored progress through waste audits and **discussed the results in class, linking small everyday actions to measurable environmental impacts**.

At EB Camarate, the transformation of the Quinta do Charco site into a multifunctional educational garden was both a physical and social achievement. The new space, co-designed with researchers from IST, the municipality and the school community, will became a **living laboratory** for biodiversity, food production and outdoor education. Activities in the garden encouraged collaboration between subjects and promoted environmental responsibility among students, while fostering a sense of ownership and pride in their collective work.

At the Instituto Superior Técnico, several campus-wide actions brought sustainability to the forefront of university life. The installation of air quality sensors in classrooms, the expansion of green and permaculture areas through the Technical + Green project, and the implementation of solar panels demonstrated a concrete institutional commitment to environmental improvement. Projects such as Bio Técnico and Técnico Makes the Difference complemented these measures by addressing waste reduction and sustainable food and community participation, showing that large institutions can lead by example through consistent and visible action.

Across all Portuguese sites, these practical interventions acted as learning tools that connected technical solutions with behavioural and cultural change. **By turning sustainability into something visible, measurable and shared**, the Portuguese partners demonstrated how concrete action can inspire long-term commitment and collective ownership of environmental goals.

Collected short examples from all countries

- One of the difficulties encountered with some of the interventions, especially those requiring the installation of equipment or devices, was that **no provisions were made for repair and maintenance**. This problem was clearly documented, for example, in the Romanian basic and high schools. Addressing this problem will require that the schools and universities allocate sufficient financial resources for this purpose, including **systematic and regular monitoring and revision of the equipment**.
- Participants at one school highlighted how the principal's active personal **involvement and formal authority** helped initiate and sustain systemic changes in the school. In this case, the head's leadership was visible through direct participation in planning and clear support for the intervention, which in turn empowered the staff. Similarly, at another school, the school administration showed a proactive, long-term commitment to sustainability, coordinating resources and stakeholders effectively. This hands-on leadership created an enabling environment for the intervention. Conversely, where leadership was less present, momentum suffered. For example, some participants noted that while a deputy head actively engaged in the intervention, the head principal's limited involvement (and even unsustainable personal habits, like driving a turbo car) dampened the initiative's impact. Notably, even in schools with committed principals, there were calls to **widen leadership beyond one person**. In one school, the staff suggested the principal should involve more teachers to distribute responsibilities, underlining that broad-based leadership strengthens sustainability efforts.
- **Clear communication** and **outreach** are enablers of sustainability. Progress in sustainability initiatives depends on actors' ability to translate complex content into accessible and motivating narratives. In several cases, communication breakdowns have undermined impact – people 'do not know about the campaigns', or find them 'embarrassing'. Where interventions were invested in outreach, visibility increased, and engagement followed. For instance, in one context, 'new options to recycle are not advertised enough to students', illustrating that even well-designed technical measures require communicative scaffolding to take effect.
- **Cooperation and negotiation skills**. Several interventions required collaborating beyond the school or university, which adds another layer to these competences. For example, in a sustainable mobility project, it was necessary to achieve 'cooperation with the municipality… [and] the city transport agency' to install infrastructure (bicycle parking areas). Other cases mention collaboration with companies or external suppliers ('external contractors or suppliers' for sustainable technology). Interventions that managed to involve municipalities, organisations or external experts expanded their impact, whereas where this collaboration was lacking (e.g. when 'the city traffic office is not interested in cooperation', as cited in a case of failure) the project faced greater obstacles. Thus, the competences of communication and collaboration extend from the internal sphere (among direct participants) to the external (partners and environment).

- **Organisational and project management** skills are needed to turn visions into reality. Transforming sustainability ideas into tangible outcomes requires competence in planning, scheduling, delegation, and coordination. Teachers who 'allow and encourage students to organise this' are not just empowering pupils – they are exercising project-management judgement. Similarly, institutions with designated committees to 'oversee the planning and implementation of the garden project' show the operational scaffolding needed for success. When 'faculty and staff [are] actively participating ... in green initiatives', they reflect integrated planning that aligns roles with responsibilities.
- Several of the schools involved belong to or intend to join **eco-school or green school networks**. This gives them commitments that appear to be very useful for integrating sustainability into their activities. For example, some Romanian and Spanish schools associated with eco-school or green school networks are already committed to dedicating teacher hours to coordinating and ensuring compliance with sustainability goals. At the universities, this phenomenon does not occur to the same extent. In fact, some universities anticipate that, as a result of recent legislative reforms, sustainability principles will be included in many university courses in the future. At the Finnish university, for example, the ECF4CLIM project interventions took place at a time when the school's future curriculum was being redefined. This allowed these interventions to provide input to the design of the new curriculum, which will now incorporate a broader perspective on sustainability. However, the students doubted whether the new content items and ways of interpreting sustainability would ultimately be taught in classes. They anticipated that a discrepancy would persist between what the curriculum says and what teachers teach in the classroom.
- At the participating high schools and universities, the participants stressed that because sustainability is a transversal topic, it can be learned and practised **both within and outside of the school.** This seemed to appeal to some students, who were already considering taking action in their neighbourhoods or cities. Links with actors outside the school were mentioned, too, such as efforts to share knowledge, information and practices with families and local communities. However, teachers and school principals regretted the scarcity of such connections with families – connections that would be needed if the schools were to contribute to transforming domestic and local environments.

Practical examples of intertwined sustainability competences

Individual competences often mediate the interactions between the personal, collective and technical-material spheres of change[86]. The presence or absence of certain competences in individuals is frequently the deciding factor that links these spheres together in synergy – or leaves them disjointed. Below, we discuss illustrative linkages for each pair of spheres, followed by an example of where all three spheres overlap, all rooted in the observed dynamics at the demonstration sites.

Individual <> Collective: One clear linkage between the individual and collective levels is leadership translating into institutional change. For example, a headmaster's competence in prioritising sustainability and coordinating stakeholders led to the establishment of a formal sustainability committee and integration of green topics across the curriculum. Conversely, collective contexts also shaped individual behaviour. One group of teachers noted that because their school management treated the sustainability project as low priority, even passionate individuals started to lose faith and scaled back their efforts. This shows how a lack of institutional support (collective) can permeate into individual attitudes, illustrating a reverse linkage. Another example of individual–collective mediation is in role modelling and norms. A few teachers skilled in modelling eco-friendly behaviour (e.g., always recycling, bringing up sustainability in class discussions) gradually influenced the norms among the broader staff and student body. Students cited that having these role models in the community made sustainable habits feel 'normal' and encouraged peers to follow suit. By contrast, a negative instance at the same site occurred when some teachers neglected recycling, showing how the behaviour of one or a few can weaken a shared ethos. Therefore, individual competences like leadership, communication and personal example serve as the bridge to either strengthen or weaken collective frameworks.

Individual <> Technical-Material: The link between individual and technical-material competences was most evident when new technologies or infrastructure were introduced as part of an intervention. Individual competences determined whether these material solutions were adopted and maintained, thus mediating technical outcomes. Teachers and students needed the technical literacy to interpret the energy data and the motivation to act on it (individual sphere). The technology alone would have been a passive feature on the roof without the human skills to integrate it into learning and daily decisions. On the other hand, we saw instances where a promising technical solution suffered due to insufficient individual competences, such as one university implementing a high-tech recycling system with multiple waste separation bins. Initially, the student body did not use it correctly – some were confused by the system, and others were apathetic about the extra effort. It was only after running workshops (imparting knowledge on waste sorting and building a sense of responsibility) that the usage of the bins improved. Several projects involved monitoring energy or water usage with digital platforms. Where students had data analysis skills, they could draw meaningful insights (like identifying wastage patterns) and recommend adjustments, making full use of the technology.

[86] D6.2 Participatory will-formation by crowdsourcing. Report of the ECF4CLIM project. https://ecf4clim.eu/project-reports/

Moreover, maintenance of technology emerged as a critical individual–technical interface: in one case, a complex irrigation system for a school garden fell into disrepair because no one had the skillset or knowledge to troubleshoot the pump and sensors. When individuals are equipped (through skills training, technical knowledge, and positive attitudes toward technology), material solutions become effective drivers. When they are not, those same solutions can become costly ornaments or even sources of new problems.

Collective <> Technical-Material (mediated by individual): Individual competences also indirectly mediate the relationship between collective structures and technical-material factors. At first glance, the collective and technical spheres might interact via funding, policies or infrastructure provisioning (e.g. a school board decides to build a new bike shed). However, our findings show that without individuals to connect the dots, these interactions may not yield results. One clear example is the need for collective planning and policy to support technical interventions. One school's administration (collective) decided to upgrade the school garden to a more context- and sustainability-based garden (technical) but, crucially, they also adapted the school's maintenance schedules (collective rules) to accommodate the changes. Thus, collective decision making was effectively translated into technical impact via the insight and skills of individuals within the institution. Another area of collective–technical linkage is resource and infrastructure access through partnerships. Several interventions sought support from municipalities or companies to obtain technical resources (e.g. use of installation infrastructure to conduct activities with students). Whether these external resources ultimately became available usually hinged on collective level agreements – such as school–municipality agreements – set in motion by staff with strong networking skills. In short, collective frameworks create the conditions for technical solutions to thrive, but they have to be animated by individuals capable of organisation, diplomacy and strategic planning.

Triadic interplay (Individual **<>** Collective **<>** Technical): To make the synergistic power of the three spheres more tangible, we present a fictional – but evidence-grounded – vignette: a school garden initiative synthesised from the role play results and project data at two of our schools. In this intervention, the technical-material sphere was represented by a newly established school garden (including planters, tools and a compost system). The collective sphere was engaged through the school's policies and agreements regarding the garden. Initially, these two spheres were not yielding results: the plants were withering because during school breaks no collective mechanism ensured their care, and some teachers were not following the schedule, treating the garden as an optional extra. The turning point came when individuals stepped up with the necessary competences to synchronise these elements. A group of students and a teacher demonstrated initiative and responsibility (individual sphere) by creating a holiday watering rota and rallying their classmates to stick to it. At the same time, a deputy principal used her organisational competence to formalise this arrangement: she drafted a written agreement clarifying responsibilities (who waters the garden, who oversees compost, etc.) and secured a small budget for maintenance materials, thus modifying the collective rules and resources to support the garden. The individual and collective competences combined to ensure the technical element – the garden – was effectively utilised and sustained. At a different site, a high-tech composting machine (technical) was installed in the cafeteria, and the principal supported it in principle (collective), but it failed because no one felt personally responsible for maintaining it or teaching students how to use it (individual gap). Food waste piled up, and eventually the machine was abandoned.

