D6.2
Evaluation of the individual competences

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WHO WE ARE

The ECF consortium consists of 10 partners. The project is coordinated by Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT).

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Universidad de Sevilla **USE**	SP	
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ABOUT THE PROJECT

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.

Applying a novel hybrid participatory approach, rooted in participatory action research and citizen science, ECF4CLIM co-designs the ECF in selected schools and universities, by: 1) elaborating an initial ECF, supported by crowdsourcing of ideas and analysis of existing ECFs; 2) establishing the baseline of individual and collective competences, as well as environmental performance indicators; 3) implementing practical, replicable and context adapted technical, behavioral, and organizational interventions that foster the acquisition of competences; 4) evaluating the ability of the interventions to strengthen sustainability competences and environmental performance; and 5) validating the ECF.

The proposed ECF is unique in that it encompasses the interacting STEM (Science, Technology, Engineering, and Mathematics)-related, digital and social competences, and systematically explores individual, organizational and institutional factors that enable or constrain the desired change. The novel hybrid participatory approach provides the broad educational community with: an ECF adaptable to a range of settings; new ways of collaboration between public, private and third-sector bodies; and innovative organizational models of engagement and action for sustainability (Sustainability Competence Teams and Committees).

To encourage learning-by-doing, several novel tools will be co-designed with and made available to citizens, including a digital platform for crowdsourcing, IoT solutions for real-time monitoring of selected parameters, and a digital learning space. Participation of various SMEs in the consortium maximizes the broad adoption and applicability of the ECF for the required transformational change towards sustainability.

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1. EXECUTIVE SUMMARY

Purpose and Objectives

Deliverable D6.2, *"Evaluation of the Individual Competences,"* assesses the current status of sustainability competences among individuals in the ECF4CLIM project's Demonstration Sites (DS): 13 schools, high schools and universities from four European countries. To this end, we rely both on the initial version of our Roadmap for Sustainability Education and on our Analytical Framework for sustainability competences.

We define i**ndividual competences** as the '*development of a combination of personal qualities and qualifications', that is, the knowledge, skills, and attitudes that individuals need in order to achieve certain goals through their actions and activities'* (Vare, 2022). In our case, such goals are *promoting sustainability and planetary wellbeing* (JYU, Wisdom community 2021). In the ECF4CLIM project, these competences refer to personal qualities and abilities and constitute one of the three spheres of our Analytical Framework for sustainability competences. This framework comprises individual, collective, and technical-material competences, as well as their interactions. Thus, we assume that personal qualities and abilities for sustainability develop within specific collective and technical-material contexts, which can either stimulate or constrain an individual's capacity to act.

The objectives of D6.2 are threefold: (1) exploring the status of individual sustainability competences at this stage of the project; (2) generating empirical evidence to validate and elaborate the initial roadmap (by examining the individual competences originally proposed and their roles as enablers or constraints); (3) encouraging self-reflection and deliberation on these competences and their role in transformative change.

Ultimately, this deliverable contributes to the project's overarching goal of refining and validating the European Competence Framework (ECF) for transformational change in education, ensuring it is grounded in evidence from practice.

Methodology

Our innovative hybrid participatory approach comprises a variety of tools and methods, both qualitative and quantitative, such as reconvened focus groups, short surveys, deliberative workshops or interviews. Quantitative strands provided descriptive statistics and cross-tabs to contextualise roles and participation. Qualitative material (role-play and workshop notes, interviews, open survey answers, SCT and SCC outputs) underwent reflexive thematic analysis (Braun & Clarke, 2021). Integration of strands allowed us to identify convergences/divergences across actor groups and competence dimensions.

Thus, our empirical evidence was generated through:

→ **Intervention monitoring templates**, capturing each intervention's focus (which sphere(s) it targeted) and its success/failure factors **(n= 59 interventions).**

- **Short post-intervention self-assessment surveys** (10-point Likert scales plus open questions) to prompt individual reflection on changes in knowledge, skills, attitudes and behaviours **(n= 568 participants)**.
- **Brief post-intervention deliberative workshops** (≈30 minutes; two core reflection questions) to stimulate group deliberation **(n= 403 participants).**
- **Sustainability Competence Teams (SCT) and Sustainability Competence Committees (SCC)** sessions 5 & 6. In SCT/SCC5, a role-play method was used to surface drivers and barriers from multiple actor standpoints. In SCT6, Problem Structuring Methods (PSM) supported whole-project reflection and prioritisation of contributions **(n= 49 meetings; 423 participants).**
- **Semi-structured interviews** with selected key actors (two protocols: adults/students) organised in five thematic blocks (engagement, expectations, technical-material, individual, collective competences) **(n= 71 participants).**
- **Observational protocols** ensured contextualisation and supported transferability/ adaptation across DS.

Our innovative hybrid participatory approach was implemented to maximise self-reflection, contextual richness and triangulation, while explicitly acknowledging non-representative samples, self-report bias, contextual heterogeneity, time constraints, and membership changes.

Results

How important is it to improve individual competences for our DS?

Our comprehensive analysis of the intervention templates shows that 76% of the 59 interventions intentionally targeted individual competences (often combined with collective ones). Moreover, 57 out of 59 interventions (97%) explicitly connected their outcomes—positive or negative—to individual knowledge, skills, attitudes or motivation. Individual competences are therefore central levers—and frequent bottlenecks—of success, justifying their prioritisation in future work.

How does our evidence relate to the individual competences suggested in the initial roadmap?

Our systematic analysis of SCT/SCC meetings and interviews across the four-roadmap dimensions largely validates the originally proposed individual competences while extending them with empirically emergent ones:

- **Engagement.** The need for basic sustainability knowledge, inclusive value reflection and dialogue skills is confirmed. Evidence extends the set with personal passion and role-modelling, motivation & empathy, and detailed cooperation/micro-planning by leadership as decisive to mobilise communities—especially when formal knowledge or mandates are weak.
- **Connections.** The roadmap's focus on recognising complexity, mapping current practices and questioning assumptions is strongly supported. Practice reveals the salience of systems thinking, collaboration & project-management, social influence competences, and lifecycle

foresight (anticipating end-of-life, rebound effects, and post-school chain consequences) to convert insight into durable governance (e.g., maintenance plans, responsibility matrices).

- **Visions.** Individual and collective visioning worked when paired with concrete, resourced implementation paths. Four new competences emerge in this dimension: boundary-spanning leadership (uniting students, staff, parents, authorities), politically/culturally neutral framing to avoid polarisation, logistical micro-planning & governance to institutionalise routines, and capacity-building for all actors to prevent collapse due to know-how gaps.
- **Action.** Leadership, teamwork, strategy and resource awareness remain core, but evidence targets them with the importance of communication infrastructures, technical maintenance/problem-solving skills, and emotional resilience & well-being to sustain momentum. Actions endured when competences were distributed, not concentrated in a single champion, and when the coordination, the training and the monitoring plans were explicit.

How does our evidence relate to the drivers/barriers suggested in the initial roadmap?

Our data confirm the roadmap's core proposition: the very same competence is a driver when present and a barrier when absent. In **Engagement,** dialogue/facilitation skills, basic sustainability knowledge and inclusive value reflection enabled mobilisation, whereas inadequate social skills, weak role-modelling by educators, distrust of research and competing academic/consumerist priorities undermined it. In **Connections,** systems thinking, lifecycle foresight, collaborative project management and social-influence competences translated insight into durable routines, while simplistic framings, techno-optimism/pessimism and unexamined assumptions ("students don't care") blocked progress. In **Visions,** boundary-spanning leadership, neutral framing, logistical micro-planning and broad capacity-building countered denial of responsibility, creativity blocks and narrow ownership. In **Action**, distributed leadership, communication/monitoring infrastructures, technical maintenance know-how and attention to well-being mitigated overload, time pressure and single-champion dependency.

Are individual competences actor-dependent?

Yes, clearly. **Students** most visibly strengthened agency, teamwork, social influence and practical problem-solving, often exporting behaviours to households (recycling, water/energy saving). **Teachers** consolidated pedagogical, interdisciplinary and facilitation competences, creating inclusive reflective spaces and integrating sustainability into curricula**. Principals/leaders** provided the critical competence of strategic, boundary-spanning leadership, aligning resources, partners and policy frames. **Technical/administrative staff** supplied continuity and operational know-how that anchored technical-material change. **Parents/external actors** occasionally acted as amplifiers—or dampeners—of school efforts, depending on alignment with values and incentives. Projects over-reliant on a single champion (of any role) proved fragile; distributed competence and leadership correlated with continuity.

Evidence on change

According to our comprehensive database on individual competences, participants most often

self-reported gains in knowledge and attitudes, with many citing behavioural spillovers at home (e.g., recycling, turning off lights, water saving). They also described enhanced critical reflection, collaboration, planning/coordination and systems awareness. However, these findings are perception-based, non-representative and context-dependent, and thus cannot be generalised statistically. We mitigated this through triangulation (intervention templates, role-plays, interviews, SCT6 outputs).

A reflection on gender

Participation was frequently female-skewed, but the evidence base is insufficient to draw robust, generalizable conclusions on gendered differences in competences. Although the wider literature often reports higher pro-environmental concern and engagement among women, our data are non-representative, perception-based, and confounded by role distributions (e.g., more female teachers) and social desirability bias, so we neither confirm nor refute those patterns here. Any gender signal observed is scattered and role-specific, and we therefore refrain from making systematic claims.

How effective is the hybrid participatory approach?

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. Participants widely appreciated the culture of co-learning it fostered. Students felt motivated and valued, while teachers found students' input inspiring and thought-provoking. Time pressure, curricular rigidity and turnover repeatedly constrained participation, underscoring the need to institutionalise participatory routines (e.g., annual SCT/SCC cycles), protect time/recognition for educators and students, and resource facilitation/coordination to keep reflective evaluation feasible and impactful. Overall, while the participatory process proved highly valuable, its long-term impact depends on systemic integration and adequate support.

