Empowering Educational Communities for Climate Action:

Policy Brief based on ECF4CLIM Findings

ECF4CLIM **project**

In the face of socioecological crises, sustainability competences are essential for humankind's survival. The required sustainability transformations need citizens with the knowledge, skills, and attitudes that enable effective individual action, as well as societal institutions that empower and encourage citizens and organisations to act in favour of sustainability. The acquisition of the necessary competences requires transdisciplinarity, that is, collaboration across disciplinary boundaries and between the different "social worlds" – in brief, science, policy, and society. Such competence-building can only succeed if citizens are enrolled in processes of continuous learning, dialogue, and empowerment.

Through a multidisciplinary, transdisciplinary and participatory process, ECF4CLIM develops, tests and validates a European Competence Framework (ECF) for transformational change, which will empower the educational community to take action against climate change and towards sustainable development. Notably, in ECF4CLIM, we broaden the concept of **sustainability competences** from an individual perspective to spheres of collective and technical-material competences.

ECF4CLIM is **genuinely transdisciplinary**. The project mobilises a **multidisciplinary group of academics** (educational sciences, social sciences, environmental sciences, IT sciences, engineers, etc.,) and **engages students, teachers, parents, and the wider educational community** (NGOs, citizen associations, local and regional authorities, etc.) **in fostering transformational change towards sustainable development.**

Applying an innovative hybrid participatory approach, rooted in participatory action research and citizen science, ECF4CLIM co-designs the Roadmap for Sustainability Competences in selected schools and universities, by:

- **Elaborating an initial ECF**, supported by crowdsourcing of ideas and analysis of existing ECFs.
- **Establishing the baseline of sustainability competences**, i.e., individual, collective, and technical-material competences.
- **Implementing practical, replicable and context-adapted technical, behavioural, and organisational interventions** that foster the acquisition of competences.

- **Evaluating the ability of the interventions** to strengthen sustainability competences.
- **Validating the Roadmap** for Sustainability Competences.

The proposed Roadmap for Sustainability Competences is unique in that it systematically explores individual, collective and technical material competences that enable or constrain the desired change.

The hybrid participatory process is unique in that it fosters a co-learning culture with equal voice for all educational actors. It provides a rich collaborative learning experience that bridges theory and practice while aligning diverse stakeholders' expectations around sustainability. Additionally, it facilitates new ways of collaboration between public, private and third-sector bodies; as well as innovative organisational models of engagement and action for sustainability (Sustainability Competence Teams and Committees) and a catalogue of showcase interventions.

To encourage learning-by-doing, several novel tools have been co-designed with and made available to citizens, including a digital platform for crowdsourcing, IoT solutions for real-time monitoring of selected parameters, sustainability assessment tools and a digital learning space.

Project **outcomes**

Working hand-in hand with 13 primary and secondary schools and universities in Finland, Portugal, Romania and Spain ECF4CLIM has produced a set of five relevant outcomes:

A **new conceptual framework** to understand sustainability competences that goes beyond individual competences and includes collective and technical-material competences.

A **validated Roadmap for Sustainability Competences** that builds upon GreenComp and outlines the key drivers for sustainability competences in educational practice to empower educational communities to take action against climate change and promote sustainability.

A **novel hybrid participatory approach** designed to support the work of educational communities in the co-design, co-implementation and evaluation of interventions aiming to promote sustainability competences.

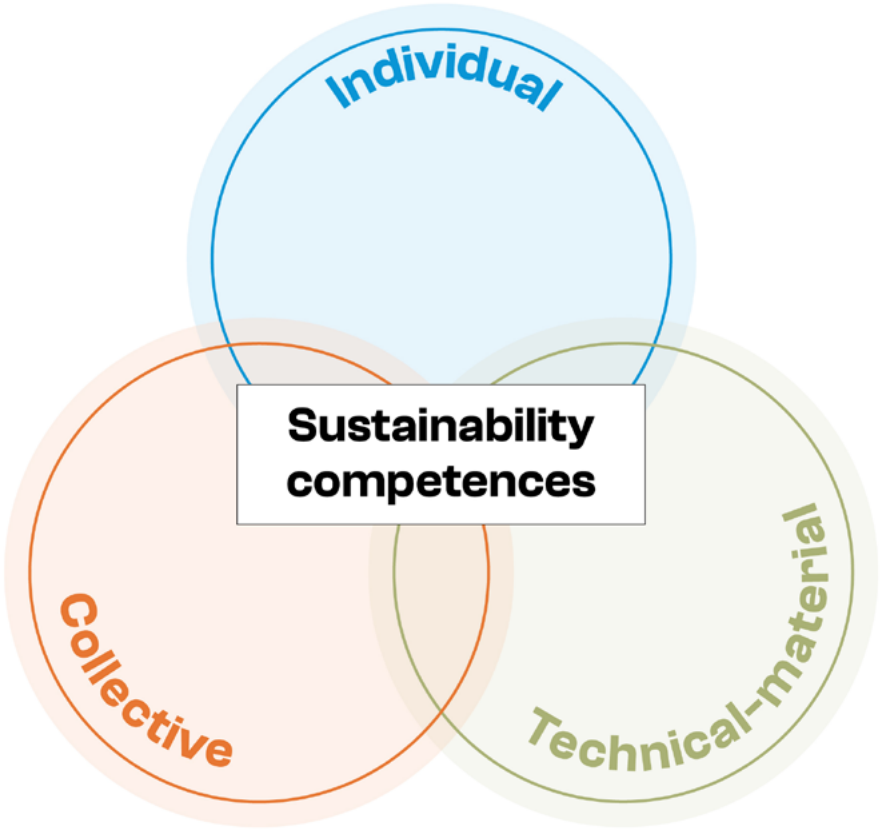
A catalogue of practical, replicable and context-adapted **showcase interventions** exemplifying successful sustainability competence-fostering practices, and providing a practical guide for their replication in other educational centres.