Not only individual, collective and technical-material competences, but also the practical focus areas related to competences themselves exist in an intertwined manner. Engagement is required in every activity within schools and universities. Understanding connections is essential when navigating complex ecosystems, human activities or differing worldviews. If basic knowledge about sustainability is lacking or not valued, planning the changes necessary for a sustainability transition becomes impossible. Promoting sustainability across all competences requires action – and constraints and enablers are inseparable parts of each competence area.

Two Interpretations: Roadmap as a Framework and as a Process

There are two ways to use this Roadmap for Sustainability Competences: as a framework or as a model for the sustainability process in schools and universities.

Roadmap for Sustainability Competences as a framework

As described above, sustainable competences in educational practice can be seen as a complex, multi-level construction encompassing individual, collective and technical-material perspectives, along with four practical focus areas related to sustainability competences: engagement, connections, change and action. This Roadmap can serve as a framework to structure and understand situations across different scales of educational settings.

We can examine a **part of a lesson**, **lecture** or **exercise** from the four viewpoints of the Roadmap:

- Am I ensuring that engagement is promoted in this exercise or lecture?
- Am I highlighting connections between the content and sustainability?
- What change in current practices, related to the contents of this learning session, is needed for a sustainable future?
- What kinds of action could be included in the lesson?

We can also reflect on a single course curriculum:

- How could sustainability be integrated into this course?
- What values does this course reflect?
- How is this subject or course connected to sustainability?
- What kinds of solutions does it offer?
- How can this course contribute to action toward sustainability?

We can assess the entire institution:

- Are we ensuring engagement with sustainability?
- Where and how do we address connections to sustainability?
- What changes are needed in our institution?
- How can we implement these changes in practice?

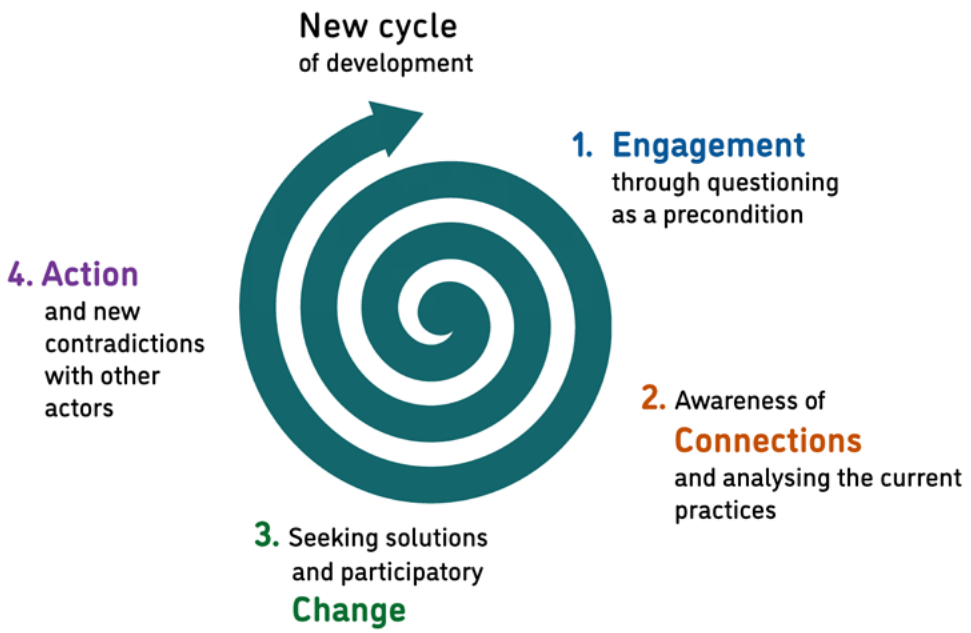
We can even consider broader society:

- Are educational institutions actively engaged in sustainability?
- What are the connections to other fields of administration?
- What changes are needed to make education an effective driver of sustainability?
- What sustainability actions are needed in administration, and what are their enablers and barriers?

Roadmap for Sustainability Competences as a process

We can also consider this Roadmap for Sustainability Competences as a process[87]. The process toward developing sustainability competences in education progresses through four main phases[88] (Figure 22).

Figure 22. The expansive cycle of sustainability competences.



1) Engagement through questioning as a precondition

The process toward sustainability in a school or university begins when someone becomes engaged in improving sustainability. This engagement may stem from personal concern about the state of the planet – shaped by societal zeitgeist, media, and public discourse – knowledge of ecological crises, or personal experiences, such as local impacts of climate change (e.g., droughts, floods, biodiversity loss of once-common and cherished species). It may also arise from practical knowledge, such as environmental measurements at the school that reveal the institution's or an individual's impact on climate change.

[87] Drawing from the Theory of Expansive Learning (Engeström 1987; Engeström & Sannino 2010)

[88] Mykrä 2021; Mykrä et al. 2023

Engagement can also be triggered by administrative or peer pressure, prompting actors to prioritise sustainability. When a contradiction arises between sustainability engagement and existing practices the motivation to promote sustainability increases. In the best-case scenario, engaged teachers, headmasters, students and the institution as a whole are willing to transform the aims and values of education to reflect a new understanding of the planet's condition. Without such contradictions, motivation to promote sustainability remains low – business as usual is easier when there is no genuine drive for change.

2) Awareness of connections and scrutiny of current practices

Awareness of sustainability's importance leads to scrutiny of current practices. What are the connections between these practices and sustainability? What are the root causes of unsustainable practices? What problems exist in current activities? These discussions foster an understanding of contradictions between current activities and sustainability goals. Such contradictions may manifest in individual behaviours, collective practices, or technical-material arrangements – highlighting the gap between traditional methods and new sustainability aims. For example, subject-based teachers may wish to incorporate sustainability content into their teaching but struggle with limited time and the importance of existing content.

3) Seeking Solutions and Participatory Change

Once unsustainable behaviours, practices or structures are identified, the next step is to seek solutions: What changes are important in our context? A participatory approach helps identify the best models for each context through collaborative elaboration. However, contradictions with other institutional activities often arise. For instance, promoting multidisciplinary teaching at a university challenges traditional administrative and financial structures, as funding is typically allocated through faculties. Deciding which faculty receives funding when multiple faculties are involved can be difficult, creating pressure to reform these structures. In secondary schools, the desire to teach in natural surroundings may conflict with rigid schedules, making it hard to travel to and from natural settings between lessons.

4) Action and New Contradictions

Ideally, after navigating these contradictions, the school or university enters the action phase, establishing new practices. However, a new contradiction often emerges: the institution's activities may not align with the broader system it operates within. For example, a school may set up recycling stations, but if the waste management service collects all waste in a single plastic bag, the effort fails to achieve its goal. In the best case, this contradiction motivates the service provider to change its practices and to enter its own transformation cycle.

The development cycle does not end here. New challenges will arise, prompting the process to begin again. Members of the school or university community can join this transformation cycle at any point, experiencing their own mini-cycles of engagement, reflection, change, and action.

6. Tools to Promote Sustainability Competences

Digital tools measuring environmental performance can promote sustainability competences and support active learning through simulation, reflection, and action-oriented experiences. To this end, **the Environmental Footprint Calculator, Retrofitting Toolkit, Sustainability Intervention Evaluation Tool and IoT Ecosystem** were developed as part of the ECF4CLIM project[89] and are hosted on the project's Digital Platform[90]. These tools further develop the results of previous projects carried out by the ECF4CLIM project partners. The tools can be adapted for use in both formal and non-formal educational contexts. Developing the technological tools has contributed to the development of this Roadmap by facilitating the tracking of the most essential sustainability competences in educational settings, especially from the perspective of technical-material competences.

Pedagogical tools provide resources for teachers and educators to promote sustainability in their teaching. The idea of a learning space, including **Flipbooks** and a **Learning Game**, was already developed during the planning phase of the ECF4CLIM project. The **Save the Planet game** and the **Roadmap** section on the MAPPA.fi platform were created during the project in response to emerging pedagogical needs and to effectively disseminate the Roadmap. All the tools can be adapted for use in both formal and non-formal educational contexts, as well as in lifelong learning.

Digital tools

Environmental Footprint Calculator

The Footprint Calculator[91] is a flexible, web-based tool that enables users to assess the environmental impact of behaviours and operations across three main user types: managers of educational centres, students and families, and a simplified version for primary school pupils.

The calculator collects input across various activities such as energy use, water consumption, waste production, transportation, and materials used. Based on a Life Cycle Assessment (LCA) methodology, it then generates results in several impact categories (e.g. climate change, water resource depletion, human toxicity, photochemical ozone formation), normalised by user, student, or building area.

The footprint calculator makes visible the environmental impact of everyday actions (promoting understanding of connections), encourages users to explore alternative behaviours and identify sustainability hotspots (promoting critical and reflective thinking), introduces users to environmental indicators and impact interpretation (data literacy), and serves as a starting point for sustainability planning and for initiating change. The calculator supports the Roadmap's Engagement, Connections, Change and Action areas by helping users reflect on their role in sustainability and prioritise areas for intervention.

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[89] ECF4CLIM project report D7.15 ECF4CLIM Digital Platform Integration. https://ecf4clim.eu/wp-content/uploads/2024/10/D7.15.pdf

[90] https://ecf4clim.eu/digital-platform/

[91] ECF4CLIM project report D7.8 Environmental Footprint Calculator https://ecf4clim.eu/wp-content/uploads/2024/10/D7.8.pdf

The tool enables users to assess the environmental impact of their behaviours and activities across multiple domains (e.g., energy, water, mobility, materials).

For each profile (managers, secondary and university students, primary students), a tailored data collection approach was implemented, allowing users to calculate environmental footprints at different scales (e.g., per user, per student, per m^2 of building area) and across various impact categories (e.g., climate change, water resource depletion, human toxicity, photochemical ozone formation).

How does the Environmental Footprint Calculator promote sustainability competences?

The development and application of this tool are directly aligned with the practical focus areas related to sustainability competences. Specifically, the calculator promotes:

- **Engagement:** Nature (Knowledge and Relation): By interacting with quantitative indicators and impact metrics, users develop competences in interpreting environmental data and drawing informed conclusions.
- **Connections:** Systems (Complexity and Roots): By making visible the interrelations between resource use and environmental impact, users are encouraged to think holistically and understand complex cause-and-effect dynamics.
- **Change:** Perspectives (Assumptions and Critical Thinking): The simulation features enable users to explore alternative scenarios and reflect on the effectiveness of different behavioural changes or institutional policies.
- **Action:** The tool encourages users to identify high-impact areas and prioritise actions for improvement, empowering them to move from awareness to implementation.