Conclusions

D6.2 provides a comprehensive evaluation of individual sustainability competences within the ECF4CLIM project, affirming the initial framework and offering insights for refinement. Individual competences have emerged as central factors influencing transformational change in educational institutions. While validating the roadmap's core competences, the evaluation suggests enhancements including passion-driven engagement, deeper systems thinking, and cross-boundary leadership. Competence development is context-specific and depends on actors (students, educators, leaders, staff) collaboratively exercising unique skills, underscoring the need for holistic empowerment strategies within educational communities.

The success of D6.2's participatory approach highlights the value of continued reflective stakeholder engagement, suggesting potential institutionalization through sustainability competences teams or committees (or other participatory structures) for ongoing improvement. Our evidence indicates that sustainability competences grow through active engagement, practice, and reflection in supportive environments. Deliverable 6.2 thus serves as a practical guide for educators, administrators, and policymakers to foster human factors essential for sustainability. It also helps the ECF4CLIM team complete and share a Competence

Framework based on real experiences, encouraging collective action on climate change.

Practical implications

- → A robust database of individual competences for sustainability across different EU educational communities, ready for further exploitation in future research.
- → An efficient, hybrid, participatory approach to promote sustainability competences within educational communities, ready for implementation in further educational institutions.
- → A validated analytical framework for conceptualising sustainability competences that could be useful for future research within educational communities.
- → A series of specific recommendations for all members of the educational community who wish to further understand and enhance sustainability competences.

Students and educators, when equipped with knowledge, skills, and motivation, and supported by their peers and environment, can indeed become agents of change. Importantly, we also saw why some changes took root while others remained tentative – reinforcing the idea that individual, collective, and technical factors must progress in unison. Where a piece was missing (say, enthusiastic individuals but no institutional follow-up, or new equipment but little engagement), the change was fragile. A major takeaway is that educational transformation for sustainability is not automatic nor effortless: it requires intentional cultivation of competences and careful attention to context and constraints

2. DEFINING INDIVIDUAL COMPETENCES FOR SUSTAINABILITY

→ Sustainability competences in GreenComp

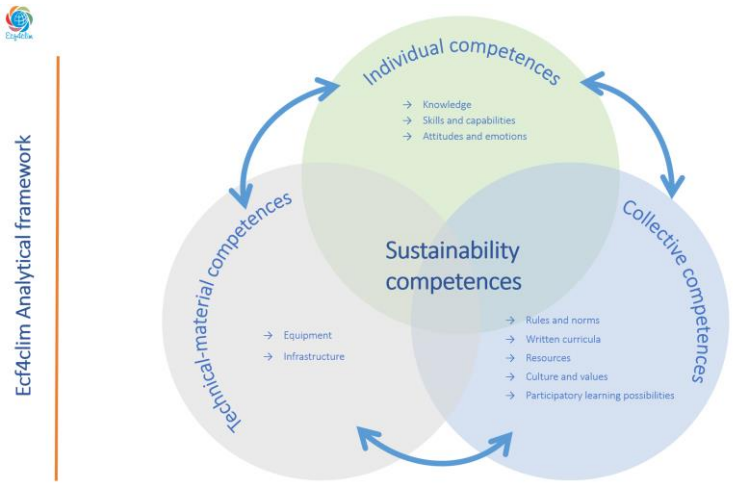
Following the European Sustainability Competence Framework (GreenComp) (Bianchi et al., 2022), '*a **sustainability competence** empowers learners to embody sustainability values, and embrace complex systems, in order to take or request action that restores and maintains ecosystem health and enhances justice, generating visions for sustainable futures. This definition focuses on developing sustainability knowledge, skills and attitudes for learners so they can think, plan and act with sustainability in mind, to live in tune with the planet'.*

According to their authors, GreenComp is designed *for learners* of all ages and education levels, in any learning setting – whether formal, non-formal or informal. Its aim is to foster a *sustainability mind-set* by helping users develop the *knowledge, skills, and attitudes* needed to think, plan, and act with empathy, responsibility, and care for our planet.

→ Sustainability competences in ECF4CLIM

In ECF4CLIM, we expand upon the definition of sustainability competence as *'as an ability to act in an appropriate way to achieve sustainability goals successfully and efficiently*'.

Furthermore, we assume that achieving sustainability goals requires the ability to act in three interconnected spheres: the individual, the collective and the technical-material. We assume that change cannot happen without collective action, which requires **individual, collective, and technical-material competences**. To effect transformative change, we must consider these three spheres and how they interact with each other. In other words, we believe that action depends on more than just mind-set.



→ Individual competences in ECF4CLIM

From this analytical framework, we define i**ndividual competences** as the '*development of a combination of personal qualities and qualifications', that is, the knowledge, skills, and attitudes that individuals need in order to achieve certain goals through their actions and activities'* (Vare,

2022). In our case, such goals are *promoting sustainability and planetary wellbeing* (JYU, Wisdom community 2021).

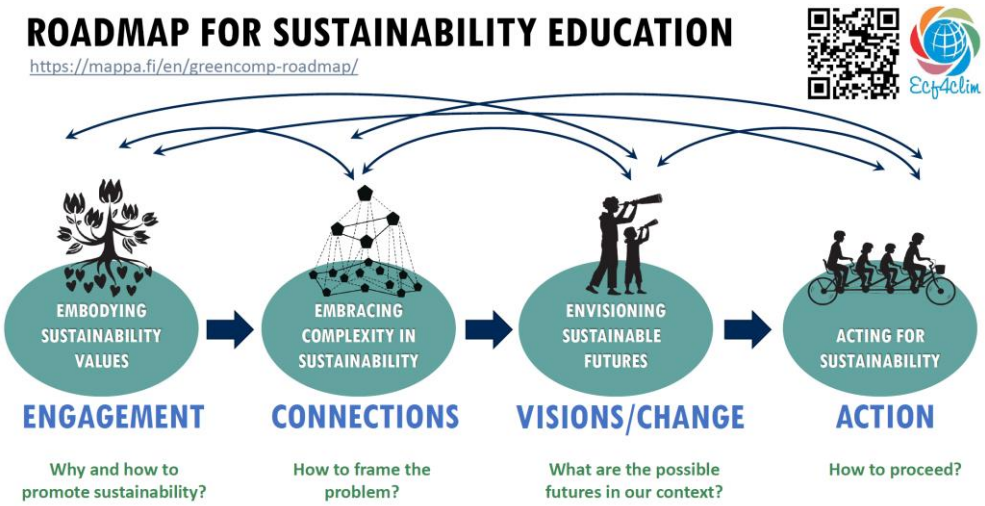
Thus, individual competences refer to ***individuals' personal qualities and abilities,*** *and constitute* ***one of the three spheres in our roadmap towards sustainability***. These personal qualities and abilities develop (or otherwise) within specific collective and technical-material contexts which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

Encouraging reflection and deliberation on these spheres and their interactions has been a key project objective, from the co-design of the interventions through to their co-monitoring and participatory evaluation.

→ Individual competences in our initial roadmap

Our initial roadmap covers aspects of the individual competences considered essential for promoting sustainability and climate mitigation actions in education. It highlights the important role of the entire educational system in fostering environments that encourage individual and collective learning and engagement with sustainability. As mentioned previously, we assume that change is not possible without collective action.

Next, we will outline how our initial roadmap set out **the individual competences that the educational community should foster in order to promote sustainability and climate mitigation actions.** We set out the suggested competences for each area in the roadmap: Engagement, Connections, Vision/Change and Action.

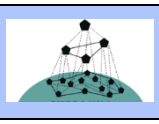


- **Engagement:** the successful promotion of sustainability demands prioritisation and collaboration. Thus, the core question is how to enhance understanding and reflection on the meaning of sustainability, and how to engage the community in promoting it together. The table below illustrates the kinds of individual competences that the educational communities need to promote engagement.

	**Individual competences in the initial roadmap** **Dimension 1. Engagement**
Engagement through a participatory process	- Knowledge about the varying motivators, meanings and values related to sustainability - Skills of promoting engagement - Criticism and resistance are relevant for the collective process - Experience the satisfaction of knowing that your experiences and opinions are relevant.
Sustainability knowledge as common grounds for discussion	- Minimum basic knowledge on sustainability - Caring attitudes and empathy to nature and the planet - Systemic knowledge about natural environments among all involved actors - Understanding the normative nature of sustainability science (how thigs should be) - Skills of dialogue - Awareness on the several goals and values of sustainability
Inclusive value reflection and dialogue	- Personal reflection on which aspects of sustainability are important and which values are relevant to you - Prioritizing of sustainability values - Educators with pedagogical competence for facilitating inclusive sustainable value reflection with their students

- **Connections:** at schools and other educational institutions everyday life flows through separate situations. The holistic nature of the issues makes them hard to grasp. Without recognising the connections and underlying assumptions, the root causes cannot be identified and the problems cannot be framed satisfactorily. Understanding the different perspectives on sustainability is also important, as is recognising how our context and cultural background shape our perception of these issues and our knowledge of them.

The table below illustrates the kind of individual competences that the educational communities need to advance in terms of connections.

	**Individual competences in the initial roadmap** **Dimension 2. Connections**
Complexity and root causes of environmental impacts	- Understanding how environmental challenges are interconnected with economic activities, culture, and environmental and educational policies at various levels of governance - Understanding the connections between different disciplines - Lifecycle thinking to identify the root causes of environmental impact at personal, community and cultural levels
Underlying assumptions	- Critical assessment of personal thinking to reveal false assumptions not backed up by evidence. - Critical reflection on personal cognitive patterns and mapping individual worldviews (linked with value reflection in Step 1)
Current state of practice	- Mapping individual and contextual unsustainable behaviours. - Skills to recognize different kinds of sustainability problems in everyday life. - Knowledge of possible solutions and the impact of potential changes at a systemic level.