Various **digital tools and learning materials** designed to promote sustainability competences and support active learning through simulation, reflection and action-oriented experiences.

Outcome 1.

The conceptual framework

Traditionally, the concept of competences, and more specifically, sustainability competences, has been considered from an individual perspective. However, 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. Therefore, we expand the concept of **sustainability competences** to encompass not only individual competences, but also collective and technical-material competences.



By **individual competences,** we mean 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. In our case, these goals are promoting sustainability and planetary wellbeing.

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, individual competences are always context-specific; 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.

By **collective competences**, we refer to the capacity of an organisation to act coherently and purposefully for sustainability. An organisation's ability to act is shaped by more than just the competences of its individual members or leaders. It emerges from collective dynamics that transcend the sum of individual competences and efforts. Thus, collective sustainability competences comprise:

- **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 with authorities at different levels of governance, etc.
- **Cultural-cognitive competences**: the internalisation of regulative and normative competences as taken-for-granted social norms of normal and acceptable behaviours; the translation of regulative and normative competences into the organisation's operating culture, daily routines, habits and practices.

By **technical-material competences**, we refer to the role of tools, infrastructures, technologies and physical environments in enabling (or constraining) sustainability action. Change (like sustainability action) depends not only on people's intentions but also on how materials and infrastructures enable or constrain those intentions. Material conditions are not neutral backgrounds, but active components of what people and communities are able to do and become. Competence, in this view, is not only a matter of human or collective abilities, but also of material conditions and capabilities.

The three spheres of sustainability competences – 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. Competences in educational practices rarely emerge from one of these domains alone, rather they are generated through their dynamic interaction.

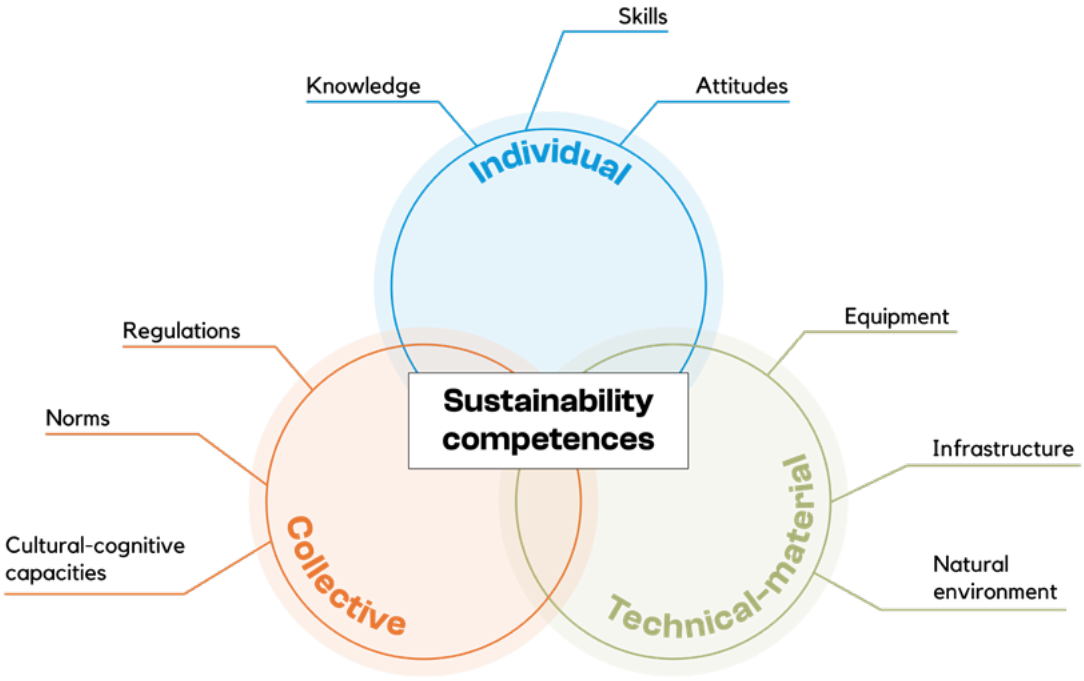


Figura 1. Overview of the three interconnected types of sustainability competences: individual, collective and technical.

Individual sustainability competences, i.e. knowledge, skills and attitudes concerning sustainability, are required when developing collective competences, or when the operational culture of a school or university evolves towards sustainability. Conversely, collective sustainability competences, such as regulations, curricula 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. Similarly, individuals and communities cannot act sustainably without considering the laws of nature and the technical and material environment. If technical-material conditions are poor, it becomes difficult for individuals or communities to make meaningful choices for sustainability. For instance, without the necessary infrastructure to enable sustainable choices, individual awareness alone

cannot minimise environmental impact. Similarly, even if regulations exist, without adequate equipment to measure environmental impact, organisations will struggle to identify the most effective ways to change their practices.

In short, what makes this framework unique is that it broadens sustainability competences beyond the individual, incorporating collective and technical-material dimensions and emphasising their deep interdependence in enabling meaningful and effective sustainability action.