The calculator supports the Roadmap by offering a practical mechanism for operationalising the competence-based approach to sustainability education. It serves as both a learning tool and a diagnostic instrument, reinforcing the iterative cycle of:

1. Initial assessment – understanding current environmental impact

2. Scenario modelling – exploring what-if alternatives

3. Decision making – identifying feasible and effective actions

4. Monitoring and reassessment – tracking change over time

By enabling both individual and collective participation, the calculator strengthens the whole-school approach and supports the long-term integration of sustainability competences into formal and non-formal educational contexts.

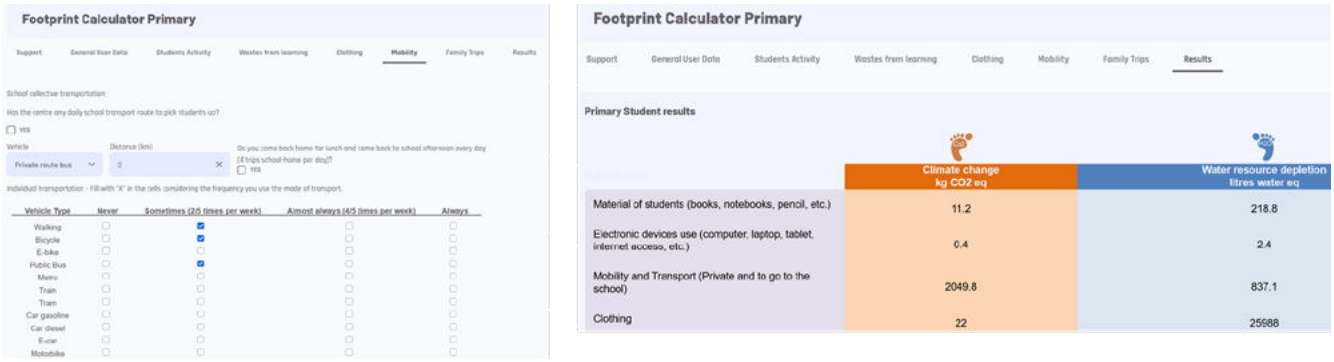
Examples: How was the footprint calculator applied in the ECF4CLIM project?

The tool was first applied to evaluate the initial baseline at the beginning of the ECF4CLIM project. The results obtained were instrumental in informing the discussions of the Sustainability Competence Teams and Committees and contributed to the selection of interventions at several demonstration sites.

In addition, simplified versions of the tool were integrated into specific educational interventions (Figure 23). For instance, in the intervention 'Water and CO_2 Market – Second-hand T-shirt Market' implemented at the CEIP Mozart primary school in Spain, a section of the tool was used to estimate the environmental impact of clothing, specifically in terms of water consumption and CO_2 emissions. In the intervention 'Planting Trees in the School', a simplified extract of the tool was applied to calculate the amount of CO_2 captured annually by the newly planted vegetation on school grounds.

These applications demonstrate the tool's flexibility and relevance in supporting both technical assessments and educational activities aimed at fostering sustainability competences among students.

Figure 23. Examples of the environmental footprint calculator



Retrofitting Toolkit

The Retrofitting Toolkit[92] developed in the ECF4CLIM project[93] strengthens awareness of building energy efficiency among users by promoting engagement in actions that foster behavioural change toward greater efficiency and sustainability. It achieves this by enhancing understanding of how climatology, urban layout, building characteristics, and user behaviour influence energy consumption and thermal comfort, particularly in school environments. The toolkit consists of two complementary web-based tools that can be used independently or in combination, across both formal and non-formal educational settings, and in lifelong learning. It is designed for three main user types, with tailored levels of complexity and user interfaces appropriate for each one: an advanced version for university students and families, educational institution managers and teachers, an intermediate version for secondary students and families, and a simplified version for primary school pupils.

Tool 1: Maps for building energy retrofitting proposals offers a comprehensive climatic and bioclimatic analysis of the local environment surrounding each educational centre, including temperature, humidity, solar radiation and wind conditions. Through interactive maps, it supports the identification of both passive

[92] https://ecf4clim-app.smartwatt.net/app/footprint-calculator

[93] ECF4CLIM project report D7.9 Retrofitting Toolkit https://ecf4clim.eu/wp-content/uploads/2024/10/D7.9.pdf

and active strategies to enhance thermal comfort and energy efficiency, during both winter and summer, tailored to the specific climatic context of each site. The tool collects input data including climate files in EPW (Energyplus Weather File) format (based on TMY – Typical Meteorological Year data for the specific location), the selected school, and heating/cooling set points. It then generates outputs such as climate maps (temperature, humidity, solar radiation), maps of applicable bioclimatic strategies (e.g., natural ventilation, thermal mass, solar gains, shading), and estimated heating and cooling needs using the Heating and Cooling Degree Days (HDD/CDD) calculation methodology.

Tool 1 highlights how local climate influences building energy performance (promoting systems thinking). It encourages users to explore more sustainable behavioural patterns by understanding how local environmental conditions influence building energy efficiency, by identifying climate trends and natural resources for improving environmental performance (promoting critical and reflective thinking), and engages users with climate maps and climate analysis tools (promoting data literacy). The tool serves as a foundation for developing climate-responsive design strategies tailored to the specific environmental context of each school (promoting action competence). This tool supports the Roadmap's Engagement, Connections, Change and Action areas by helping users understand how local climate shapes thermal demand and energy-related decisions in schools, predicting whether passive heating or cooling measures are likely to improve thermal comfort inside the schools.

Tool 2: Dynamic building energy performance evaluates the energy impact of retrofit measures applied to a representative classroom. Through dynamic modelling, it estimates annual energy savings in heating/cooling demands from interventions such as insulation upgrades, replacing windows, solar protection systems or adjusting operating schedules. The tool collects input data of local climate and construction features of the classroom and operational parameters (heating/cooling set points, occupancy schedules, ventilation rates, and room location). It then generates outputs such as annual thermal energy demand (heating and cooling), projected energy savings per retrofit measure, and side-by-side comparisons of multiple intervention scenarios.

Tool 2 shows the interconnectedness between climate, building envelope, indoor conditions, and energy demand by simulating 'what-if' scenarios based on different design choices (promoting systems thinking competence). It enables users to compare design options and reflect on the impact of architectural decisions and allows flexible planning by testing various combinations of structural and behavioural factors (promoting critical and reflective thinking). Tool 2 supports informed decision making by visualising the effects of retrofit strategies on comfort and energy use through school context-specific simulations, and facilitates collaboration between students, teachers and facility staff. The tool introduces environmental indicators (e.g. temperature profiles, heating/cooling demand) and promotes the interpretation of simulation outputs (promoting scientific and data literacy).

The Retrofitting Toolkit aligns with the ECF4CLIM Roadmap by engaging students in understanding how simple actions can lead to greater comfort and environmental benefits (Engagement); by helping them comprehend how buildings, such as the schools where they study, interact with the local climate and user behaviour (Connections); by encouraging them to explore different retrofit strategies and observe the resulting improvements (Change); and by enabling the immediate application of new knowledge in daily life (Action). The toolkit turns awareness into concrete actions, promoting more sustainable lifestyles and choices

that benefit both people and the environment. The Retrofitting Toolkit was designed and implemented as one of the simulation tools within the ECF4CLIM digital platform. It focuses on promoting awareness and understanding of energy efficiency in school buildings, engaging users in the relationship between local climate, building characteristics, and occupant behaviour.

For each group (teachers and managers, students and families, and primary school pupils), the complexity of content, visualisation and interaction is adapted to support progressive learning from simple climate comparisons to scenario-based simulations and decision making.

How does the Retrofitting Toolkit promote sustainability competences?

Specifically, the toolkit fosters:

- **Engagement:** Nature (Knowledge and Relation): Through engagement with quantitative indicators and analytical tools to interpret the data, such as climate maps based on temperature, humidity, solar radiation and wind conditions, as well as energy demand estimations. Users develop skills in interpreting environmental data and drawing reasoned conclusions.
- **Connections:** Systems (Complexity and Roots): By revealing the interactions between local climate, building envelope, indoor conditions, and energy performance, users are encouraged to think holistically and understand complex cause-and-effect dynamics.
- **Change:** Perspectives (Assumptions and Critical Thinking): The simulation tools support the comparison of alternative retrofit strategies and invite users to reflect on the effectiveness of different solutions in real-world scenarios.
- **Action:** By identifying impactful measures and estimating their outcomes, users are empowered to prioritise decisions and move from awareness to implementation. It provides a basis for crafting design strategies that respond to climate conditions and are adapted to the unique environmental characteristics of each school site.

The Retrofitting Toolkit supports the Roadmap by offering a practical and participatory pathway for developing sustainability competences in the context of energy-efficient school buildings. It aligns with the iterative process promoted by ECF4CLIM:

1. Initial Assessment – Understanding local climatic conditions and the current energy and comfort performance of school buildings

2. Scenario Modelling – Exploring and simulating bioclimatic and retrofit strategies

3. Decision making – Selecting and prioritising feasible actions to improve comfort and reduce environmental impact

By combining climate data interpretation, user-adapted simulations, and real-life classroom interventions, the Retrofitting Toolkit acts as both a learning tool and a practical resource to support behaviour change and school-level sustainability planning.

Examples: How the Retrofitting Toolkit was applied in the project framework and during interventions

In addition to its digital format, the Retrofitting Toolkit was applied in the intervention 'Learning Space: Retrofitting Toolkit', an educational session designed to strengthen awareness among students and the

broader educational community of the energy efficiency of buildings. The intervention aimed to highlight both the environmental and social benefits of energy efficiency, fostering the understanding and use of passive bioclimatic strategies to improve indoor comfort while reducing energy consumption at home and at school.

The session was delivered to 6th-grade (age 12-13) primary school students and combined both physical and digital components. It was highly participatory and featured a bioclimatic house model equipped with sensors to demonstrate the thermal effects of retrofitting measures, such as the influence of different building envelope types on indoor temperature. Students were also introduced to building monitoring tools, including sensors for temperature, humidity and wind, as well as devices measuring energy production from photovoltaic panels.

Additionally, basic physics concepts related to energy and climate variables were explored through hands-on classroom experiments. Both tools from the Retrofitting Toolkit were introduced, integrating digital simulations with tangible, real-world observations. This blended approach helped illustrate how passive and active design strategies can enhance indoor comfort and reduce energy demand, while reinforcing sustainability competences through experiential learning.

Sustainability Intervention Evaluation Toolkit

The Sustainability Intervention Evaluation Toolkit[94] aimed to support the development of individual and collective sustainability competences and to contribute to the evaluation of technical-material competences at our DS. It could be used to support the evaluation and improvement of the environmental performance of educational institutions, while simultaneously fostering the development of sustainability competences among students, teachers and managers. It is composed of two complementary components:

1. The **Sustainability Intervention Tool**, which assesses the environmental performance of schools and universities across seven thematic areas.