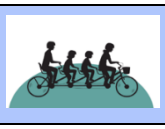
- **Visions:** without a vision, we are driven to reinforce current unsustainable practices and ways of thinking, acting and reacting. Creating a more sustainable collective reality requires us to work together to identify and map the alternatives available to us. We need to unleash our creative and intuitive faculties to see things differently, unlearn unsustainable practices and learn how to create things that do not yet exist.

The table below illustrates the kinds of individual competences that educational communities require to advance in terms of visions and change.

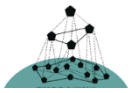
	**Individual competences in the initial roadmap** **Dimension 3. Visions**
Visioning preferred and presumable futures and short-term scenarios	- Individual understanding of how the future lies in our common hands - Critical reflection on how to realize the visions of a sustainable future in one's own life and in the community - Collective visioning to promote individuals' will to act in a more sustainable way
Promoting cognitive, emotional & behavioural adaptability	- Acknowledge that thinking about future can evoke uncomfortable feelings (eco-anxiety and ambiguity) that are individual and need to be encountered in a supportive and safe atmosphere - Knowledge about possible ways to reduce harmful environmental impacts and foster desirable change in society - Facing inconvenient facts about future and realising the scale of changes needed in one's personal life can be stressful.
Exploration through creative & relational knowing	- Creativity and intuitiveness for encountering the wicked sustainability issues. - Creating novel solutions to novel wicked problems - Transdisciplinary knowledge and systems understanding

- **Action:** our success depends on our ability to 'walk the talk'. Acting for sustainability in a school or other organisation involves individual initiatives from students, teachers and other staff. However, change is not possible without collective action. If we want to promote societal change through education, educational organisations must have political and societal influence. At all levels, we need both individual and collective competences. While acting, we should also consider the environmental performance and impact of our actions.

The table below illustrates the kind of individual competences needed to advance in terms of action.

	**Individual competences in the initial roadmap** **Dimension 4. Action**
Structures for change	- Leadership: crucial role of principals and other staff - Leaders' knowledge, skills and attitudes to prioritize different values and goals of education - Leaders, teachers and students' skills in promoting ecological sustainability - Acknowledging or creating regulations
Creating strategy & action plan	- knowledge about the environment and systems to create suitable strategies - Skills of teamwork to design of the most effective actions - Engagement of all actors in the planning work & learning process
Resources for change	- Personal resources define what kind of individual initiatives one can undertake - Knowing one's own potential and limits - Well-being, positive emotional atmosphere - Further training

Moreover, the initial roadmap also illustrates how individual competences can either facilitate or hinder transformational change and it does so for each area: engagement, connections, vision/change, and action. The table below illustrates how our initial roadmap outlines **the role of individual competences as either constraints or enablers of the desired transformational change**.

Individual competences as …		
	Constraints	**Enablers**
ENGAGEMENT 	- Strong negative attitudes to sustainability - Disregard for research-based knowledge - Inadequate social skills	- Dialogue and listening skills - Basic ecological knowledge - Facilitation skills for inclusive value reflection among students and staff
CONNECTIONS 	- Simplistic view of solving environmental problems - Inadequate education on ecosystems - Too optimistic or too pessimistic attitude towards technological solutions	- Knowledge about complex intertwined systems - Skills to assess critically own and cultural assumptions - Positive attitude towards the work of framing the problem
VISIONS 	- Lack of understanding of visioning's value - Personal blocks to creativity - Resistance to creative processes - Denial of responsibility and relevance	- Intra- and interpersonal competences - Belief in shared futures ("Future is in our common hands") - Encouraging creativity - Willingness to act for sustainability
ACTION 	- Overload and time pressure - Competing personal priorities - Lack of peer support	- Leadership knowledge on sustainability - Personal well-being and resources - Ongoing training to enhance competences

3. OBJECTIVES

Following the second review of the project, and in light of the challenges associated with participatory action research in our educational communities, the approach to evaluating individual competences was redefined. As outlined in the second project review, the evaluation of individual competences in ECF4CLIM has been significantly impacted by the limitations of data collection at our Demonstration Sites (DS). Maintaining full control over the sampling and data collection procedures, especially at the individual level, was not possible, and the time available for data collection was very limited. There have also been numerous changes to the membership of our Sustainability Competence Teams (SCTs) and Committees (SCCs) throughout the project.

Therefore, rather than evaluating against the baseline of individual competences established in Work Package 4 (WP4), we will focus on the current state of these competences. To this end, we will use both the initial version of the roadmap and our analytical framework. It should be noted that neither of these conceptual frameworks was available when the baseline was set up.

These are therefore the refined objectives for evaluating individual competences.

- → Explore the **status of individual competences** at our DS at the current stage of the project.
- → Generate **empirical evidence to validate the initial roadmap** by considering both the originally suggested individual competences and their potential roles as constraints and/or enablers.
- → Promote **self-reflection and deliberation on individual competences for sustainability** and on their roles within our educational communities.

4. METHODOLOGY

Following the suggestions by the reviewers in the first reporting period, new tools and methods have been incorporated into our hybrid participatory approach to improve the quality of the evidence on individual competences for sustainability at our DS. In line with the principles of participatory action research, our aim is to engender self-reflection, which in turn fosters the potential for the transformative changes we aim to generate. The focus is therefore on developing tools that stimulate thinking and self-reflection on sustainability competences at our DS. We assume that individuals are not passive subjects but active actors in the research process and in drawing conclusions from what they learn.

The new practical and applicable tools and methods to promote self-reflection and transformative change incorporated into our hybrid participatory approach combine interviews with selected members of the educational community, short self-assessment surveys and deliberative workshops, and observational protocols, supported by a variety of templates and guidance. These tools and methods prioritise qualitative research and encourage a precise description of the context, as suggested by the reviewers. The combination of methods and tools ensures a well-rounded evaluation process.

4.1. Methods and tools

Next, we describe the set of methods and tools to promote self-reflection on individual competences for sustainability at our DS:

- → Ad-hoc designed **tool for the monitoring of the interventions** (intervention templates).[1]
- → **Short surveys & deliberative workshops**.
- → **Hybrid participatory process**: Sustainability Competence Teams and Committees (SCT/SCC) (sessions 5 and 6).
- → **Interviews** with key selected actors.

a) Intervention templates

WP5 developed an intervention template to collect information about the interventions and their evaluation[2] and each research team worked closely with our educational communities to fill in the template for each intervention at each DS. The template included an introduction providing a brief description of the analytical framework — the three spheres of sustainability competences and how they are intertwined. The intervention template is exhaustive, encompassing general data, focus, success factors, links with the roadmap, task descriptions, milestones, and outputs. The intervention templates also include guidance and notes to help the research teams and DS complete them.

Our analysis of individual competences is based on data collected in the ´focus´ and ´success' factors sections, as outlined below.

[1] See D5.1 and D5.2 for more details on the intervention templates.

→ Focus of the interventions:

The 'focus" helps to collect data on both the nature of the intervention (whether individual, collective or technical-material) and on its objectives (whether it aims to enhance individual, collective or technical-material/environmental competences).

Focus: nature & objectives	
Nature of the intervention	* technical (equipment or modification of infrastructure) * involving individual action * requiring collective action.
Short description of the objectives	* individual competences: knowledge, skills and capabilities, attitudes and emotions * collective competences: rules & norms, written curricula, resources, culture & values, participatory learing possibilities * environmental performance: equipment & infraestructure

The template provides guidance on how to consider the potential interactions between the nature of a given intervention and its objectives. For example, it highlights that a 'technical' intervention may primarily aim to raise awareness and improve skills and knowledge, or enhance the community's capacity to act, in the individual or collective spheres.

→ Success factors:

'Success' refers to the critical preconditions for a successful intervention. Here we collect data on the sustainability competences that should be in place for the intervention to deliver its objectives.

It comprises both the preconditions for success and for failure.

Success factors": the critical preconditions for a successful intervention	Which collective and individual competences, as well as environmental/technical elements, need to be in place, for the intervention to deliver its stated objectives?
	In other words, and conversely, which are the main risks and uncertainties? Please try to think which are the critical factors whose absence can lead to the failure of the intervention.

Data on the focus of the interventions and the related success factors will help us to achieve **objective 1** (exploring the status of individual competences) and **objective 2** (generating evidence to support the validation of the initial roadmap).

b) Short survey & deliberative workshops

→ Short survey

This survey is intended as a quick and easy self-assessment tool to help participants evaluate the impact of the intervention on their sustainability competences. All participants involved in the intervention completed the survey once it was over.

The survey used a combination of ten-point Likert scales and open questions to encourage self-reflection on the effect (if any) of the intervention on one's individual competences. Participants were asked to provide an overall evaluation of the intervention, followed by specific questions on their knowledge, skills, attitudes and behaviours, and whether these had changed as a result of their involvement in the intervention. Participants were invited to illustrate their answers with specific examples. The survey concluded with an open question where participants could raise any additional issues. The short survey is included in Annex A.

→ Brief deliberative workshop

The purpose of this tool is to encourage collective reflection and discussion about the effect of interventions on sustainability competences. It is a focus group discussion lasting no more than half an hour. The moderator launches a debate and encourages participation in answering the following two questions:

- What did you take away from this experience/intervention (what surprised you the most, what caught your attention, what did you learn, what moved you?), and why?
- Once you return home or to school, based on your experience here, would you change anything, or do anything differently? What and why?

Participants first reflected on each question individually, then shared their opinions and experiences with the group for about 10 minutes.

Data from the short survey and the deliberative workshops will help us to achieve **objective 1** (exploring the status of individual competences) and **objective 2** (generating evidence to support the validation of the initial roadmap).

c) Hybrid participatory approach: SCT and SCC meetings 5 and 6

Sessions 5 of our Sustainability Competence Teams and Committees focus on the evaluation of a set of selected interventions, while sessions 6 focus on the evaluation of the whole project. Next, we summarise the tools and methods used in these sessions with particular attention to those that provide empirical evidence for evaluating individual competences.