Recommendations

For policy makers

- Expand the conceptualisation of sustainability competences in the current European framework of sustainability competences (GreenComp) by, besides the individual competences, incorporating collective and technical-material competences, as well as the interrelationships between them.
- Incorporate collective and technical-material competences into laws, programmes, plans and strategies in the field of education for sustainability. Ensure that curricula adequately and sufficiently cover this type of competence.
- Allocate material and human resources to schools and universities to ensure the suitability of technical-material competences: efficient and sustainable infrastructure and equipment, staffing for the proper maintenance and operation of infrastructure and equipment, and training of staff in these areas (heating, electricity, air quality, food services, waste management, transportation systems, green spaces, green procurement, etc.).
- Allocate resources, human capital, and time to schools and universities to ensure the suitability of collective competences: teaching hours to facilitate their involvement in participatory processes or other initiatives; incentives for teachers to facilitate their involvement in activities outside school hours; training for teachers in sustainability competences; provision of additional staff.

- Provide incentives and training to promote motivation, knowledge and skills among school and university leaders to facilitate the promotion of sustainability competences.
- Support research through dedicated calls and/or topics to clarify and operationalise collective and technical-material competences intertwined with individual competences.

For the educational community

- Facilitate incentives and training to promote motivation, knowledge and sustainability competences among teachers and staff at schools and universities.
- Promote cooperation networks with other educational communities, local and/or regional authorities, NGOs and universities/research centres to reinforce transdisciplinarity and strengthen collective competences.
- Include activities related to the promotion of sustainability competences in the internal rules and regulations of educational centres, as well as in their annual action programmes.
- Prioritise environmental sustainability criteria in the acquisition of equipment and infrastructure, as well as in the provision of the material resources necessary for the activity of educational centres.
- Prioritise social and economic criteria (e.g. fair trade, social and solidarity-based economy networks, avoiding labour exploitation) when acquiring equipment, infrastructure and material resources.

Outcome 2.

The Roadmap for Sustainability Competences

Traditionally, the concept of competences, and more specifically, sustainability competences, has been considered from an individual perspective. However, 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. Therefore, we expand the concept of **sustainability competences** to encompass not only individual competences, but also collective and technical-material competences.

The Roadmap for Sustainability Competences developed in the ECF4CLIM project 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.

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. Initial data was collected through crowdsourcing, and the initial roadmap was tested through our innovative hybrid participatory approach in project schools and universities. Throughout its development the Roadmap was assessed both internally and externally.

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. This idea is based on the theory of practice architectures, which suggests that

competences are formed and enacted within practice. It is also based on sociomaterialist and capability theories, which argue that material conditions are active components of what people and communities are able to do and become, rather than neutral backgrounds. Our data confirms these theoretical underpinnings: collective and technical-material competences can be developed, and they can also support the development of individual competences.

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 our project and our insights from demonstration sites, which have deepened our understanding of sustainability competences in practice. This approach ensures that the framework is grounded in real educational practices rather than being purely theoretical.

This Roadmap for Sustainability Competences elaborates on competences through four key focus areas that are important for promoting sustainability in educational practices: engagement, connections, change and action. We structure each area around individual, collective and technical-material competences in educational practice, and also describe their intertwinedness as we have found that all spheres and practical focus areas related to sustainability competences are deeply intertwined.

The Roadmap for Sustainability Competences demonstrates that 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. 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.