2. The **Energy Engine**, which provides a deeper, technical analysis of energy-related interventions.

The Sustainability Intervention Tool enables the assessment of sustainability levels across seven environmental domains (transport, water, waste, green procurement, green areas, indoor air quality, and energy) by means of specific Key Performance Indicators (KPIs) that allow comparisons between schools and link interventions with measurable outcomes. It includes a flexible data collection structure and a multi-criteria methodology to generate sustainability indexes and support evidence-based decision making.

Designed in the Microsoft PowerApps environment, the tool ensures accessibility and adaptability to different institutional contexts. Its structure is based on two main sections: a data menu (for information input and case study definition) and a calculation menu (for computing sustainability indicators). This modular approach allows users to carry out audits with different levels of detail (high, medium, low) depending on the available data and user expertise.

[94] Available: https://ecf4clim.smartwatt.net/simulators-space/

The Sustainability Intervention Tool is available in three tailored versions, ensuring suitability for diverse educational levels:

- **Advanced v**ersion for university students, families, institution managers and teachers;
- **Intermediate** version for secondary school students and families;
- **Simplified** version for primary school pupils.

The **Energy Engine** is targeted exclusively to users with a more technical background, typically university level.

Beyond its technical functions, the Sustainability Intervention Evaluation Toolkit promotes **learning-by-doing**. By engaging in sustainability audits, students and teachers collaborate in data collection, analysis, and interpretation, and jointly propose actions for improvement. In this way, the tool becomes both a **diagnostic instrument** and a **pedagogical resource** that encourages reflection and participation, integrating sustainability assessment into everyday school practices.

The Sustainability Intervention Tool supports the Roadmap by offering a practical and participatory pathway for developing sustainability competences in the context of several thematic areas (transport, water, waste, green procurement, green areas, indoor air quality, and energy). It aligns with the iterative process promoted by ECF4CLIM:

1. Initial Assessment – Understanding the baseline of the school's sustainability performance.

2. Scenario Modelling – Exploring and simulating different strategies in each thematic area.

3. Decision making – Selecting and prioritising feasible actions to improve the sustainability performance of the school/university.

How does the Sustainability Intervention Tool promote sustainability competences?

The **Sustainability Intervention Tool** contributes to the development of the practical focus areas related to sustainability competences:

- **Engagement: Nature (Knowledge and Relation)**: By involving students and teachers in practical sustainability audits, the tool fosters understanding of environmental performance indicators and encourages curiosity about the state of their school environment.
- **Connections: Systems (Complexity and Roots)**: Users learn to recognise interrelations between sustainability domains (e.g. how energy use affects air quality or waste management). This holistic view strengthens systemic thinking and helps identify the root causes of sustainability challenges.
- **Change: Perspectives (Assumptions and Critical Thinking)**: Through the evaluation of baseline conditions, the simulation of potential measures, and the assessment of their impacts, users develop analytical and reflective competences. They learn to question assumptions and critically interpret the results of their interventions.
- **Action:** The tool empowers users to design and implement targeted sustainability actions, such as promoting sustainable mobility, improving recycling systems, or enhancing energy efficiency. It thus supports the transition from awareness to concrete implementation.

By operationalising the four stages of the **ECF4CLIM Roadmap – Engagement, Connections, Change and Action** – the tool strengthens both **individual competences** (critical thinking, systems understanding, problem-solving) and **collective competences** (collaboration, shared decision making, institutional learning). Additionally, it reinforces **technical-material competences** by helping institutions understand and improve the physical and technological infrastructures that enable sustainability.

Examples: How the Sustainability Intervention Tool was applied in the project framework and during interventions

The Sustainability Intervention Tool was applied in various interventions to evaluate the environmental performance of several thematic areas and to improve the awareness and knowledge of students and teachers regarding the topic.

In these applications, students – supported by teachers and researchers – jointly conducted thematic audits using the tool's data collection and analysis modules, identifying potential improvements and understanding how sustainability performance could evolve with implementation.

As an example, interventions SP-DS01-IN03 and SP-DS01-IN10 took advantage of the tool to show students the impact that the incorporation of a bioclimatic system and photovoltaic (PV) panels had on the school's environmental performance, while simultaneously raising awareness and consciousness about renewable energy and energy consumption.

In other cases, such as SP-DS01-IN01, the tool was used to evaluate the school's performance regarding green areas and to guide working groups in proposing which types of trees should be planted in the schoolyard.

Some uses not included in a specific intervention were developed by students – for example, a group of students used the tool to conduct a mobility analysis of the school community through its capabilities and interaction with Microsoft Forms.

Moreover, a training session was organised within the framework of the 6th General Assembly, held in Bucharest in 2024, for teachers from all demonstration sites to learn about the tool and how to use it.

Through these applications, the tool has proven to be a useful resource, combining technical evaluation with participatory learning and enabling educational communities to transform sustainability assessment into meaningful action.

IoT Ecosystem

The IoT Ecosystem framework[95] was designed and developed in the ECF4CLIM project[96] to acquire indoor air quality and energy consumption data to facilitate environmental performance evaluation and carbon footprint assessment of the educational communities' activities. By contributing to the calculation of specific Key Performance Indicators (KPIs), users could monitor their performance in four different areas: Comfort,

[95] https://ecf4clim.smartwatt.net/iot-ecosystem/

[96] ECF4CLIM project reports D7.11 ECF4CLIM IoT Platform v.1 https://ecf4clim.eu/wp-content/uploads/2024/10/D7.11-ECF4CLIM-IoT-Platform-v.1-tested-at-QUE-Lab-premises.pdf and D7.12 IoT Platform v.2 https://ecf4clim.eu/wp-content/uploads/2024/10/D7.12.pdf

Energy, Indoor Air Quality and Ventilation (Figure 24). Additionally, users could compare their results with different schools in the same country or educational level. The KPIs related to energy describe the energy consumption per student and per classroom square metre.

The IoT Ecosystem platform and its implementation at the demonstration sites of the ECF4CLIM project contributed to exploring the technical-material competences of the schools and universities.

With IoT Ecosystem, schools can monitor their KPI scores and examine their historical data to identify habits and behaviours that result in inadequate classroom air quality and high energy consumption, empowering them to act accordingly to foster a sustainable environment. All the data are available to the educational community on the ECF4CLIM digital platform, making it possible for users to select the preferred data category and period for their classroom (Figure 24).

Additionally, users can monitor their real-time indoor air quality and energy consumption data. Through the ECF4CLIM mobile app, users are able to visualise their classroom data through an intuitive view and grasp the effect of their actions in their space (Figure 24). Instead of illustrating the actual measured values, the application notifies the user about the indoor air quality regarding CO2 and PM2.5 concentration levels in a qualitative way (i.e., 'excellent', 'good', 'medium', 'inadequate' and 'poor'), utilising the levels suggested by WHO (World Health Organisation).

Figure 24. **Examples from IoT Ecosystem: Indicative example of KPIs on the ECF4CLIM platform; example of an indoor air quality multisensor; and ECF4CLIM platform graphs of high CO2 concentrations within the classrooms, implying that the classroom should ventilate more efficiently.**

Through the incorporated ECF4CLIM mobile app functionalities, users are spurred to take action towards more sustainable (and healthy) use of their classroom. If the air quality indicator reads poor or inadequate, the users know to ensure proper ventilation (e.g. opening windows) in their space to increase air exchange, or if power consumption is shown to be significantly high after a lesson, this might indicate that classroom lights had been left on, for example.

How does IoT Ecosystem promote sustainability competences?

The IoT Ecosystem framework aligns with the four focus areas related to the sustainability competences of the Roadmap.

- **Engagement: Nature (Knowledge and Relation):** Students and teachers, through intuitive user interfaces like the web platform page and mobile apps, are able to visualise Indoor Air Quality (IAQ), ambient conditions and energy consumption information with interactive charts with a click of a button.
- **Connections: Systems (Complexity and Roots):** Appropriate IoT equipment is deployed and connected to the classroom's energy consumption and indoor air quality (IAQ) systems, enabling real-time data streaming to the educational community. This allows users to monitor how their behaviours affect the operation and performance of the building's technical systems. Consequently, users are able to understand the complexity of the system's operations and the carbon footprint that they leave on the environment.
- **Change: Innovation (Creativity and Transdisciplinarity):** The IoT Ecosystem platform delivers a set of KPIs that provide insights on how the educational community's daily routine affects the energy consumption, ambient and IAQ conditions. By monitoring IoT Ecosystem KPIs, schools are able to examine historical data in order to identify habits and behavioural patterns that may result in inadequate classroom air quality or high energy consumption. The tool further provides functionalities that allow for comparison of outcomes among different schools or classrooms, reflecting the effectiveness of the interventions. Ultimately, it provides the opportunity for educational communities to exchange experiences and information by comparing their respective energy and Indoor Air Quality KPIs.
- **Action:** The IoT Ecosystem framework empowers students and teachers to act to foster a sustainable environment by applying tailored interventions. Example real-life scenarios: when an air quality indicator on the mobile app reads poor or inadequate, users know to ensure proper ventilation (e.g. opening windows) in their space to ensure adequate air exchange. Similarly, regarding energy efficiency, if high power consumption is recorded after a lesson, this might indicate to users that the classroom lighting was left on.

IoT Ecosystem supports the Roadmap by promoting sustainability awareness, acting as an innovative information platform that empowers collective and individual participation in sustainable initiatives.

1. Initial Assessment – Understanding classroom indoor air quality conditions and energy consumption patterns.

2. Scenario Modelling – Tracking the environmental impacts of interventions through quantitative KPIs.

3. Monitoring and Reassessment – Tracking change over time.

Pedagogical tools

Learning Space including Flipbooks and a Learning Game

During the ECF4CLIM project, a Learning Space[97] encompassing educational resources was developed to enhance citizens' awareness and capacity to combat climate change and foster sustainable development. The space provides links to educational resources related to sustainability: Digital Interactive Learning Content[98] and a Learning Game[99].

These resources are thoughtfully structured around the four key areas of the ECF4CLIM Roadmap – Engagement, Connections, Vision, and Change – alongside an introductory area, Sustainability Awareness, which introduces learners to the foundational concepts of sustainability. This organisation ensures a progressive and pedagogically coherent learning journey, guiding users from initial awareness through deeper understanding, creative visioning, and ultimately to transformative action for sustainability. Each area builds upon the previous, supporting learners as they develop the knowledge, skills and attitudes needed to become active agents of change in their communities and beyond.