→ Sustainability Competence Teams Session 5 (SCT5)

Sustainability Competence Team Session 5

- Welcome (5 min.)
- Presentation of the 1-2 interventions (15 min.)
- Facilitated group discussion (role-play) on the intervention(s) (40 min.)
- Final discussion on key questions (20 min.)
- Farewell and next steps (5 min.)

In preparation for SCT5, each DS collaborated closely with the research team to select one or two interventions for in-depth evaluation. Ideally, these interventions were chosen to address at least two of the three competence dimensions: individual, collective, and technical-material (or environmental).

Once the research team presented the selected interventions, participants took part in a role-play exercise. The role-play method was based on crowdsourcing workshops conducted at the beginning of the ECF4CLIM project, as well as on the Method of Empathy-Based Stories (MEBS; Wallin et al., 2019), which was applied during those workshops. The central questions of learning—who, why, what, and how (Engeström, 2001)—also guided the planning of the method, as learning is central to transformational change. Role-play is commonly used in education to enhance learning (Fu & Li, 2025), and in this case, we applied it as a tool for data collection. From the perspective of their chosen role, and considering the responsibilities

associated with it, participants argued which factors contributed to the success or failure of the intervention. The method help participants articulate concrete insights into the constraints and opportunities encountered during the intervention. It also ensured active engagement from all participants, as each role offered a unique perspective that needed to be heard

At the end of the session, participants engage in a plenary discussion addressing for key questions: why the intervention did or did not achieve its objectives; how and why there were unexpected outcomes; what surprises or lessons emerged; and how the intervention could be redesigned from scratch. Participants shared their personal views, noting areas of agreement and disagreement.

→ Sustainability Competence Committee Session 5 (SCC5)

Sustainability Competence Committees Session 5

- Welcome (5 min.)
- Presentation of the 1-2 interventions (15 min.)
- SCT5 results presentation: role-playing exercise (10 min.)
- Debate: Individual reflection from the "real" role (20 min.)
- SCT5 results presentation: evaluation questions (10 min.)
- Debate: Collective reflection towards success (20 min.)
- Farewell and next steps (10 min.)

In SCC5, the wider education community in each DS engages in evaluating the interventions.

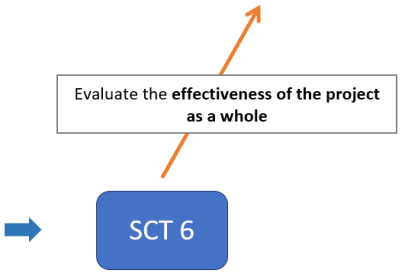
The research team presented the key findings from the SCT5 session with a particular focus on failure and success factors, and the responsibilities of the various stakeholders. The moderator then invited each participant to reflect on their personal roles and responsibilities in light of the SCT5 outcomes, as well as any other aspects they wished to add. A summary of the SCT5 responses to the four evaluation questions (objectives achieved, unexpected outcomes, surprises/learnings and visions for redesign) then formed the basis of a group debate on how to improve the interventions and identify other contextual factors that could drive change in their institutions.

Simple **observational protocols** were designed to promote contextualisation, facilitate transferability and, if necessary, enable adaptation of the methods and tools (Lynch, 2002).

Data from the role-play will help us to achieve **objective 2** (generating evidence to support the validation of the initial roadmap).

→ Sustainability Competence Team Session 6 (SCT6)

As mentioned above, SCT6 focus on the evaluation of ECF4clim as whole. To this end, after an overview of the main outputs of the project by the research teams at each DS, participants engage in reflection and deliberation on both the outcomes and the process of ECF4CLIM.



Part of the debate focus on evaluating the outputs of our hybrid participatory approach and, more precisely, on whether it was successful in enhancing self/reflection and deliberation on sustainability competences, indeed including individual competences. Using Problem Structuring Methods (PSM), participants individually identified the main contributions of ECF4CLIM originating from the hybrid participatory process and then engage on a debate to prioritize its main contributions.

Data from SCT6 will help us to achieve **objective 3** (promoting self-reflection and deliberation on sustainability competences).

d) Interviews with key actors

To deepen our understanding of individual competences and encourage further reflection within our educational communities, we designed an interview protocol to be used with three to five representatives from each DS who had been involved in the project from the outset.

We designed two interview protocols: one for adult participants (secondary and university students, teachers, school staff, school management, etc.) and one for primary school students. Both protocols are based on our analytical framework and initial roadmap, and consist of open-ended questions (20 for adults and 10 for children), as well as three background questions concerning the date, the participants' roles in the project, and their gender. The following five topic areas were explored in all interviews: engagement, expectations, technical-material competences, individual competences and collective competences. Interview protocols are included in Annex B.

Data from the interviews will help us to achieve **objective 2 (**evidence to support the validation of the initial roadmap) and **objective 3** (promoting self-reflection and deliberation on sustainability competences).

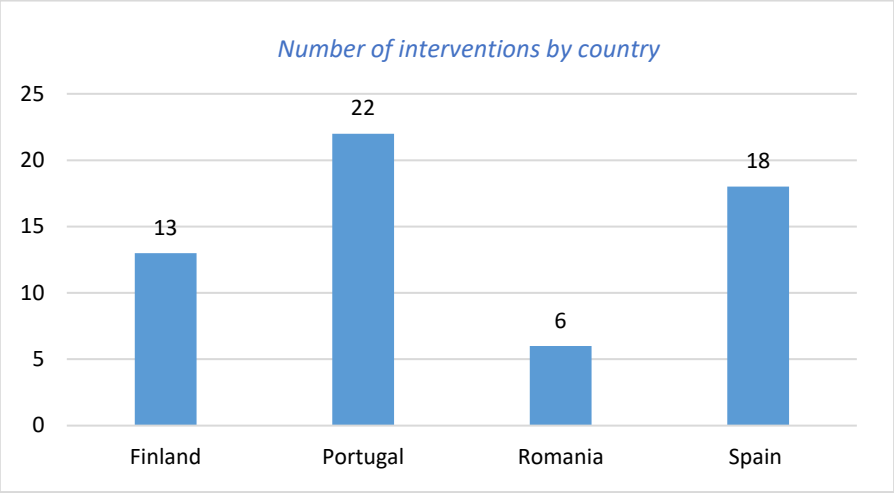
In conclusion, we must acknowledge that the proposed data collection methods and tools were adapted according to the specific characteristics of each educational community and research team, such as available time and resources, experience with social research methods or preferences for qualitative versus quantitative approaches. Thus, to promote self-reflection and deliberation, some of our DS found that deliberative workshops were much more efficient than short surveys, and vice versa. Some countries organised a single SCC, while others had two or three. Flexibility lies at the heart of our participatory approach and this has indeed an impact on the nature of the empirical evidence. This must be recognised.

4.2. Samples

This section presents the various samples utilized within the methods and tools implemented to promote self-reflection on personal competences for sustainability in our DS.

→ Interventions templates (n=59 interventions)

A total of **59 intervention templates** from completed or ongoing projects were analysed. The following table shows how these interventions are distributed by country.



→ Short surveys & deliberative workshops (n= 971 participants)

The evidence from the short surveys and deliberative workshops is based on the analysis of responses from **568 participants** who completed the short surveys and around **403 participants** who took part in the deliberative workshops. These tools were used to evaluate 48 of the aforementioned interventions.

→ Sustainability Competence Teams and Committees 5 & 6 (n= 423 participants)

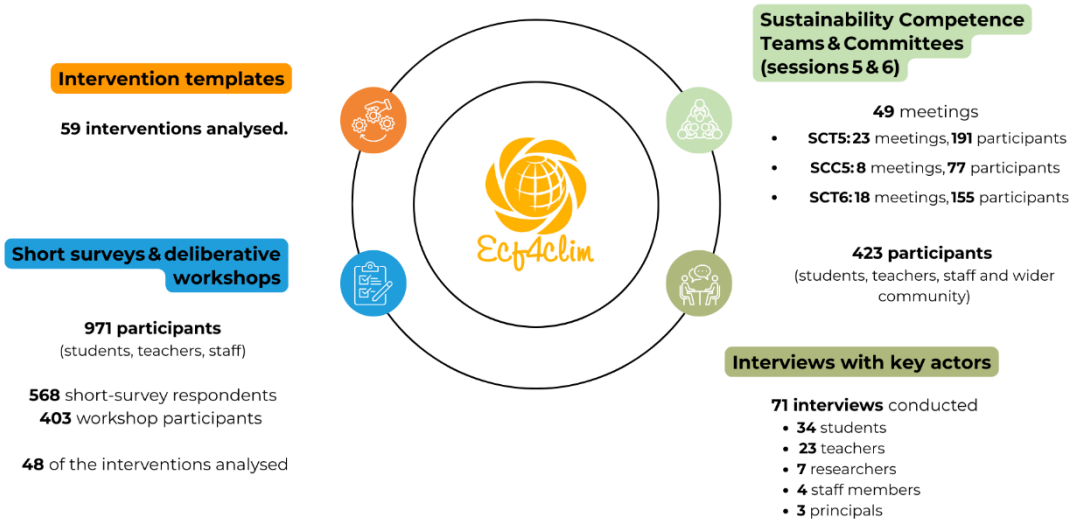
A total of **49 meetings** of Sustainability Competence Teams (sessions 5 and 6) and Sustainability Competence Committees (session 5) have been held at the different DS, involving a total of **423 participants** (including students, teachers, staff and other members of the wider educational community). The following table shows how many meetings were held in each SCT and SCC session, and how many people participated in each one.

	Meetings	*Participants*
SCT5	23	191
SCC5	8	77
SCT6	18	155
TOTAL	**49**	**423**

→ Interviews with key actors (n= 71 participants)

A total of **71 interviews** were conducted with individuals who had been involved in the project from the outset across the four countries. In particular, 34 students, 23 teachers, 7 researchers, 4 members of staff, and 3 principals have been interviewed in our DS.