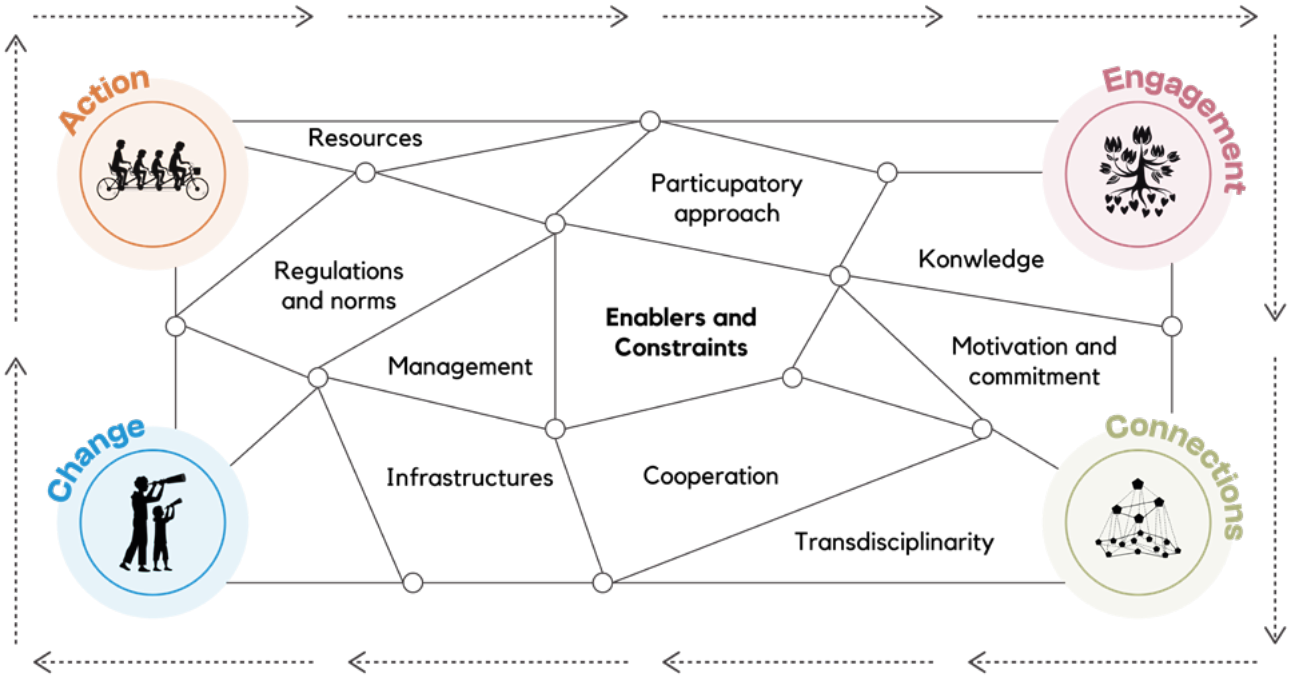


Figura 2. Roadmap for Sustainability Competences

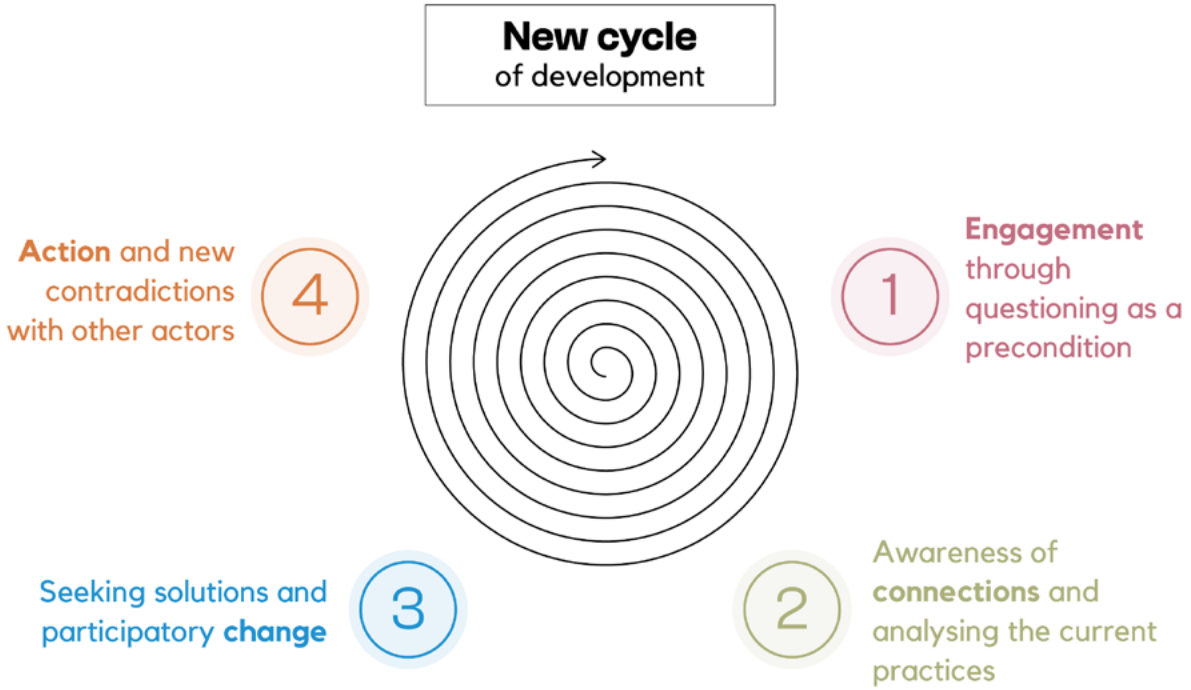


Figura 3. Spiral showing the iterative development cycle: Engagement, Connections, Change, and Action.

The Roadmap for Sustainability competences 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.

From the perspective of educational practices, this Roadmap for Sustainability Competences has potential for scaling up. The Roadmap is also 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.

In short, the Roadmap for sustainability competences, building on the European GreenComp framework, expands sustainability competences beyond the individual to include collective and technical-material dimensions, emphasizing their interconnection in practice. Developed through a transdisciplinary and participatory process across multiple European countries, the Roadmap identifies key enablers—such as management, cooperation, resources, and commitment—and offers a structured approach around four focus areas: Engagement, Connections, Change, and Action. **EC4CLIM devoted special efforts to validating the Roadmap, through both internal and external processes. Grounded in real educational practices and made accessible via the MAPPA.fi platform, it supports both the implementation and scaling up of sustainability competences in schools and universities.**

Recommendations

For policy makers

- Create a national/regional/local **Strategy and Action Plan on Education for Sustainability** that prioritises sustainability across all levels of education policy and **explicitly links educational objectives to the four dimensions** (Engagement, Connections, Change, Action) and the three competence spheres (individual, collective, technical-material) outlined in the Roadmap for Sustainability Competences.
- **Institutionalise sustainability** through norms, governance, and resource allocation. Require educational institutions to develop sustainability plans, define responsibilities, and allocate sufficient human resources (additional teachers, maintenance and support personnel), financial resources and time to implement and monitor them. Require the educational institutions to meet minimum standards in sustainability.

- **Integrate sustainability across the curriculum.** Address sustainability issues in multiple subjects and/or through the coordinated teaching of different subjects to promote systemic, interdisciplinary and critical thinking. Encourage creative, practice-based learning that connects classroom theory with real-world challenges, taking into account values and diverse interests and supporting students' creativity to discover new connections.
- Establish national and regional support mechanisms—including **training, mentoring, and professional networks**—to empower educators as agents of change. Provide clear guidance, resources, and incentives for school leaders and teachers.
- Support **research and knowledge transfer**. Facilitate cooperation between researchers and educational institutions to facilitate that new findings and technical innovations in sustainability are effectively transferred into practice.
- Encourage **data-driven monitoring**. Promote cooperation between educational institutions, local authorities, and external stakeholders in collecting and publishing data on sustainability in education to inform evidence-based decisions and track progress.