The **Digital Interactive Learning Content** fosters a holistic approach to sustainability education by providing interactive educational resources made for students, educators and the wider educational community. These resources aim to enhance awareness and empower action against climate change and towards sustainability. Each Digital Learning Content item is presented as five interactive flipbooks and integrates real-life examples – primarily sourced from ECF4CLIM demonstration sites – alongside videos and hands-on activities. These elements are designed to promote critical thinking, systems understanding, and values-based reflection, all aligned with the GreenComp framework. By combining authentic case studies with multimedia and interactive exercises, the flipbooks offer learners a dynamic and engaging experience that connects theory to practice and encourages meaningful exploration of sustainability challenges, helping teachers to apply learner-centred exercises in class, to reflect on sustainability.

The **Learning Game** is strategically designed, based on the Digital Learning Content, to enhance the effectiveness of educational resources, ensuring they are not only informative but also captivating. The Learning Space complements other digital learning content and provides a gamified environment for users. Users can engage with the game repeatedly, enhancing their understanding through trial and error while accessing theoretical knowledge through the flipbooks. The game mirrors the structure of the ECF4CLIM Roadmap, allowing learners to apply concepts from each module – including an introductory module on 'Sustainability Concepts Awareness' – within simulated decision-making scenarios.

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[97] https://ecf4clim.smartwatt.net/learning-space/

[98] ECF4CLIM project report D7.14 ECF4CLIM Digital Interactive Learning Contents https://ecf4clim.eu/wp-content/uploads/2024/10/D7.14.pdf

[99] D7.13 ECF4CLIM Learning Game (gamification) https://ecf4clim.eu/wp-content/uploads/2024/10/D7.13.pdf

The game incorporates various interactive formats, including quizzes, decision trees, drag & drop, and true or false questions, and uses storytelling to enhance user motivation. This approach aligns with gamification principles. Pilot implementations in schools across Europe have shown that this blended approach – combining narrative-based learning, interactive tools and real-world examples – boosts learner engagement and fosters long-term behavioural change.

Moreover, the Teachers' Resources area is designed to empower educators with a rich and diverse collection of materials, curated to support sustainability and climate education across all age groups. Here, teachers will find ready-to-use lesson plans, interactive activities, videos, games, and digital flipbooks, all organised by age range and thematic area – such as Engagement, Connections, Change, Action, and Environmental Awareness. These resources are aligned with the GreenComp framework and the ECF4CLIM Roadmap, making it easy to integrate sustainability into everyday teaching. Each resource includes direct links for quick access and practical application, enabling teachers to adapt materials to their classroom needs and foster critical thinking, creativity and active citizenship among students.

The platform also features digital tools, such as footprint calculators and retrofitting kits, to help educators measure and improve their school's sustainability performance. By exploring and sharing these resources, teachers become key agents of change, inspiring students to take meaningful action for a more sustainable future.

The learning space offers one perspective on individual competences related to awareness and basic knowledge of sustainability.

Save the Planet game

The Save the Planet game was developed by the University of Jyväskylä to introduce the initial ECF4CLIM Roadmap to students and foster engagement and other sustainability competences. The game was tested and further developed to different levels of education, beginning from university level, to primary, lower secondary and upper secondary in the Finnish demonstration sites. On the upper secondary level the tasks of the game were very carefully planned, tested and re-modified several times according to the feedback received from students. Finally, the game is currently integrated as part of an obligatory physics class for all students. The game was designed for international use and translated into English for ECF4CLIM partners for the General Assembly in May 2025.

The idea of the game is to look at the Roadmap areas from the perspectives of individual, collective and technical-material competences. Different tasks were thus planned related to each Roadmap competence area.

Tasks for Engagement

What kinds of regulations and statements have been defined and given that obligate schools and universities to promote sustainability in their pedagogy and practice? – Identifying key sustainability regulations and statements relevant to schools and universities.

In what ways can different people be motivated to promote sustainability? – Identifying and understanding sustainability motivation profiles and recognising one's own profile.

Tasks for Connections

What is the importance of individual choices with regard to carbon emissions? – Comparing the emissions impact of various individual actions and ranking them in order from highest to lowest emissions.

All academic disciplines and school subjects can be involved in fostering some sustainability competences. – Matching sustainability competences with different teaching contents and subjects.

Tasks for Change

Reflection on the sustainability skills and competences needed in future working life. Imagining personal future jobs with regard to sustainability and the sustainability competences needed in the field.

Introducing inspiring innovations to decrease environmental emissions. Fostering critical and systems thinking to determine if the suggested innovations are possible, real and realistic to implement in practice.

Tasks for Action

Fostering awareness, based on statistics, of how much work towards sustainability is currently ongoing as well as the large number of professionals that are working on environmental issues and ecological sustainability.

Reflection on and making personal handprints of what I, personally, can do to promote sustainability in my own life, in my school or university, or in society.

MAPPA.fi and the Roadmap for Sustainability Competences

The Roadmap for Sustainability Competences is available for teachers and educators on the MAPPA.fi platform (Figure 25)[100]. MAPPA.fi offers a user interface that presents the **Roadmap** in a simple, practical and easily usable form. The core message of the **Roadmap** and its four practical focus areas – Engagement, Connections, Change, and Action – are clearly visualised and each focus area is easily accessible to the user for further content. MAPPA.fi is the main forum offering teachers and educators tools and materials for utilising the **Roadmap**, and it presents the **Roadmap** alongside and strongly linked to GreenComp competences, helping teachers to implement both the Roadmap and GreenComp in practice. Content producers and users can share and find teaching and learning materials linked to the Roadmap and GreenComp also in the future, so the platform is a living arena for new tools and materials for teachers and educators to use.

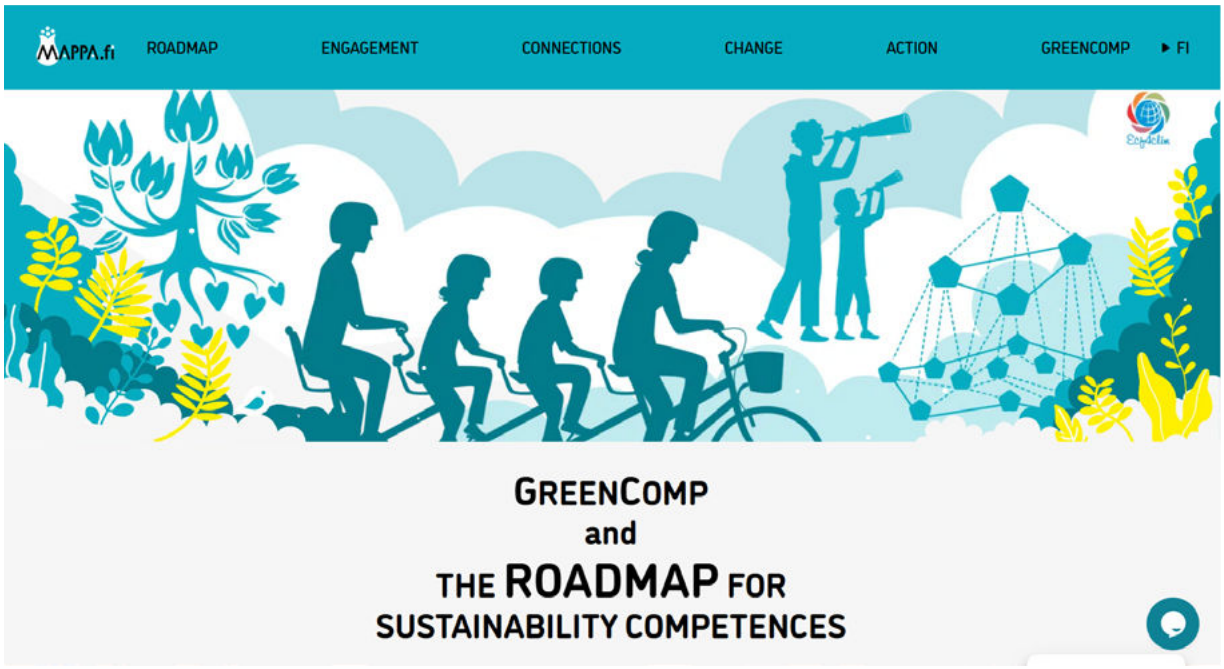
MAPPA.fi is Finland's largest open-access search and sharing platform for materials, tools, services and networks related to environmental and sustainability education. It is designed to support educators, youth workers, and other professionals by providing tools, resources and inspiration for teaching about nature, climate, biodiversity, and sustainable development. It is maintained by the Finnish Association of Nature and Environment Schools, an Associated Partner of ECF4CLIM, and partly funded by the Ministry of Education and Culture. MAPPA.fi compiles learning materials from various producers in the fields of environmental education, sustainability education and outdoor learning. Its strength in storing and sharing educational materials is based on three factors:

[100] https://mappa.fi/en/greencomp-roadmap/

- First, MAPPA provides a centralised and reliable platform where resources remain accessible and usable in the long term.
- Second, its search functions, thematic collections and curriculum-linked tools enable effective organisation and pedagogical integration of materials.
- Third, MAPPA fosters collaboration by offering a publishing platform for multiple actors and facilitating the sharing and use of resources among teachers.

Through these features, MAPPA.fi serves as a repository for educational materials, a platform for NGOs and other service providers to offer their services and as a resource that strengthens teacher collaboration.