In summary, and as illustrated in the following figure, we employed a variety of methods and tools to evaluate individual competences for sustainability at our DS, engaging a substantial number of participants from the wider educational communities.



4.3. Data analysis

A mixed-methods design was used to examine evidence on individual competences. On the quantitative side, descriptive statistics, simple frequency counts, and cross-tabulations of background variables were used to identify participant roles and help contextualize the qualitative findings (Creswell & Plano Clark, 2018). For the qualitative part, reflexive thematic analysis followed Braun and Clarke's flexible, iterative process: careful reading of transcripts, open coding of meaningful segments, and refining and naming themes through analytic memo writing and peer discussions (Braun & Clarke, 2021).

Combining the numerical overview with the emerging themes allowed direct comparison of common patterns across subgroups and highlighted differences, which increased the credibility of the analysis (Johnson & Onwuegbuzie, 2004; Sandelowski, 2000). Rigor was ensured through a clear audit trail, regular dialogue among researchers, and explicit acknowledgment of sampling limitations or interpretation challenges in relevant sections.

5. RESULTS

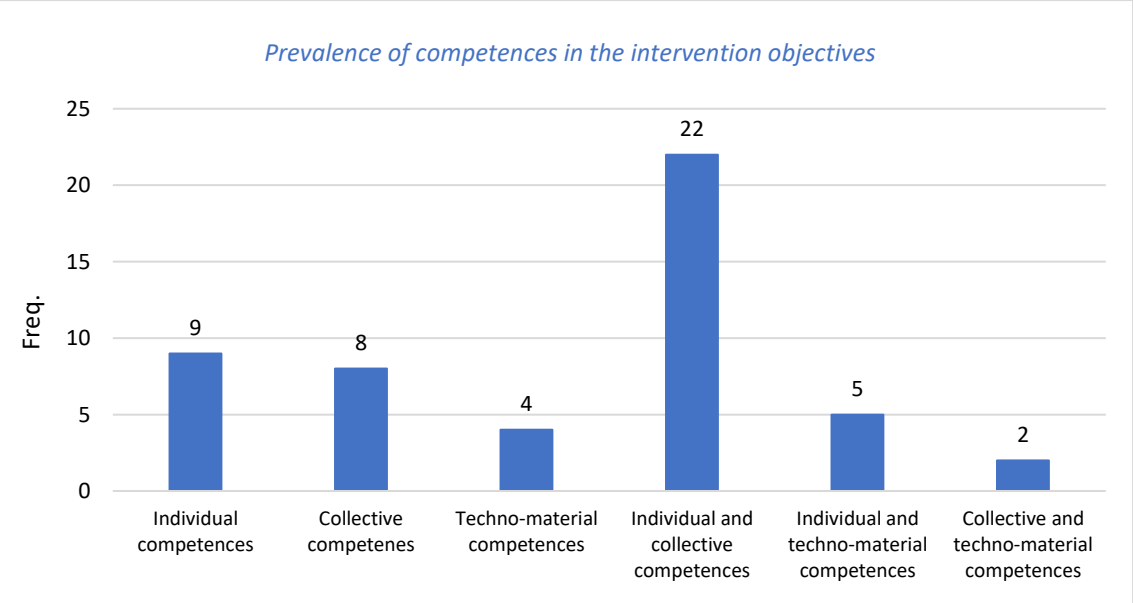
This section presents the evidence gathered through our hybrid participatory approach relating to individual competences in our DS. First, we consider the importance of these competences for our DS. Secondly, we examine how the evidence on individual competences aligns with that suggested in the initial roadmap. Thirdly, we analyse how our evidence indicates whether individual competences act as success or failure factors for sustainability, comparing this with

the suggested enablers and constraints in the initial roadmap. Fourthly, we explore whether our empirical evidence suggests that individual competences are actor-dependent. Fifth, we reflect on the gender-specific findings. Finally, we analyse how individual competences have evolved throughout the project and the effectiveness of the hybrid participatory approach.

5.1. How important is it to improve individual competences for our DS?

The first step in monitoring the interventions at our DS was to identify the objectives of each intervention (using an ad hoc monitoring tool). The research team collaborated closely with DS representatives to deliberate and reflect on the specific objectives of each intervention.

Of the 59 interventions, evidence shows that 45 (76%) include individual competences in their objectives. Twenty-two interventions aimed to impact a combination of individual and collective competences (37%). Nine interventions targeted only individual competences (15%), while nine others incorporated all three competence areas (individual, collective, and techno-material) into their objectives (15%). Eight interventions focused solely on collective competences (14%), five on a combination of individual and techno-material competences (9%), and four on only techno-material competences (7%). Interventions combining collective and techno-material competences were less frequent, accounting for just 3% of interventions.



These results demonstrate the prevalence of interventions integrating both individual and collective competences, followed by those focusing solely on individual competences.

5.2. How does our evidence relate to the individual competences suggested in the initial roadmap?

The roadmap outlines a four-dimension journey: Engagement, Connections, Visions, and Action, each of which requires specific individual competences. In this section, **we explore how the evidence on individual competences** gathered through our hybrid participatory approach **aligns with those suggested in the initial roadmap.**

As detailed in the 'Methodology' section, during sessions 5 of the SCTs and SCCs, each DS collaborated closely with the research team to select one or two interventions for in-depth evaluation. They then engaged in a role-play to stimulate reflection and collective deliberation on the impact of the interventions on sustainability competences at the different DS. The method helps participants articulate concrete insights into the constraints and opportunities encountered during the intervention. It also ensured active engagement from all participants, as each role offered a unique perspective that needed to be heard.

The evidence presented in this section originates from data collected at the role-play. It is essential to bear in mind the specific nature of this evidence. There are no direct quotations as data was collected through observational protocols and data collection protocols along the role-play exercises. The research teams prepared reports for each SCT/SCC5 session at all the DS, based on the researchers' detailed notes and a template provided by the task leader. Notably, as the role-play focused on evaluating a selected number of interventions, the evidence relates to those interventions only, not to the full range of interventions at each DS. Pseudonymisation codes are used to ensure that data protection requirements are met.

Engagement

The initial roadmap highlights that individuals need the competence to **actively engage stakeholders through a participatory process and build shared understanding** about sustainability. Basic knowledge on sustainability is important for informing discussions and credible advocacy. Without factual understanding of the issues, engagement efforts lack substance. Finally, an **attitudinal openness to reflection on values** is crucial. Individuals must be willing to examine their own beliefs and priorities regarding sustainability.

	**Individual competences in the initial roadmap** **Dimension 1. Engagement**
Engagement through a participatory process	- Knowledge about the varying motivators, meanings and values related to sustainability - Skills of promoting engagement - Criticism and resistance are relevant for the collective process - Experience the satisfaction of knowing that your experiences and opinions are relevant
Sustainability knowledge as common grounds for discussion	- Minimum basic knowledge on sustainability - Caring attitudes and empathy to nature and the planet - Systemic knowledge about natural environments among all involved actors - Understanding the normative nature of sustainability science (how thigs should be) - Skills of dialogue - Awareness on the several goals and values of sustainability
Inclusive value reflection and dialogue	- Personal reflection on which aspects of sustainability are important and which values are relevant to you - Prioritizing of sustainability values - Educators with pedagogical competence for facilitating inclusive sustainable value reflection with their students

We will now present our evidence relating to these competences. While the data provides useful evidence to either support or further elaborate most of the suggested competences, it is important to acknowledge that we could not find relevant examples for some of them. These are highlighted in grey in the above table.

Engagement through a participatory approach

Knowledge about the varying motivators, meanings and values related to sustainability

Participants in P04-LG observed strong intrinsic enthusiasm for their garden, signalling that direct contact with nature can be a powerful driver of engagement. Participants in P04-LT reported similarly high levels of student enthusiasm and active participation. In P01-LA, participants noted that informal peer conversations fostered positive attitudes towards sustainability actions, although also in P01-LA, students' prioritization of consumerist values demonstrated the barriers that arise when intrinsic motivators are misaligned with sustainability values. Taken together, these findings support the assumption in the roadmap that motivation is heterogeneous. Intrinsic curiosity, collective excitement and informal peer influence all act as enablers. The findings also suggest that motivation is an attitude competency whose strength determines whether it accelerates or slows down early engagement.

Skills of promoting engagement

Participants at P02-LQ highlighted enhanced student skills in knowledge assimilation and planning, while participants at P02-LR acknowledged gains in collaboration, planning and coordination. Participants at P04-LT suggested that teachers effectively fostered these skills, underlining the educator's facilitative role. 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 are essential. Participants' experiences showed that without good facilitation, initial engagement faltered.

Experience the satisfaction of knowing that your experiences and opinions are relevant

An important nuance noted in several DS was the collective experience that each individual's voice really mattered and contributed positively to long-term commitment when sufficiently recognized and validated. The P02-LQ, in particular, showed across all roles that commitment and feeling recognized mattered in the way that parents perceived the values that their children taught them, or in the way that external actors implicated themselves in the project. Participants at P01-LA reported that many students enjoyed the highly visible vegan-tasting days, providing immediate feedback that their ideas mattered. At P04-LT participants highlighted that distributing eco-bags for recycling extended students' influence into households, while participants at P02-LR noted practical benefits such as shorter cleaning times due to neater student behaviour.

Sustainability knowledge as a common ground for discussion

Minimum basic knowledge on sustainability

Participants at P02-LW, reported that the solar-energy lessons laid new foundations, giving students first-hand familiarity with solar photovoltaic technology and day-to-day energy

production. Participants at P04-LT acknowledged that students gained substantial practical knowledge and skills about sustainability and renewable energy, describing whole-class exploration of recycling cycles and local power sources. Meanwhile, participants at P03-LO highlighted that teachers provided educational materials to increase student awareness about environmental significance, distributing age-adapted guides and short video explanations across year groups. Across these three centres, the statements underscore that a clear, shared baseline of facts is essential to promote engagement.