For the educational community

- **Make sustainability visible in daily practices.** Use the school environment as a learning resource—highlighting energy use, waste management, mobility impacts, and green spaces—to cultivate awareness and concrete understanding among students.
- **Provide training and support for teachers and non-academic staff.** Encourage teachers and staff to participate in training activities related to sustainability competences and technical and digital literacy.

- **Support emotional engagement and wellbeing.** Recognise the emotional dimension of learning about sustainability. Provide students with opportunities for constructive action that transforms eco-anxiety into hope and agency.
- Sustain **long-term commitment** through continuous learning and engagement of the whole educational community. View sustainability education as an evolving process embedded in the **institution's mission**. Allocate time, resources, and technical systems for ongoing reflection, measurement, and improvement.
- **Foster collaboration and networks.** Engage in partnerships with other institutions, municipalities, community actors to share practices, co-design initiatives, and amplify impact. Engage in sustainability research projects.

Outcome **3.**

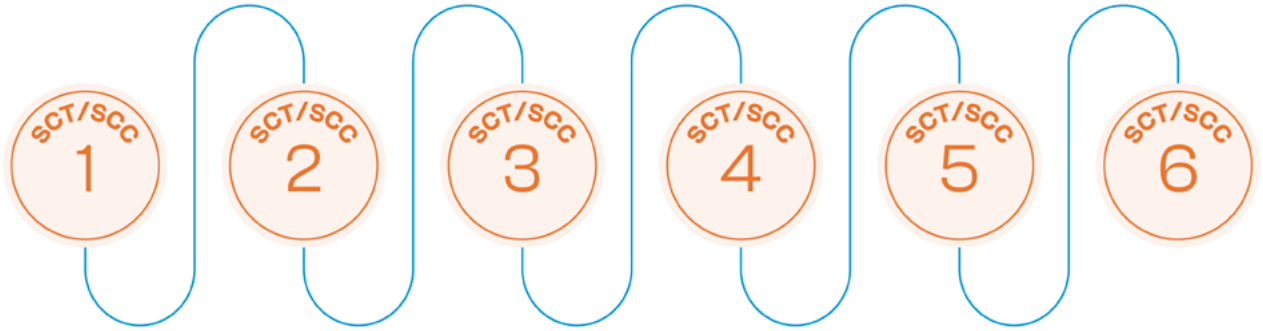
The hybrid participatory approach

The ECF4CLIM hybrid participatory approach, rooted in participatory action research and partly based on the STAVE tool (Systematic Tool for Behavioural Assumption, Validation and Exploration) **encourages students, teachers, staff and external stakeholders to work together to assess sustainability competences and reflect on the impact of actions.** By emphasising creativity, transdisciplinarity and iterative reflection, it supports transformative change and enhances institutional capacity to address sustainability challenges.

In each of our 13 Demonstration Sites (DS) in Finland, Portugal, Romania and Spain, we have established two types of innovative organisational structures: **Sustainability Competence Teams (SCTs)**, composed of students, teachers and staff, and **Sustainability Competence Committees (SCCs)**, which also include representatives from the wider education community, such as families, experts, authorities, NGOs, etc.

Each of them meets up to six times over the course of the project to encourage reflexivity and deliberation.

Over 500 students, teachers, staff and representatives from the wider educational communities at our DS are actively involved in our SCTs and SCCs (130 SCT meetings and 50 SCC meetings).



SCT/SCC session 1:

Establishing the baseline of sustainability competences at our demonstration sites (DS).

- Employing a wide range of quantitative and qualitative methods, the project establishes the initial state of play at schools and universities in terms of the individual and collective competences and the environmental performance.
- The methods include: environmental KPIs, environmental audits, short surveys, interviews, documentary analysis, and reconvened focus groups.

SCT/SCC session 2:

Co-designing interventions to foster the acquisition of competences.

- Drawing on the empirical evidence from the baseline assessment and through the participatory and deliberative process in SCT/SCC session 2, each demonstration site co-designs a tailor-made initial set of interventions to foster sustainability competences and climate action.
- The co-designed interventions include behavioural (e.g., changing habits, routines, social norms, organisational structures, etc.) and structural (e.g. small-scale retrofitting solutions, green spaces, green procurement procedures) measures.
- Out of 159, 64 interventions were selected for implementation.

SCT/SCC sessions 3 & 4:

Co-implementing practical, replicable and context-adapted interventions.

- To support the participatory implementation of our interventions, several monitoring mechanisms are in place: intervention templates (the research team, in close collaboration with the DSs, collects information on the interventions); monthly reporting; and SCT/SCC sessions 3 & 4 (to promote reflection on the interventions and gather initial evidence on the impact of the interventions on sustainability competences).

SCT/SCC sessions 5 & 6:

Participatory evaluation of the interventions and of the project as a whole.

- The theory-based stakeholder evaluation guides our evaluation approach to explore the relationships between the interventions (and the whole project) and sustainability competences.
- On the one hand, we analyse the expected and observed outcomes of the intervention (and of the whole project), and on the other hand, the expected and observed relationships between the intervention (and the whole project) and its outcomes.