Figure 25. **GreenComp and the Roadmap for Sustainability Competences on the MAPPA.fi platform.**

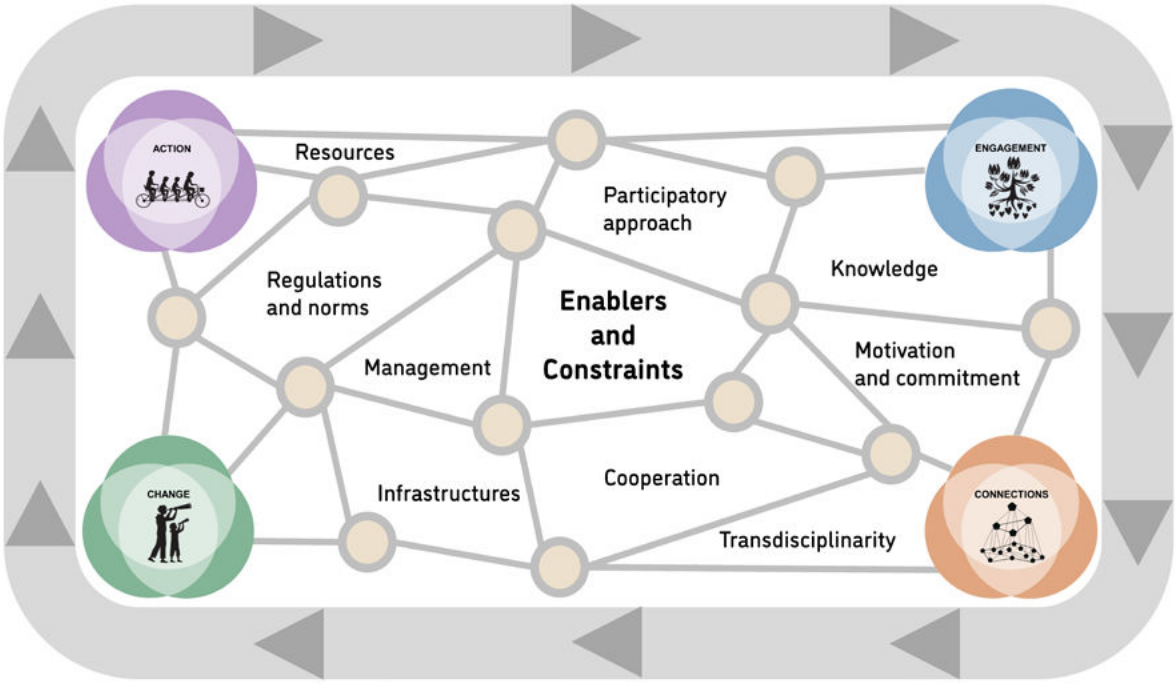


7. Impact and Lessons Learned

This Roadmap for Sustainability Competences presents areas essential for the development of sustainability competences – Engagement, Connections, Change and Action – and examines them from the perspectives of individual, collective and technical-material competences. It also elaborates on how these areas and perspectives are deeply intertwined. The Roadmap offers real-life examples from schools and universities. During the ECF4CLIM project, all areas of this Roadmap and spheres of competence were found to be relevant in educational settings.

The Roadmap for Sustainability Competences (Figure 26) describes enablers and constraints in promoting sustainability in education: management, motivation, knowledge, cooperation, participatory approaches, resources, commitment, regulations and norms, transdisciplinary knowledge, and infrastructures. These factors can act as enablers – or, when absent, become constraints. When we study these enablers or constraints, we see that they are closely related to the presence or absence of individual, collective or technical-material competences. For example, if managers, leaders or teachers lack motivation, sustainability knowledge or individual competences to cooperate or facilitate participatory approaches, promoting sustainability competences in education becomes challenging. Institutions with poor collective sustainability competences may not be committed to sustainability in their norms or regulations, may fail to allocate resources for sustainability work, and may lack structures for cooperative networks or support for participatory and transdisciplinary approaches. Missing infrastructure restricts the development of other technical-material competences. If technical-material sustainability competences are lacking, transdisciplinary knowledge and concrete learning environments are also absent.

Figure 26. Roadmap for Sustainability Competences.



This Roadmap can be interpreted as a model of a development process (grey line with arrows) creating expanding cycles of growth. Alternatively, it can be used to study opportunities to promote sustainability in specific situations by analysing them through the lenses of Engagement, Connections, Change and Action, and identifying individual, collective and technical-material competences within them. These perspectives are suitable, for example, for understanding the dynamics of an individual learning moment, a course, a curriculum, or an administrative strategy. Through such situational analysis, the most effective ways to promote sustainability in a given context can be identified. The Roadmap is not intended to be a universal solution. However, the issues it addresses are not strictly context-bound; these perspectives can be explored in various settings in both formal and non-formal education, as well as in lifelong learning.

This Roadmap for Sustainability Competences has limitations. It is based on practical experiences in specific educational institutions and demonstration sites across four countries. It describes what has been possible in those institutions and the constraints they encountered. There are certainly other practices and options that may be even more effective in different contexts. The aim of this Roadmap is not to present perfect solutions, but to depict what has been proven possible. Future steps in schools and universities can build on these ideas, deepening and expanding sustainability efforts. Also, pedagogical questions provide help for schools and universities in promoting sustainability competences in practice.

The data for this Roadmap were collected through action research methods, relying on participants' creativity. In the ECF4CLIM project, this creativity was supported by various exercises. However, imagination often remains limited to existing solutions – it is difficult to transcend the boundaries of one's own experience. Vygotsky introduced the concept of the Zone of Proximal Development[101], which refers to the difference between what a learner can do independently and what they can do with support from a more competent person. Within these limits, learning can occur. In the ECF4CLIM project, both teachers and researchers were learners, and they also faced limitations. In future iterations, the zone of proximal development could be broader.

Transdisciplinary collaboration helped expand thinking, as different disciplines and individuals in various roles contributed their experiences. The research was conducted in four countries, across 13 institutions, involving multiple academic disciplines. While there were many perspectives, collaboration between schools and researchers was mostly limited to within each country. Researchers' backgrounds and cultural differences may have influenced how action research was implemented. On the other hand, the involvement of diverse disciplines enriched task design, enabling expanded thinking – even if implementation details varied.

The broad scope of this Roadmap would not have been possible without interdisciplinary collaboration. As both the subject matter and collaborative efforts continue to evolve, the next development cycle may allow for deeper exploration. Nevertheless, the Roadmap offers one possible and tested path toward sustainability.

[101] Vygotsky, L. S. (1978, 86). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

The Roadmap for Sustainability Competences is designed to provide a comprehensive overview of key considerations for developing sustainability education. It encourages us to examine sustainability not only from an individual perspective but, more importantly, from a collective one. It also invites us to understand how technical and material conditions enable or constrain sustainability efforts and function as a learning environment for developing sustainability competencies.

The community and the technical-material environment are not merely contexts for individual behaviour and competences; they also possess their own capacity to act for sustainability. These capacities are not static – they can be developed. That is why we have expanded the concept of competences beyond the individual to include collective and technical-material competences. We base this idea theoretically on the Theory of Practice Architectures, which suggests that competences are formed and enacted within practice, and on sociomaterialist and capability theories, which argue that material conditions are not neutral backgrounds but active components of what people and communities are able to do and become. Our data confirms these theoretical underpinnings: collective and technical-material competences can be developed, and they can also support the development of individual competences. In this dynamic and evolving whole, individual competences act as mediators.

Sustainability competence is best learned – and strengthened – not through theory alone, but through practical engagement and collaborative action. Learning from mistakes and working together to solve shared problems are key elements in this process. This Roadmap can help identify obstacles and discover potential solutions that actually work.

8. Recommendations for Advancing Sustainability Competencies in Educational Institutions

Based on the development work and this Roadmap, we have formulated recommendations for advancing sustainability competences in educational institutions within each focus area: Engagement, Connections, Change, and Action. The recommendations are further focused on promoting individual, collective and technical-material competences, respectively. More detailed examples are presented in Chapter 5, in tables that describe enablers and constraints.

Recommendations related to engagement

- **European Union: Make decisions that support prioritising sustainability in education** In many countries and educational institutions, sustainability is already part of the curriculum, but not everywhere. The role of sustainability in education should be clarified in all curricula and other educational policies to demonstrate collective engagement with sustainability and to help teachers integrate sustainability more effectively into their teaching.
- **National education administration: Strengthen national curricula related to sustainability** Curricula guide schools and teachers in developing students' sustainability competences. Curriculum development should enable the prioritisation and integration of sustainability, support transdisciplinary learning, foster student engagement, and promote participatory approaches to sustainability.
- **Teachers and managers: Empower students as sustainability actors** Students can play a vital role in driving change within educational institutions. Their sustainability efforts should be supported by providing time and space for action. For example, students should be invited to participate in development workshops where they can contribute to sustainability proposals, promote inclusion, help remove barriers, and support non-discrimination.
- **School and university managers: Design inclusive and participatory policies** Educational communities consist of diverse actors. A fair sustainability transition requires inviting all stakeholders to participate in and contribute to the transformation process.
- **Teachers and managers: Make practices more visible** A school building can be a powerful teacher if students are aware of where water, electricity and heat come from, where waste goes, what the environmental impact of mobility is, and what green spaces mean. Making practices visible through awareness-raising campaigns can be highly effective.
- **Teachers: Organise hands-on activities that consider values and diverse interests** It is important to recognise that conflicting values and interests exist in both individual and collective actions. When students become aware of these contradictions, they can make conscious decisions that reflect a commitment to sustainability.

Recommendations related to connections

- **National and regional administration: Encourage data collection, publication and impact evaluation** Understanding the connections between school activities and sustainability and the overall state of sustainability in schools helps identify the most urgent issues. When administrations ask for data collection, this signals engagement with sustainability and reinforces the need to prioritise it.
- **School and university managers: Promote networks and cross-sectoral policies** Cooperation between teachers, other school staff and external stakeholders supports sustainability efforts. Different groups bring diverse perspectives, making it easier to find connections and solutions to sustainability challenges. Cross-sectoral policies enhance the effectiveness of these actions.
- **Teachers: Include sustainability in the everyday curriculum across different subjects** Sustainability issues are complex and understanding them requires knowledge from multiple disciplines. Integrating sustainability into regular teaching supports the development of systemic and critical thinking.

Recommendations related to change

- **National and regional administration: Support leadership and educators in the change process** School leaders and educators responsible for sustainability education need external support to reflect on their practices and stay motivated. This requires resources and supportive national and regional structures that are responsive to local needs and adapted to specific contexts. Participation in networks and projects is vital as these initiatives provide encouragement, accountability, and a sense of purpose by connecting individual efforts to a broader change toward a sustainable future.
- **Administration of educational institution: Provide training and support for teachers and administration** Both teachers and administrative staff need further training, mentoring and access to professional networks to enhance their competencies in sustainability education and management. This enables the entire organisation to engage in integrating sustainability into educational practices. Additionally, training on technical and data literacy is essential, especially when using equipment designed to monitor or reduce environmental impact.
- **School and university managers: Support practice-based development and co-design of action plans** When the strategy and action plan for sustainability are created through active participation in real-world problem-solving within the institution's sustainability and educational development processes, it becomes easier to commit to the actions and responsibilities that sustainability entails.
- **Teachers: Strengthen integrated and creative studies** Solving sustainability challenges requires innovative solutions. Supporting students' creativity is essential. Integrating different subjects broadens thinking and teaches students how to discover new connections.
- **Teachers and researchers: Pay attention to emotions** Students may experience strong emotions when engaging with sustainability challenges. Learning to cope with emotions is important, as they can significantly influence the development of sustainability competences. Further research into the role and meaning of emotions in this context is welcome.
- **Researchers: Facilitate research transfer** Schools are interested in the latest developments in sustainability research. Researchers should communicate new innovations in sustainability education and technical solutions, making it easier to apply them directly in educational institutions.