Caring attitudes and empathy to nature and the planet

Participants at P02-LQ observed that students adopted proactive attitudes toward sustainable resource use, recounting classroom pledges to turn off lights and reduce water waste. Participants at P02-LR reported increased positive awareness and behaviours toward resource saving and environmental responsibility, noting frequent peer reminders about closing taps and collecting litter after breaks. Participants at P01-LA noted that students appreciated belonging to the school's environmental team, providing an opportunity to discuss sensitive environmental issues comfortably. They described lunchtime gatherings where members exchanged personal stories about choosing vegetarian options or cycling to school. Similarly, at P04-LG, the school garden elicited genuine personal investment in living plants, while in P03-LO school the seedling-tending routine transformed the abstract duty of stewardship into a tangible, daily responsibility that young learners willingly embraced. Our findings illustrate how students in various DS adopted positive attitudes and reported increased awareness, fostering a personal and proactive connection to sustainability

Systemic knowledge about natural environments among all involved actors

Participants at P02-LQ suggested that the intervention provided a replicable model aligned with the school's sustainability goals, outlining how technical staff, teachers and students jointly monitored electricity output and savings. Participants at P02-LY reported an improved ability to critically analyse complex situations, draw connections and understand diverse perspectives, citing class discussions that linked waste streams, urban planning and climate legislation. Participants at P01-LK noted that the existing curriculum enables integrating sustainability effectively into individual subjects and courses, mentioning geography lessons on carbon budgets and economics assignments on circular business models. Participants at P02-LW highlighted that solar panels provided valuable infrastructure upgrade, lowering the school's environmental impact and serving as a model for other institutions, detailing energy dashboards placed in corridors so every visitor could follow production in real time. The interventions emphasised the importance of sharing systematic knowledge among students, teachers and technical staff to enhance sustainability efforts through collaborative understanding and action.

Skills of dialogue

Participants at P04-LT highlighted that the Youth Parliament initiative created platforms for student-led discussions and activities on sustainability, noting plenary debates where pupils proposed cafeteria waste-reduction motions. Participants at P01-LA noted that belonging to the school's environmental team offered students a comfortable space to discuss sensitive environmental issues, describing circle-time techniques and peer-facilitated reflection cards.

Participants at P04-LG suggested that creative promotion 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.

Inclusive value reflection and dialogue

Personal reflection on important sustainability aspects

Participants at P02-LY reported that their course provoked critical reflections on community interactions and collective actions, fostering deeper awareness of social norms and their impacts, indicating that lectures and workshops deliberately encouraged students to examine how everyday choices influence wider society. In contrast, participants at P01-LA observed the presence of student groups prioritising expensive fashion items over sustainability, noting casual conversations in corridors about popular brands and limited-edition trainers. At P02-LW, individuals who openly examined their own beliefs about education and sustainability created an atmosphere of trust and inclusion. Their reflective approach showed how self-questioning can lead to wider engagement. By contrast, P04-LG illustrated what happens when that same competence is missing: a few staff member role-player, who were initially reluctant to question their habitual practices, caused friction that slowed collective progress, demonstrating that absence lack of personal openness can quickly erect barriers. Our findings suggest that personal reflection is crucial in achieving long-term engagement: openness to self-examination fosters inclusion and progress; its absence, however, hinders collective efforts.

Prioritising sustainability values

Participants at P01-LK reported that students overwhelmingly selected courses aligned with upcoming graduation exams, overlooking optional climate courses, detailing registration data that showed high enrolment in exam-relevant English and mathematics modules and only a single sign-up for the new climate elective. Participants at P03-LO noted that teachers and students occasionally viewed the activities as imposed responsibilities rather than engaging opportunities, reducing enthusiasm, citing feedback sheets where pupils described watering schedules as extra tasks. Participants at P04-LT highlighted that some teachers neglect recycling practices, thereby setting a negative example for students, recounting incidents where mixed waste was placed in general bins despite colour-coded labels. At P02-LW, parents' limited recognition of environmental goals weakened the link between home and school. Our evidence suggests that sustainability values were often deprioritised due to competing academic demands, a lack of engagement, inconsistent leading by example and limited parental support.

Educators with pedagogical competence for facilitating inclusive reflection

Participants at P04-LT acknowledged the development and use of sustainability-focused educational materials, describing illustrated guides on waste streams distributed in science classes. Participants at P01-LA reported that teachers integrated sustainability themes into lesson plans, deepening student learning, noting geography projects on local carbon footprints and local language essays on food miles. Participants at P01-LK suggested that teachers designed a special climate course as an elective during the school's extra study week, outlining a syllabus

that combined climate-science basics with local policy debates. Participants at P03-LO noted that teachers actively encouraged student engagement, clearly assigned environmental responsibilities and promoted team-based activities, such as rotating garden-bed duties and peer-tutoring on composting. Participant's role-players at P03-LF provided a clear model, weaving structured dialogues into daily lessons so that support staff, technicians and students could all contribute on equal footing. Our evidence shows how educators can demonstrate pedagogical competence by integrating sustainability into curricula, fostering inclusive reflection and creating collaborative learning environments in which all members of the school community actively participate.

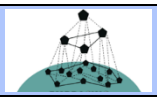
NEW COMPETENCES FOR Engagement

Evidence from our role-play offered new angles that expand the roadmap's view of individual competences for engagement.

- Evidence from P01-LA pointed out that 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.
- **Motivation and empathy** – the ability to connect sustainability to people's values – are essential competences at the engagement stage (e.g., overcoming apathy among students at P04-LT and P01-LK. In P04-LT role-play, a teacher suggested that some colleagues lacked personal commitment and failed to model pro-environmental values, undermining student engagement.
- At P02-LQ, participants noted that **effective cooperation and detailed planning by the school leaders** had helped to rally the community. Such cooperation was essential in driving engagement.

Connections

The second dimension in our initial roadmap deals with connections. Schools and educational organisations are closely connected to and part of broader societal systems, which makes shifting towards more sustainable practices challenging. While some environmental impacts are easy to identify, the **deeper root causes**, such as **cultural norms and attitudes**, are harder to detect. A crucial step in advancing sustainability is **assessing current practices** by identifying negative impacts (such as CO_2 emissions) and positive actions (such as sustainability education). Such mapping exercise helps identify key sustainability challenges and define the problem clearly.

	**Individual competences in the initial roadmap** **Dimension 2. Connections**
Complexity and root causes of	- Understanding how environmental challenges are interconnected with economic activities, culture, and environmental and educational policies at various levels of governance

environmental impacts	- Understanding the connections between different disciplines - Lifecycle thinking to identify the root causes of environmental impact at personal, community and cultural levels
Underlying assumptions	- Critical assessment of personal thinking to reveal false assumptions not backed up by evidence. - Critical reflection on personal cognitive patterns and mapping individual worldviews (linked with value reflection in Step 1)
Current state of practice	- Mapping individual and contextual unsustainable behaviours. - Skills to recognize different kinds of sustainability problems in everyday life. - Knowledge of possible solutions and the impact of potential changes at a systemic level.

We now present our evidence along these competences.

Complexity and root causes of environmental impact

Understanding how environmental challenges interlink with economy, culture, policy

In several interventions, our educational communities explicitly linked ecological initiatives with financial and policy dimensions: for example, participants at P02-LQ noted that their solar panel intervention aligned with the school's strategic sustainability goals but lamented the lack of broader institutional and municipal support. Likewise, at P02-LR, the principal role-players highlighted that installing water-saving sensors had significantly cut the school's water bills, demonstrating economic benefits that could justify further sustainability investments. Participants at P03-LO made explicit reference to global policy frameworks by tying their school garden activities to the Sustainable Development Goals (SDGs), a move that considerably enhanced the educational value and relevance of the project.

However, the evidence also uncovers gaps and missed connections. At P04-LT, the school's recycling campaign ran up against a community where the general population tends to be uninterested in such practices and where a lack of governmental incentives for recycling hindered progress. In P01-LA some parents openly dismissed the students' sustainability activities as pointless, and consumerist influences (e.g., trends for expensive fashion) were noted as competing with eco-conscious behaviour. In response, students' role-players emphasised social dimensions – one initiative was forming peer discussion groups (school's environmental team) to make sustainability socially cool through friend-to-friend conversation. At P03-LF, students challenged assumptions about scale by questioning the impact of planting trees at a single school unless this was replicated in other schools.

Understanding the connections between disciplines

Participants at P01-LA noted that some teachers successfully integrated interdisciplinary sustainability themes into their regular lesson plans. Similarly, the gardening-related interventions provided opportunities for interdisciplinary education: teachers' role-players at P04-LG highlighted their ability to use the school garden in science and art lessons to enhance experiential learning and environmental literacy. At P03-LF, the tree-planting was consciously aligned with the biology curriculum on climate change – the new trees not only greened the campus but also served as a living demonstration of carbon capture for classwork. One key success factor identified in the role-play at P03-LO was the deep integration of the project into

the school's curriculum (not treating it as an isolated club), ensuring that environmental learning became part of everyday teaching.

However, systematically embedding interdisciplinary sustainability education also proved difficult in practice Participants at P01-LK explained that, although the timetable allowed a special elective climate course, take-up was very low: most students opted instead for sessions devoted either to intensive revision in their core examination subjects or to their regular sports blocks. Staff of P01-LK concluded that the curriculum remained too fragmented—sustainability topics sat in isolated silos, without an overarching framework that helped pupils connect climate science, economics and civic studies. Participants at P02-LY similarly reported difficulties in integrating transdisciplinary content into a traditionally specialised technical faculty' curricula. This led to substantial delays and barriers in engaging students – highlighting how rigid academic structures can hinder interdisciplinary approaches. Even at primary and secondary levels, teachers' role-players noted time constraints in the timetable that limited outdoor or project-based learning (staff of P04-LG found it hard to schedule regular garden sessions amidst a packed curriculum). Cases of internal resistance also emerged: at P01-LA, a planned recycling-themed market had to be cancelled when physical education staff refused to adjust their lessons.