The ECF4CLIM experience shows that the hybrid participatory process fosters a culture of co-learning by establishing new relationships among students, teachers, and external participants, encouraging mutual exchange and collaboration. It strengthens teamwork through joint planning, decision-making, and implementation, while ensuring inclusive and empowering participation that gives everyone a voice. Learning becomes more active and engaging, helping participants develop a deeper, more holistic understanding of sustainability and see how small actions contribute to broader environmental goals. At the same time, it bridges the gap between theoretical knowledge and real-world application, making learning meaningful, practical, and impactful. The iterative nature of the process enables the development of long-term sustainability projects that extend beyond isolated, one-off actions.

Overall, the participatory approach - bringing together students, teachers, staff, and external actors in shared planning and decision-making - was highly effective in catalysing self-reflection, deliberation and co-learning, effectively turning evaluation into a competence-building process. As with the Roadmap, ECF4CLIM devoted particular attention to evaluating the quality

of the participatory approach, in terms of both processes and outcomes. This was achieved through dedicated SCT/SCC sessions and short surveys conducted after each participatory initiative in our schools and universities.

Recommendations

For policy makers

- Develop policies that promote **equitable and socially inclusive sustainability transitions** in education, involving the entire educational community.
- Promote the **hybrid participatory methods** proposed in this project at different levels of decision-making and policy processes to foster sustainability competences within educational communities.
- **Recognise and institutionalise participatory governance models**. Encourage the formal creation of Sustainability Competence Teams and Committees or other kinds of organizational models for sustainability within educational institutions and include them into their governance structures.
- **Allocate resources** for the creation and maintenance of these organisational models for sustainability in educational institutions.
- Develop policies that support the **evaluation of participatory processes**. Allocate resources and guidance to assess the quality of both the process and the outcomes of participatory initiatives and processes.
- Support **research** to promote the development and implementation of evaluation theories and methods through dedicated calls and topics.

For the educational community

- Promote **inclusive and participatory governance**. Encourage decision-making processes that involve teachers, students, families, and local communities.
- **Promote and institutionalise participatory routines** (e.g., annual SCT/SCC cycles). Allocate time, foster recognition for educators and students, and resource facilitation/ coordination to keep reflective evaluation feasible and impactful. Facilitate systemic integration and adequate support.
- **Empower students as active sustainability actors.** Create spaces for student-led initiatives, workshops, and projects where they can contribute to sustainability proposals, participate in decision-making, and promote inclusion and non-discrimination.
- **Build participatory and inclusive school cultures.** Involve all community members—teachers, students, administrative staff, and local stakeholders—in co-designing and co-implementing sustainability action plans to foster a sense of shared ownership and collective responsibility.
- **Prioritise participatory processes** and allocate time and resources for their organisation, implementation and evaluation. Make timetables more flexible and allocate spaces.

Outcome **4.**

Catalogue of interventions

Through our innovative hybrid participatory process, involving Sustainability Competence Teams (SCTs) and Committees (SCCs), the ECF4CLIM project has co-designed, co-implemented and co-evaluated a high number of sustainability interventions to foster sustainability competences in our demonstration sites: **13 schools and universities from four EU countries over three school terms. A total of 159 interventions were initially designed, of which 87 were selected for implementation. Ultimately, 64 interventions were implemented during the project lifetime.**

In close collaboration with the demonstration sites, we identified and selected a set of showcase interventions that exemplify successful practices in fostering sustainability competences. This selection was made using a combination of qualitative and strategic criteria. These included their impact on the educational community, their potential for replication in other contexts and how well they covered the four dimensions of the Roadmap for Sustainability Competences (Engagement, Connections, Change and Action) and the three competence spheres defined in the ECF4CLIM conceptual framework (individual, collective and technical-material competences).

This selection of practical, replicable and context-adapted interventions for the promotion of sustainability competences in the educational community aims to provide a practical guide for replicating the sustainability measures developed by the ECF4CLIM project in other educational centres.

The selected interventions address a wide variety of sustainability-related topics, ranging from energy and water consumption and food production to the installation of solar panels and water sensors, the organisation of second-hand clothing markets and the provision of better canteen food, including vegetarian options and the sale of surplus food. Community gardens and green spaces were also created with student participation, and university courses and modules dedicated to ecological transition and climate justice were launched. In terms of waste management, weekly flag systems were employed, and competitions were held between

classes to encourage recycling, combining gamification with environmental awareness. Other interventions focused specifically on awareness campaigns, escape room games and the use of digital tools, such as WhatsApp groups, to reinforce communication. Educational talks and campaigns covered topics such as fast fashion, cycling, plant-based diets and nature-based activities, often supported by materials created by students and social media accounts managed by the school. New curricular units were also introduced to strengthen interdisciplinary learning, and dedicated teaching materials and cross-cutting learning spaces were designed to explore sustainability from diverse academic angles. Finally, educational visits provided hands-on experience of local environmental issues, reinforcing students' sense of responsibility.