Recommendations related to action

- **National and local administrations: Steer educational institutions to develop their norms, structures and technical-material environments** National and local administrations can issue recommendations, or even requirements, for educational institutions to meet at least a minimum standard in sustainability. This may include having a concrete sustainability plan with specific steps and adequate follow-up, incorporating sustainability into annual planning, maintaining a sustainability development group, allocating personnel resources for sustainability, and setting limits on the direct environmental impact of educational institutions. Training and materials aligned with these decisions should also be provided.
- **Local administration and school/university managers: Establish alliances** No school or university can solve sustainability challenges alone. Collaborating toward a shared sustainability goal is the most effective approach.
- **School/university managers:** Embed sustainability and a participatory approach in institutional structures

Embedding sustainability into design, implementation and evaluation processes is essential. The collective and inclusive development of pedagogy and practices helps establish clear visions. Strategies should also define shared responsibilities. It is important to listen to proposals from students, teachers and support staff, with the aim of acting as facilitators and promoters in collaboration with the city council or ministry, depending on who is responsible for education services.

- **School and university managers: Recognise sustainability education as an ongoing process** Sustainability education should be understood as a continuous, evolving process rather than a fixed goal. Promoting sustainability can serve as a positive and empowering force, fostering belonging, ownership, and meaningful engagement in both work and study. It is essential to integrate sustainability into the institution's core activities, rather than treating it as an add-on or peripheral initiative.
- **School and university managers: Allocate resources for sustainability** Sustainability requires the dedicated allocation of resources to support hands-on, context-specific participatory learning and institutional transformation. Additionally, establishing and maintaining technical systems for measuring or minimising the environmental impact of an institution also demands sufficient resources.
- **Teachers: Invite students to practical activities promoting sustainability** Eco-anxiety can be paralyzing for students. Offering practical activities with clear, tangible outcomes for a more sustainable world can help address these emotions and provide hope for a better future.

9. Conclusion

This Roadmap for Sustainability Competences has taken shape through the interplay of various academic disciplines, traditions of sustainability education and practical experiences in educational institutions across different countries. Environmental engineering has provided methods for translating sustainability ambitions into concrete, measurable metrics, as well as technical solutions for assessing and reducing the environmental impacts of educational institutions. The **sociomaterial** theories, Capability Theory and Activity Theory helped us understand the role of the technical-material world in practical situations. Practice Architectures Theory has deepened our understanding of how practices are shaped by socially, materially and discursively mediated arrangements. Institutional Theory has served as a foundation for understanding the development and functioning of organisations. The Theory of Expansive Learning has offered a model for examining processes of change within communities. Intervention Theory has supported the design of a participatory approach in which practitioners themselves act as agents of sustainability in schools and universities. Research on sustainability competences and the GreenComp framework has helped us position our work as part of a shared continuum toward sustainable education. And last – but perhaps most importantly – our results are grounded in practice and highlight the focus areas within educational institutions that are essential for advancing sustainability.

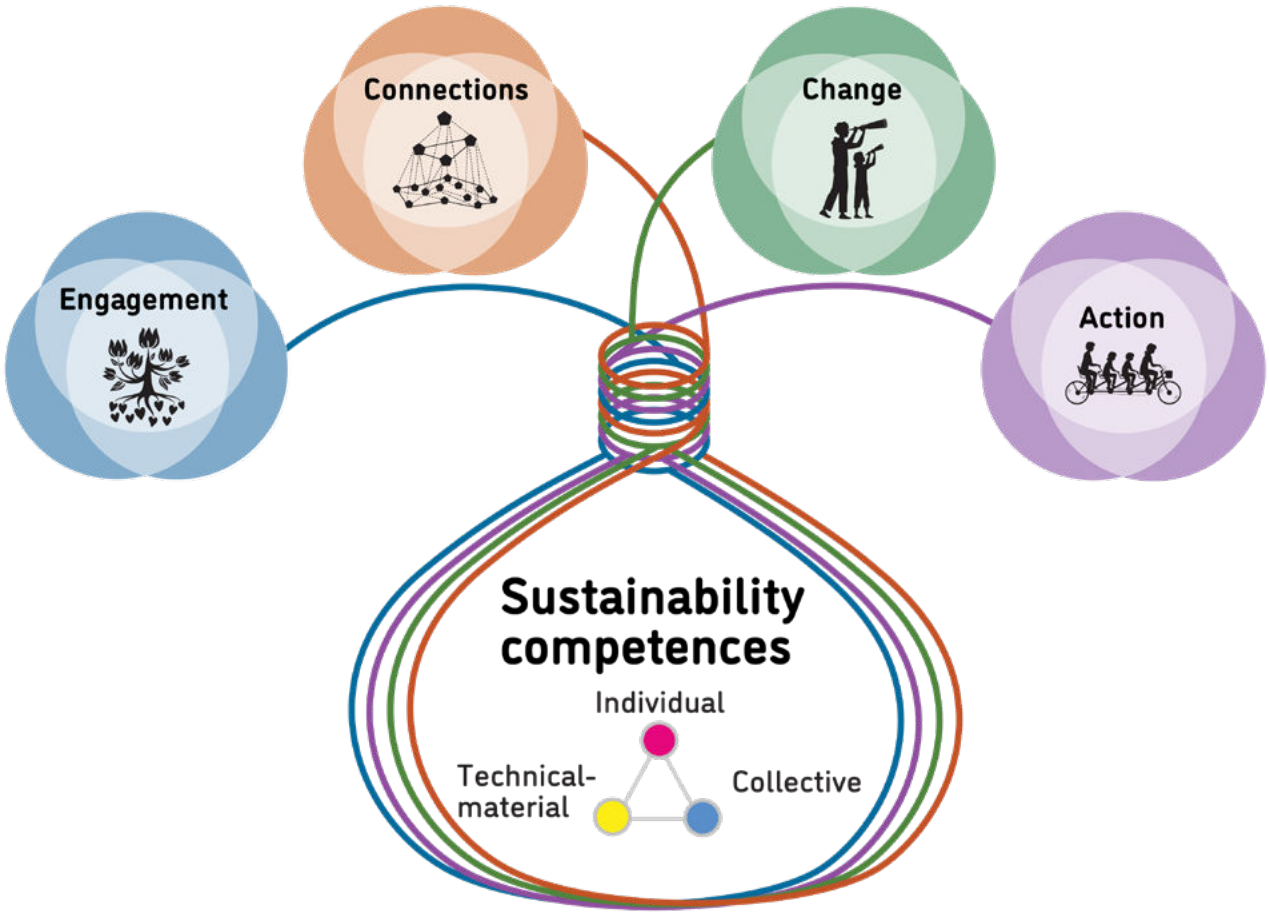
Sustainability competences in education are a multifaceted phenomenon. There is no single recipe where the right ingredients yield a perfect solution. Rather, it is a complex and evolving entity shaped by time and place. The perspectives of engagement, connections, change and action can elevate the promotion of sustainability competences to a new level. The intertwined strands of individual, collective and technical-material competences act as the lifting ropes. Likewise, engagement, connections, change and action are themselves interwoven (Figure 27).

This Roadmap for Sustainability Competences offers a good starting point for new research projects. The interplay between individual, collective and technical-material spheres of sustainability competences should be scrutinised more carefully, and multi-disciplinary cooperation should be deepened to expand our understanding between disciplinary silos.

From the perspective of educational practices, this Roadmap for Sustainability Competences has potential for scaling up, and the MAPPA.fi platform supports its implementation. The Roadmap can be used in the development of everyday sustainability practices in educational institutions, and it can be integrated and disseminated e.g. in Erasmus+ programmes, GreenComp community activities, Teacher Academies or UNESCO-ESD networks.

A major takeaway of this project is that educational transformation for sustainability is neither automatic nor effortless: it requires intentional cultivation of competences and careful attention to context and constraints, but also equality and justice perspectives. Promoting sustainability can be hard and costy, but we have no other option: the cost of not promoting sustainability competences is even bigger, and can have serious consequences. We nevertheless recognise the reality of unequal resources (financial, human, technical, material and time) across countries, cultural differences, and challenges in sustaining practices beyond project life cycles. The only way ahead is to continue our efforts in combating these challenges.

Figure 27. **Perspectives of engagement, connections, change and action as elevating forces of sustainability competences in education, with intertwined individual, collective and technical-material components.**



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Annex 1. List of the data

The type of data	Short description of the data
Dream and nightmare school workshops	To stimulate discussions on participants' experiences regarding the enablers and constraints of sustainability education, using the Method of Empathy-Based Stories (MEBS). 31 workshops, a report from each workshop, recordings, and a total of 1745 Post-it notes reflecting who does what and why in the imagined 'dream' or 'nightmare' school of sustainability. 500 persons participated.
Based on dream and nightmare workshops, an eDelphi online discussion	All participants of the workshops were invited to this online discussion to obtain a deeper understanding of the issues addressed in the crowdsourcing workshops. Four questions, answers consisting of 7230 words. 68 persons participated.
Policy documents	100 national and local policy documents from the four project countries and 13 demonstration sites, including e.g. laws and acts, curricula, strategies, and plans.
Reports about interventions	A total of 61 interventions across 13 educational institutions in four countries were successfully implemented. From each intervention, there is a report describing the objectives, targeted sustainability competences, critical preconditions and main risks and uncertainties, links with the ECF4CLIM roadmap, implementation tasks and milestones, co-monitoring mechanisms, achieved outputs, and a final section on conclusions and lessons learnt.
Reports from teams and committees at demonstration sites (SCTs/SCCs)	Every of 13 demonstration sites had teams (SCTs) and committees (SCCs). Around 800 participants were actively involved in 89 SCTs and 33 SCCs. In the ideal case, teams and committees had 6 meetings each, but in reality, some of the meetings were combined. Reports were written from each meeting.
Interviews to selected key actors	A total of 71 interviews were conducted with individuals who had been involved in the project from the outset across the four countries.
Short surveys	Short surveys were conducted during the STCs and SCCs (569 responses), based on the themes of the meetings, and online at the demonstration sites regarding the roadmap (115 responses).
KPI data	Data on transport, green procurement, green spaces, energy, water and waste from 13 demonstration sites for KPI calculations

Annex 2. Expert comments and responses to them

The statements are organised from those with the highest level of expert agreement to those with the least. Statements that were identified by more than one expert as among the most important are **bolded**, and the two most important (according to the experts) are highlighted in **green**. In the Responses column, the modifications made based on the recommendations are described.