The role-plays sometimes helped to reveal the importance of interdisciplinary awareness where it was initially lacking. At P02-LR, the principal role-player recognised that there was limited support from educational authorities for integrating sustainability into the official curriculum – effectively a call for more cross-curricular policy support from the top. Meanwhile, some teams innovated outside formal channels: P04-LT participants leveraged a Youth Parliament program to discuss sustainability at the civic level, bridging environmental education with social studies and local politics.

Lifecycle thinking to identify the root causes of environmental impact at personal–community–cultural levels

In P02-LQ, the technical staff raised a forward-looking concern: what would happen to the solar panels at the end of their life? The role-play noted uncertainty regarding panel lifecycle management (recycling and disposal), signalling that students and staff were considering the full lifespan of the technology. At P03-LP, students exhibited lifecycle awareness by probing what happens after they sort their waste – many voiced distrust that the recycling would be sustained if the same collection trucks ultimately mixed the waste. This critical question pushed the group to consider the full chain of waste management beyond the campus. For instance, participants at P02-LW observed that students' newly acquired habits – like turning off lights and avoiding waste were carried into their homes, where parents noticed and applauded more mindful electricity use by their children.

Critical assessment of personal thinking to reveal false assumptions

An example occurred in P04-LT during debates on why waste wasn't being separated. Some staff role-player initially attributed the litter and lack of recycling to student laziness or indifference, effectively blaming youth behaviour. However, students and other teachers' role-players pushed back, pointing out that there were no recycling bins in key common areas (like the playground) and arguing that if bins were provided, students would use them. This exchange forced the group to re-examine the assumption that students "don't care" – the real issue was partly infrastructural. In fact, students' role-players suggested the problem was not wilful neglect but practical convenience, even noting that existing bins often lacked bags, which discouraged use. In another scenario, at P04-LG, participants realised they had assumed a lack of student interest in the rundown school garden. Upon reflection, they agreed students currently had little interest in the school garden, as it is – an abandoned space – but that this would change if the space were revitalised. Our evidence shows how critical reflection can challenge false assumptions by revealing underlying infrastructural and contextual factors, highlighting the importance of questioning biases to better understand and address sustainability issues.

Critical reflection on cognitive patterns & world-views

A recurring theme was the clash between emerging pro-sustainability attitudes among youth and more traditional or indifferent attitudes in the surrounding society. For example, at P02-LQ, staff observed that despite the project's educational efforts, many students insufficiently internalized sustainability values and remained predominantly consumerist in their outlook. Participants at P01-LA similarly noted general societal attitudes of indifference or negativity toward sustainability that made broader cultural change difficult. In P04-LT, it was agreed that the local community's apathy toward recycling – many parents and neighbours simply did not prioritise it – was a major barrier, one lying outside the classroom's direct influence.

At the same time, evidence shows that the interventions began to seed shifts in world-view, at least locally. At P03-LF, the principal role-player noted the intervention was fostering an emerging culture of environmental respect in the school. Similarly, teacher's role-players at P02-LR reported stronger student stances against resource waste and more openness in discussions after their water-saving intervention. P01-LA role-play mentioned some parents considered the sustainability club nonsensical or that certain student cliques still prized high-consumption fashion trends over sustainable practices.

The role-plays provided moments of personal introspection for educators and leaders. At P01-LA, teachers' role-players reviewed the fact that some of their colleagues (including themselves) flew to international project meetings – behaviour at odds with the sustainability ethos. In the same school, role-players provided additional examples of unsustainable commuting habits, such as using a 'turbo car'.

Current state of practice

Mapping individual & contextual unsustainable behaviours

At P04-LT the group identified very concrete issues: the school had no proper recycling bins in its playground or corridors, and it was common for janitorial staff to mix recyclables with general trash, effectively undoing students' sorting efforts. They also observed that many families in the community weren't recycling at home. At P01-LA, students' role-players described how some of their peers eagerly bought the latest fast-fashion and gadgets (prioritising conspicuous consumption over eco-friendly choices) and noted that such attitudes made it uncool for certain groups to engage in sustainable activities. Participants at P03-LF noted that while many students were willing to help care for the newly planted trees, some of them saw tree care as just "extra work" and showed little interest in getting involved. In the primary-school garden projects, it was commonly reported that without constant engagement, students would lose interest – at P03-LO, many pupils quickly forgot about watering the plants after the initial excitement, and at P04-LG students had to contend with peers littering in the very garden they were trying to cultivate. Teachers' role-players, too, were part of this diagnosis: in P04-LT, some teachers were seen to neglect recycling practices themselves, inadvertently setting a poor example for students. In P02-LQ, it was acknowledged that outside the core group of eco-club students, most of their schoolmates still behaved in a "business-as-usual" way – for instance, being quite careless with energy and waste. The interventions identified several challenges to sustainability efforts, including infrastructural gaps, a societal focus on consumption, inconsistent engagement and conflicting examples from peers and educators.

Skills to recognise diverse sustainability problems in everyday life

In P04-LT, for example, students who learned about recycling didn't stop at tidying their classroom; they went home and convinced their families to start separating waste, even utilising school-provided eco-bags to kick-start household recycling. Similarly, in P02-LR, role-players noted that student's actions could became mindful of water waste at school influenced their parents to adopt simple water-saving practices (such as using less water when washing or fixing leaks) in the household. Parent's role-players reported these positive changes, confirming that students were recognising sustainability challenges in everyday routines – in this case, excessive water use – and were actively responding to them outside of a school assignment.

At P01-LA, one outcome was an honest look at the school's food culture: students worked with cafeteria staff to identify why vegetarian options were not appealing, eventually negotiating for better seasoning and small additions (introducing popular items like vegetarian balls and even a vegan chocolate cake in the context of vegetarian day, or more spices). Students at P03-LP identified a gap in their recycling. Many of them expressed concern that the same municipal trucks were hauling both general and recycled waste, potentially undoing their efforts. Identifying that weak link in the chain required them to think beyond campus and consider the daily operations of city waste management. In P03-LF, the introduction of initiatives such as the school's weekly "environmental score" competition for classes further exemplifies this skill. The school essentially institutionalised the practice of monitoring everyday behaviours (energy saving, waste disposal, etc.) and flagging problems or successes regularly. Our findings show how students developed the practical skills needed to identify and address a range of sustainability challenges in their daily lives (such as influencing their families to adopt recycling and water-saving practices), thereby extending their positive impact beyond the school environment.

Knowledge of possible solutions & their systemic impact

At P03-LO, for example, participants didn't just say: 'we need to water the plants'. During the role-play they suggested a comprehensive approach: integrating gardening into formal science lessons, explicitly connecting it to broader sustainability goals such as the Sustainable Development Goals (SDGs), and budgeting for adequate tools and high-quality plants. They also suggested community-wide measures – engaging families and neighbours through workshops and volunteer planting days – to extend the project's impact beyond the school. Similarly, participants at P03-LP recognised that adding more recycling bins was not enough; they proposed boosting the visibility and credibility of the entire recycling system by measures such as relocating the Sustainability Office to a more prominent spot on campus, improving signage, and regularly publishing data on waste diversion to build trust.

Participants at P04-LG drafted the idea of a "Memorandum of Responsibilities" – essentially a written agreement clarifying who would do what (students, teachers, non-teaching staff, and municipality) for garden upkeep – to prevent tasks falling through the cracks. They also discussed making the space inclusive by design (adding wheelchair-accessible paths, sensory plantings, etc.), showing awareness that a solution isn't truly a solution if it doesn't work for everyone. Additionally, by suggesting the incorporation of garden duties into class credit or service hours, they aimed to embed the solution into the school's normal functioning. Participants also often recognised that for solutions to have systemic impact, they need scaling and networking. A notable case was P03-LF where, after acknowledging the limits of a single-school effort, the team proposed sharing their project's data and stories with other schools. P02-LR, for their part, worked with the school inspectorate to publicise their successful intervention as a "good practice" example for other schools. Thus, our evidence provides practical examples of how participants proposed comprehensive, inclusive and scalable sustainability solutions, such as integrating projects into curricula, formalising responsibilities, increasing visibility and sharing best practice

NEW COMPETENCES FOR Connections

- **Systems thinking and complexity competence.** In P02-LY, teachers explained that the sustainability module helped students "critically analyse complex situations, make connections, and understand different perspectives," so they could anticipate both the technical requirements of a solar installation and the community habits that would shape its impact. In P04-LT, uncertainty about how photovoltaic panels would be maintained or recycled led to hesitation, revealing a gap in life-cycle foresight.

- **Collaboration and project-management competences.** A teacher from P02-LR observed that students gained "valuable collaboration, planning and coordination skills" as they organized themselves to change behaviour and monitor water use. Where the same skills extended across roles - for example, linking students with external actors and support staff - projects flourished: in P03-LF, a clear, jointly agreed matrix of responsibilities for tree care meant that no duty was overlooked. Conversely, in the P04-LG garden, uneven teacher participation and no formal maintenance schedule threatened the consistency of the plants until a memorandum of responsibilities was drafted to link all actors in a collaborative structure.

- **Social-influence competences.** Students at P04-LG devised a school-radio slot and a mascot competition that turned the garden into a campus talking-point; their creative leadership attracted new helpers and carried the project beyond formal lessons. Where no such youth champions or engaging communication outlets existed, initiatives fizzled: role-players at P04-LT noted that without visible peer advocates, recycling enthusiasm dropped off sharply.
- **Lifecycle thinking across levels**. In many role-plays, participants demonstrated what could be called lifecycle thinking: an awareness of how sustainability efforts unfold over time and across different social levels (from personal habits to community culture). Participants at P03-LO realised that a critical failure point would be the lack of consistent follow up – students enthusiastically planted saplings but might quickly forget about them without a plan for ongoing care. Similarly, at P04-LG, the absence of an explicit maintenance plan (e.g., for watering the garden during school holidays) was highlighted as a risk that could cause the garden to deteriorate despite students' initial zeal. P03-LF as well as P03-LO students debated the broader impact of their tree planting – concluding that it remained modest unless the model spread to other schools.