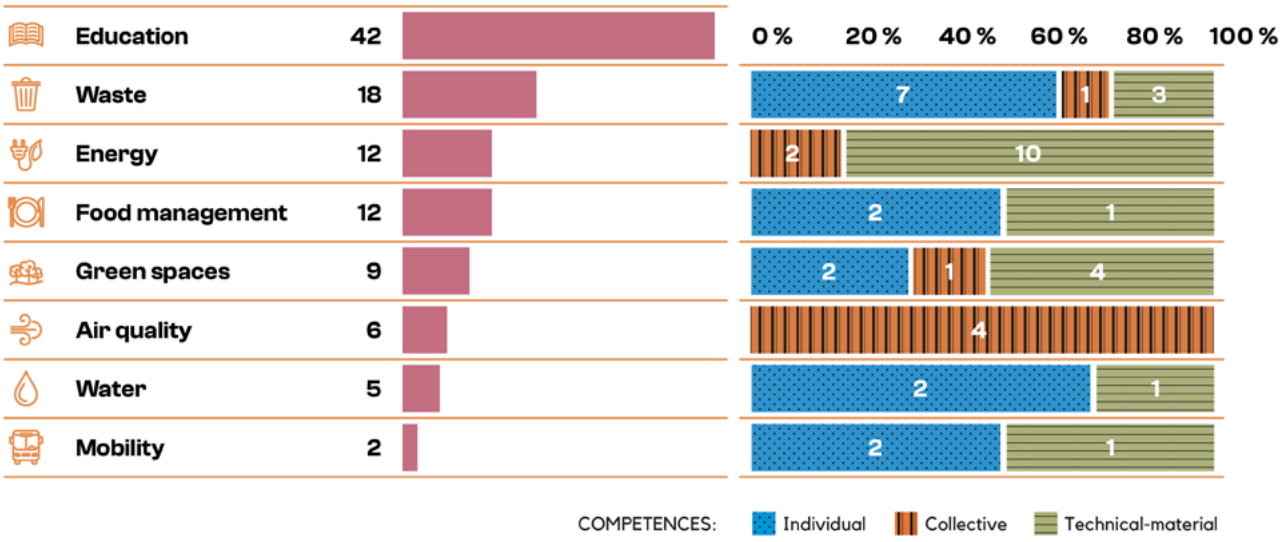


Figura 4. Classification of measures selected by main topic and ECF4CLIM Analytical Framework spheres

Monitoring these interventions involved various methods and tools, such as the Sustainability Competence Teams and Committees meetings, the intervention templates, and a monthly reporting procedure. This reflective, iterative and systematic follow-up approach enabled a deeper understanding of the practicalities of the different interventions, including their goals, tasks, milestones, outputs as well as the associated challenges and opportunities.

In short, the ECF4CLIM project co-designed, implemented, and evaluated a high number of interventions across 13 schools and universities in four EU countries. Selected interventions, covering topics from energy and water management to sustainable food, waste reduction, green spaces, and ecological education, were chosen for their impact, replicability, and alignment with the Roadmap's four dimensions—Engagement, Connections, Change, and Action—and the three competence spheres: individual, collective, and technical-material.

Systematic monitoring, evaluation and reflective follow-up allowed the project to assess practical outcomes, challenges, and opportunities, providing a replicable guide for fostering sustainability competences in other educational communities.

Recommendations

For policy makers

- Provide sufficient **financial support** for the co-design, co-implementation and co-evaluation of sustainability projects, ensuring equity and inclusiveness. Ensure that all types of schools and universities, including those with fewer resources or located in rural or disadvantaged areas, have access to funding and resources.
- Facilitate **knowledge exchange and replication**. Support networks and platforms where schools and universities can share their sustainability interventions, results, and best practices. Promote the use of the Roadmap for Sustainability Competences, tools and interventions as models for replication across regions and countries.
- Develop **evaluation frameworks and indicators**. Provide institutions with clear guidance and flexible methodologies for monitoring the outcomes of sustainability interventions. Encourage the use of evaluation approaches that combine qualitative reflection—for example, through the hybrid participatory method developed in ECF4CLIM—with quantitative indicators - such as the Environmental Footprint Calculator or the Sustainability Intervention Evaluation Tool.
- Provide sufficient **technical, financial, administrative and institutional support** for the implementation of technical and infrastructural interventions in educational settings, such as the installation of solar panels or water monitoring systems.

For the educational community

- **Plan and allocate time** for participatory learning creating time within the school schedule for students, teachers and staff to engage in interventions. Embrace reflection and adaptability, discussing both successes and challenges and refining interventions and adapting them to changing local needs and resources.
- Embed sustainability in everyday practice. Integrate **sustainability interventions into teaching activities, and school management** using the ECF4CLIM catalogue of interventions as adaptable models for local implementation.
- Encourage **cooperation across disciplines and between teachers, students, and local communities**. Working together on concrete sustainability interventions strengthens collective and technical-material competences while enhancing also individual competences.
- Facilitate the collection of **consistent data** and the definition of **meaningful indicators**, and make these visible to the educational community. **Assess progress** driven by interventions across diverse dimensions of engagement, connections, change and action, as well as the three spheres of individual, collective and technical material competence.

Outcome 5.

Tools and learning materials

As part of the ECF4CLIM project, **we have developed digital tools and learning materials designed to promote sustainability competences and support active learning through simulation, reflection and action-oriented experiences.** These include an Environmental Footprint Calculator tailored for educational communities, a Retrofitting Toolkit for assessing building energy efficiency, a Sustainability Intervention Evaluation Tool for improving sustainability competences at educational settings, and an IoT Ecosystem for acquiring indoor air quality and energy consumption data. All of these tools are hosted on the project's digital platform.

The project has also developed pedagogical tools to provide teachers and educators with resources to promote sustainability in their teaching, including Flipbooks and a Learning Game. These resources were co-designed with the educational communities at our demonstration sites in response to emerging pedagogical needs, and were used throughout the project. Serving as both learning tools and diagnostic instruments, they provide a practical mechanism for implementing the competence-based approach to sustainability education set out in the Roadmap for Sustainability Competences.