Comment or recommendation of experts (initial Roadmap, autumn 2022)	Response
The competences need to be developed throughout the entire curriculum and in all different academic disciplines. This is impossible without an effective commitment and coordination within the school or university in question. **School teachers tend to consider only one of the dimensions (the one closest to their own area of specialisation). Lack of interdisciplinarity in the educational system is a barrier to sustainability. The project should think about ways of overcoming this barrier.** **The idea of interdisciplinarity should be more clearly incorporated in the project.**	TMentions of different disciplines and their cooperation have been added to the subchapter Connections. In the Enablers section, some examples are provided. Inter-, multi-, and transdisciplinarity, as well as cooperation, are elaborated throughout the Roadmap – more extensively than in the initial version.
It is important to reflect and discuss about values supporting sustainability, but also about those values that support business as usual and unsustainable practices, structures, and mental models.	The subchapter Engagement places greater emphasis on this perspective than in the initial roadmap.
Achieving a perfect balance between the three classic dimensions of sustainability (environmental, economic, and social) is practically impossible. It would be better to aspire to some kind of ecotopia, which would imply a radical change of today's economic growth paradigm towards one that emphasises a new understanding of wellbeing. Throughout the document, the environmental dimension prevails over the rest (which is understandable in the situation we face), while social and economic dimensions are given less attention.	The entire chapter **Historical Perspectives on Sustainability** elaborates on this perspective. Additionally, the sections Constraints and Pedagogical Questions in the subchapters Connections and Change also contribute to it.
The definition of 'collective competences' is somewhat confusing. It is not clear if such competences refer to organisational aspects or to leadership.	We have further elaborated the definition in the subchapter **Collective Sustainability Competences**, and the Conclusions chapter also provides clarification.
It should not be assumed, as GreenComp did, that all schools can use an active methodology (although this is ideal). It is necessary to recognise the real-life limitations, notably the specific factors that constrain the possibilities of action in any given school or university.	Enablers and constraints in everyday school practices are elaborated in Chapter 5: **Four Practical Focus Areas related to Sustainability Competences Based on Interventions** and its subchapters: **Engagement, Connections, Change,** and **Action**, based on experiences from the ECF4CLIM project.

Comment or recommendation of experts (initial Roadmap, autumn 2022)	Response
The different educational contexts are sufficiently observed in the document, but only those relating to formal education. Non-formal educational contexts should also be taken into account.	We did not have non-formal intervention sites, so we couldn't focus on them. However, non-formal education and lifelong learning can still benefit from the perspectives offered in the Roadmap for Sustainability Competences, as its areas can be applied to any individual learning situation, as described in the subchapter Roadmap for Sustainability Competences as a Framework.
Future scenarios grounded in sound scientific data are essential tools for describing the impact of our actions and the means that we have available for avoiding the worst climate scenarios.	This perspective is elaborated in the sub-sections **Engagement** when discussing nature, **Connections** when addressing problems, and **Change** when exploring the future.
The proposal represents a linear idea of the way in which educational schemes operate: 'feel, think and do'. The real challenge is to adopt a more cyclical approach, moving from 'doing' to 'being'. This would also be better in line with the four pillars of education proposed by UNESCO. More competences related to evaluation and accountability should be included, to underline the cyclical nature of the process. This would also be more consistent with the idea of sustainability.	The figure of the Roadmap has been revised. The cyclical perspective is elaborated more deeply in the subchapter **Roadmap for Sustainability Competences as a Process**.
The competences should be assessed by using some of the tools defined in the document: questionnaires, environmental audits, quality assessments, surveys taking notes of the SCTs and SCCs, etc. However, they are mainly useful for measuring individual competences, whereas collective competences and environmental performance need further exploration. The best way to assess the development of competences is through contextualised indicators similar to those proposed for the SDGs.	In this Roadmap, we suggest that collective and technical-material competences can be assessed, for example, by analysing the connections discussed in the subchapter **Connections**. Environmental audits also play a central role in evaluating environmental performance. They are described in examples. We have added pedagogical questions to the subchapters of **Chapter 5**, which we hope will support the assessment of these competences.
The political dimension remains somewhat blurred; it would need greater clarity and attention.	The political dimension is elaborated further in the subchapter **Action** and in the discussion on **Advocacy**.
It would be useful to include a short historical survey of the sustainability concepts and policies (the Club of Rome report, the Brundtland report, the Rio Summit, etc.), to help individuals see and place themselves within a larger process.	A subchapter titled **Historical Perspectives on Sustainability** has been added.

Comment or recommendation of experts (initial Roadmap, autumn 2022)	Response
Basically, the document does not propose other measures than those that already exist in educational practice.	The novel approach of the Roadmap is to highlight that collective and technical-material competences are essential and should be developed – they are more than just a context for individual competences. During the project, the intervention sites developed many new practices, which are described in more detail in other deliverables of the ECF4CLIM project. Some concrete measures are also presented in this Roadmap, in the Stories sections of **Chapter 5**.
The document does not mention concrete 'measures' to strengthen the competences, but only 'tools'. It is not clear whether these are tools for the project itself or for the competences that the students should achieve and develop.	We have clarified the distinction between competences and enablers (which include tools and measures) in **Chapter 5** by restructuring the subchapters slightly compared to the initial version of the Roadmap. Concrete contextual measures are also described in the Stories sections.
The proposal should include more explicitly the problem of climate change and the loss of biodiversity as the most important crises of our times. (Sustainability is desirable, climate change is urgent.)	We have clarified this perspective in **Chapter 1, Introduction**. We also emphasise that climate change and biodiversity loss are the most significant aspects of sustainability. They are not separate concepts; rather, sustainability is a broader framework that encompasses both. This has been clarified in the first subchapters of **Chapter 2, Concepts, Theories, and Frameworks Underlying the Development of the Roadmap**.
'Environmental performance' is a term widely mentioned throughout the document, but it is hard to see the concrete competences that could be associated with this issue.	This Roadmap further develops the understanding of environmental performance and introduces the concept of technical-material sustainability competences, which is defined in the subchapter **Collective Sustainability Competences**. This concept is then applied throughout the document, with examples provided in various sections.
A dictionary or a glossary at the end of the document might be useful.	A glossary has been added at the beginning of the document.

Comment or recommendation of experts (final Roadmap, October 2025)	Response
Describe who makes up the educational community.	Description has been added in Chapter 1: Introduction.
Throughout the document, the focus is on formal education (schools and universities), though in some places "other educational institutions" and even "non-formal education" are mentioned. It might be helpful to clarify or unify the terminology.	In Chapter 1 the focus on general and higher education is clarified as being due to the data that this Roadmap is based on; in other parts of the document we have now clarified our understanding of the possibility of also applying this Roadmap to lifelong learning.
There is some imbalance between environmental and social dimensions: Although the document's approach privileges the ecological crisis (climate change and biodiversity, Figure 4), it would be worthwhile to mention more aspects of social justice, equity, or community well-being. It would also be possible to incorporate references to approaches such as "sustainability justice" or "just transition."	Social sustainability issues have now been made explicit in Chapter 2, and references have been added.
Reference to SDG goals 4 and target 4.7 + more specific GAP contents.	These are added in Chapter 2: Historical perspectives.
It can be helpful to add a subtitle for the section that includes the theories, within Chapter 2 (Concepts, Theories, and Frameworks Underlying the Development of the Roadmap).	The subtitle **Theoretical Foundations of this Roadmap** has been added to Chapter 2.
Suggestion: including a figure and/or table identifying the types of data collected and the participants involved.	The table is presented in the Annex 1. A reference to the annex was added in Chapter 3. Some details were added to the table.
Chapter 3 should end with a brief subsection that could be titled Limitations and Future Research Directions, identifying possible biases related to unequal resources and time across participating countries, cultural differences in competence interpretation, and challenges for sustaining practices after H2020 funding ends.	Subsection **Limitations and Strengths of the Methodology** Used has been added to Chapter 3. Future research directions are discussed in the concluding chapter.
In the conceptual development, one might miss an explicit reference to a critical capacity – the ability to question the system and rethink our ways of being in the world. Beyond adaptation (or seeking creative alternatives), it could also emphasise resistance and critical questioning.	Critical capacity was one of the topics discussed during the interventions. The demonstration sites found it challenging and did not consider this perspective essential for developing sustainability in schools. However, it did come up during the work with Connections. Nonetheless, additional references to critical capacity have been included in Chapter 5, which describes these challenges.
The actual form seems to be quite complex for teachers and it could be difficult for them to develop these competences in schools. The structure, use of grids, and differentiated colours are all very helpful, but the sheer amount of information can make it difficult to process everything. It might be worth simplifying or establishing clearer priorities.	We have developed a platform for the Roadmap in the MAPPA.fi service for teachers and educators. There, the Roadmap is in a user-friendly form, highlighting the main perspectives, and with tools and materials available. We have also added clarifications and further information about MAPPA.fi in Chapter 6: section **MAPPA.fi and The Roadmap for Sustainability Competences**, and in Chapter 9: **Conclusion**.

Comment or recommendation of experts (final Roadmap, October 2025)	Response
While technical competences is well justified in the document, attributing them agency comparable to that of individuals or collectives raises a critical issue.	More discussion of technical-material competences is provided in the sections **Technical-material Competences** and **Intertwined sustainability competences** in Chapter 4.
The report should acknowledge the practical problems and costs of implementing this approach in schools while mentioning that the cost of not implementing it is even bigger and it will have serious consequences.	These useful considerations have been added to Chapter 8.
In the Intertwined section, a visual figure could help enhance clarity and emphasis.	There are figures about intertwinedness both in Chapter 3, in the section **Intertwined sustainability competences**, and in the concluding Chapter 9. The figures have been revised to improve clarity.
Some tools do not seem to follow the same structure. It might be useful to classify them and explain why these particular tools were selected.	Subsections **Digital tools** and **Pedagogical tools** have been added to Chapter 6. This also removes the problem of structural difference by better addressing the differences in the content of each category of tools. A sentence has also been added explaining why these particular tools were selected.
It would be advisable to include a short Synthesis and Outlook summarising the methodological process and cross-cutting lessons; highlighting the main connections among participation, technical innovation, and environmental justice; and suggesting avenues for scaling up. It could also be valuable to include a brief conclusions section that ties back to the objectives and theoretical framework, summarising what has been achieved.	Chapter 7 has been divided into two, andone part of it moved to a new Chapter 9: **Conclusion**, and suggested perspectives were added.
The report should acknowledge the practical problems and costs of implementing this approach in schools while mentioning that the cost of not implementing it is even bigger and it will have serious consequences.	This perspective was strengthened in Chapter 9: **Conclusion**.
Future Research Directions, identifying possible biases related to unequal resources and time across participating countries, cultural differences in competence interpretation, and challenges for sustaining practices after H2020 funding ends.	These perspectives were added in Chapters 3, 7 and 9.
Multiple suggestions from external experts on recommendations.	Recommendations added to Chapter 8.

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