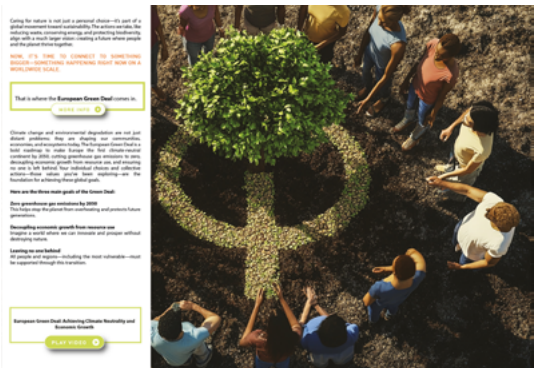
All the tools can be adapted for different educational levels and used in both formal and non-formal educational contexts, as well as for lifelong learning. These resources are also hosted on the project's digital platform.

The digital tools developed in the ECF4CLIM integrate data collection, self-assessment, and participatory learning features within a unified digital ecosystem, enabling schools and universities to analyse their sustainability practices, plan improvements, and engage their communities in meaningful action.

A particularly distinctive feature is the Environmental Footprint Calculator, which has been specifically adapted to the characteristics and needs of educational centres and educational communities. This tool allows institutions to measure and understand their environmental impact, beyond climate change impacts, through parameters directly linked to school

operations—such as energy consumption, mobility, waste management, and resource use—making it both an educational and decision-making instrument. Complementing it, the Sustainability Intervention Evaluation Tool enables schools to assess their performance and to evaluate the effects of sustainability interventions across a series of environmental KPIs (energy, waste, green procurement, green spaces, transport, water), providing evidence-based insights into the outcomes of their actions. In addition, the Retrofitting Toolkit supports the technical and infrastructural transformation of educational buildings by helping institutions identify, plan, and implement improvement measures that enhance energy efficiency, reduce environmental impact, and align with broader sustainability goals. It bridges the gap between pedagogical practices and the technical material environment, reinforcing the Roadmap's approach to sustainability competences.

In addition to these digital tools, **the interactive flipbooks and the learning game foster the pedagogical and motivational dimensions of sustainability education.** Both make explicit reference to the Roadmap for Sustainability Competences, helping educators and students understand and apply its principles in practice. They also include concrete examples of sustainability interventions carried out within the project, which serve as inspiration and practical guidance for implementing the Roadmap in other educational institutions. The flipbooks present complex sustainability concepts in an engaging, visual, and accessible way, while the learning game promotes active engagement and collaboration among students, enabling them to internalise sustainability competences through experiential and playful learning.



Overall, these tools stand out for their integration of educational, organisational, and technical dimensions: they function not only as learning materials but also as instruments for institutional transformation. Developed collaboratively with educators, students, and technical partners, they ensure pedagogical relevance, usability, and adaptability across diverse European contexts. In line with the overall evaluation strategy of the ECF4CLIM project, the tools and learning space underwent several internal and external validation processes.

Recommendations

For policy makers

- **Integrate digital sustainability assessment tools into national education curricula**. Recognise tools such as environmental footprint calculators and retrofitting simulators as valuable resources for developing sustainability competences at individual, collective and technical-material level, and include them in teaching recommendations and textbooks.
- **Support teacher training and professional development:** Allocate funding and design continuous learning programmes for educators to use these digital resources effectively.
- Create **long-term support mechanisms.** Encourage partnerships between ministries, regional governments, research projects and providers of educational materials to ensure that digital learning tools are maintained and updated beyond the project lifecycle.
- Foster **evidence-based policy**: Fund research and pilot programmes to monitor and evaluate the impact of digital sustainability assessment tools on the development of individual, collective and technical-material competences.

For the educational community

- Integrate tools into **real-life learning projects:** Use the tools in project-based learning to connect classroom activities with actual school/university sustainability interventions.
- Promote **collaborative learning and reflection**: Encourage students, teachers and school/university managers to jointly analyse sustainability data and reflect on possible interventions to improve sustainability competences at individual, collective and technical-material level.

- Build **local learning networks:** Share experiences and results with other institutions to create communities of practice around digital sustainability assessment tools.
- Promote **digital and sustainability competences simultaneously**: Leverage the IoT Ecosystem and digital resources to enhance both digital literacy and sustainability competences.
- Provide educators with the **time and institutional support** they need to incorporate these digital resources into their teaching.

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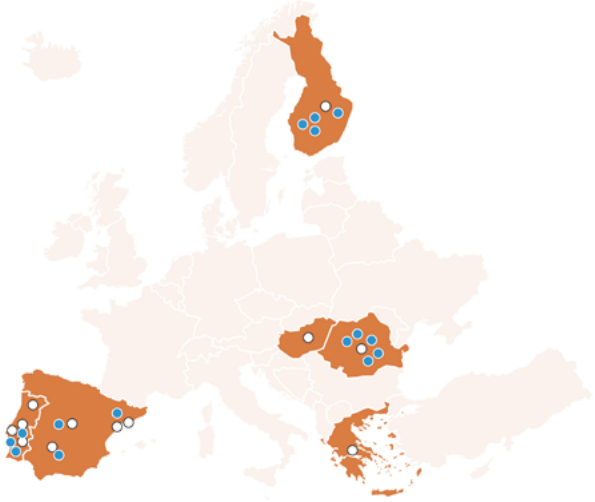

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