Visions

The third dimension in our initial roadmap deals with Visions. Without a vision, we are driven to reinforce current unsustainable practices and ways of thinking, acting and reacting. Creating a more sustainable collective reality requires us to work together to **identify and map the available alternatives**. This requires us to unleash our **creative and intuitive faculties**, see things differently, unlearn unsustainable practices, and learn to create things that do not yet exist.

	**Individual competences in the initial roadmap Dimension 3. Visions**
Visioning preferred and presumable futures and short-term scenarios	- Individual understanding of how the future lies in our common hands - Critical reflection on how to realize the visions of a sustainable future in one's own life and in the community - Collective visioning to promote individuals' will to act in a more sustainable way
Promoting cognitive, emotional & behavioural adaptability	- Acknowledge that thinking about future can evoke uncomfortable feelings (eco-anxiety and ambiguity) that are individual and need to be encountered in a supportive and safe atmosphere - Knowledge about possible ways to reduce harmful environmental impacts and foster desirable change in society - Facing inconvenient facts about future and realising the scale of changes needed in one's personal life can be stressful.
Exploration through creative & relational knowing	- Creativity and intuitiveness for encountering the wicked sustainability issues. - Creating novel solutions to novel wicked problems - Transdisciplinary knowledge and systems understanding

We now present our evidence along these competences.

Envisioning likely and preferred futures and short-term scenarios

Individual understanding of how the future lies in our common hands

Participants at the P03-LP 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 P02-LR. After installing smart taps, students affirmed that now "we say no" to excessive consumption, signalling that small, tangible changes can spark a more sustainable future. During a tree-planting campaign at P03-LF, some students dismissed caring for the seedlings as extra work unless other schools joined in.

These findings suggest that engaging participants with a compelling, shared vision of the future—grounded in their individual realisation that they can act and have impact—is essential for sustaining momentum.

Critical reflection on how to realise visions in life & community

Participants at P04-LT 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 (for example, distributing recycling bags to residents). Additionally, participants identified structural challenges like student turnover – each year new pupils arrive as others leave – which disrupts 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. At P03-LO, for instance, the group emphasized clear, long-term planning: they insisted on well-defined responsibilities, schedules for monitoring, and realistic budgeting to ensure their sustainability vision would materialize and last. Participants at P02-LQ and P04-LT 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 visions step-by-step. On the other hand, several groups encountered setbacks. In P02-LW, for example, the 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.

The evidence illustrates how participants engaged in critical reflection on ways to transform sustainability visions into lasting change, such as through structured planning, curriculum integration and clear responsibilities, while also learning from setbacks caused by gaps in long-term maintenance and continuity.

Collective visioning to promote individuals' will to act in a more sustainable way

Participants at P04-LG and P04-LT envisioned revitalising their neglected outdoor garden; they agreed that students currently showed little interest in the barren area but this would change if the space were revitalised, noting strong enthusiasm for having classes outdoors in nature. Envisioning an inclusive green space (with wheelchair access and communal gardens) as a group clearly boosted their motivation to pursue it. Similarly, participants at P02-LW highlighted unexpectedly high and enthusiastic participation in the interventions, observing that collective involvement yielded lasting knowledge, useful in life and society. At P04-LT, a student-led Youth

Parliament initiative was widely praised for successfully engaging students to improve their habits through collective action. Conversely, where a unifying vision was not shared widely (for instance, when only small groups were involved, like the case in P02-LQ), willingness and participation lagged, confirming that vision competences function as a critical enabler of action when widely cultivated,) but a barrier when confined to a few. Thus, collective visioning proved essential in motivating sustainable action. Shared goals, such as revitalising outdoor spaces or participating in youth initiatives, fostered stronger engagement. However, limited inclusion hindered participation and impact.

Emotional, cognitive, and behavioural adaptability

Acknowledging individual eco-anxiety & ambiguity in a supportive atmosphere

At P01-LA, members of the school's environmental team say they appreciated belonging to the team, providing an opportunity to discuss sensitive environmental issues comfortably. In P03-LP waste-sorting intervention heard a blunt admission from one role-player student, as uncertainty over whether waste is re-mixed after collection undermines confidence in the system, pinpointing the anxiety that effort might be pointless. P03-LF experienced a similar development, some role-players saw tree care as "extra work" and doubted its impact unless many schools participated. Student responded with a weekly classroom environmental score and photo exchanges with neighbouring schools; the same students now help keep the scoreboards updated, an approach that "builds ownership" and steadily shifts the mood from fatigue to pride. Finally, at P03-LO the garden–recycling programme initially felt imposed, negatively influencing student's willingness to engage. To prevent these effect teacher role-players in the same school suggested reframing tasks as team challenges and supporting them with clearly assigned roles and collaborative reflection sessions, which significantly enhanced student motivation and involvement.

The findings show that fostering a sense of ownership and trust was key to sustaining student engagement. Open dialogue, shared responsibility and reframing tasks as collaborative challenges can help to shift perceptions from scepticism and fatigue to motivation.

Knowledge about possible ways to reduce harmful environmental impacts and foster desirable change in society

At P02-LQ, for example, the installation of water-saving sensors was hailed as a success, with participants reporting that it improved the school's performance by reducing water consumption and environmental impact. Similarly, at P02-LW, both students and staff recognised the solar panel installation as an effective way to reducing carbon emissions. The solar panels supplied a significant proportion of the school's electricity, even during power cuts, and greatly reduced the school's carbon footprint, setting a positive example for other schools. Participants at P04-LT also noted community-level solutions, such as distributing reusable eco-bags to families, which effectively encouraged home recycling and raised broader sustainability awareness. Participants at P02-LW also reported that by working with solar panels first-hand, students gained tangible, practical experiences in implementing renewable energy solutions.

Likewise, at P04-LT, students involved in the recycling project acquired substantial practical skills and understanding of renewable energy and sustainability, which empowered them to influence their families' habits.

The interventions showed that participants gained practical knowledge of how to reduce environmental impact, for example by installing solar panels, using water-saving technologies and encouraging recycling. This improved school sustainability and empowered students to drive change in their communities.

Facing inconvenient facts and coping with stress

At P01-LA, it was acknowledged that not all teachers were on board with the sustainability efforts – some faculty members were sceptical or even saw recycling as ideologically loaded, limiting their engagement. At P03-LO, teacher's role-players admitted occasional forgetfulness (e.g., neglecting to water the garden plants), and they identified better planning and delegation as ways to cope with such stress induced lapses.

One inconvenient fact repeatedly faced was that change can be slow or partial, and this could be discouraging. For example, in P01-LK, teachers innovated an elective course on climate, only to find that almost no students signed up due to exam pressure. Rather than deny the delay, the team confronted it head-on and identified systemic academic pressures as the cause. Students at P03-LP likewise raised uncomfortable questions about their new recycling scheme: they worried that despite their sorting efforts, the waste might be mixed together by the city's trucks, which undermines confidence in the system. In some role-plays, confronting reality meant accepting limits: at P03-LF students recognized that planting a few trees, while valuable for shade and school climate, was negligible unless replicated broadly

Exploration through creative and relational knowing

Creativity & intuitiveness for wicked problems

At P03-LO, for example, the local City Council role-player contributed a burst of creativity by suggesting novel ideas to support the school's garden – providing greenhouse space for fragile plants, setting up a plant sponsorship webpage for community members to adopt plants, and installing protective devices to guard the greenery. These inventive solutions went beyond the school's initial plan and tackled challenges (like plant care and community involvement) with intuitive, out-of-the-box thinking. Participants at P03-LO also noted the creativity in addressing practical challenges shown by external experts, who offered innovative technical advice during the project. For instance, participants acting as "researchers" at P03-LO described how an environmental research institute proposed creative ideas – closing a street to create green space, using ultraviolet lamps to help plants grow in winter, and even upcycling materials into a scarecrow for the garden. In P04-LT, teachers themselves took intuitive initiative by developing custom sustainability teaching materials and lesson plans to weave the project's themes into everyday learning.

Creating novel solutions

At P03-LO, the principal role-player has taken some creative steps - installing an automatic irrigation system for the garden and even placing figures among the plants as a low-tech annoyance warning. Participants noted that these practical innovations protected the garden and kept students engaged (curious to climb the roof and see the panels or to monitor the scarecrows, even if that sometimes distracted them in class). In P01-LA, students came up with creative lifestyle solutions, such as recycling fashionable clothes among peers, making sustainability cool and influencing friends to adopt greener habits.

A clear example comes from P01-LK, where teachers responded to students' interests by designing a new climate-change course during a special study week. In other cases, novel solutions were smaller in scale but equally significant: at P02-LQ, the school's project to install solar panels was novel in that community, providing a working example of clean energy in action and even influencing local authorities by its success.

Participants at P02-LQ noted that the intervention helped the school take another step towards becoming a green school, listing energy certificates displayed beside the main entrance. Participants at P02-LR acknowledged that they had identified small-budget interventions as strategically valuable for broader applications, citing the low-cost sensor project as a template for other public buildings. Participants at P04-LT observed that their project provided a clear and replicable sustainability model, describing printed infographics mapping short, medium and long-term targets for waste, energy and water.

Transdisciplinary knowledge & systems understanding

At P02-LW, the solar panel installation is used as a practical educational experience to enhance students' understanding of technical principles and sustainability. It gives pupils a tangible example of how environmental measures can be implemented, which, according to the inspectorate role-player, will help them to understand the cycle of solar energy holistically in real-life contexts. At P02-LR, the installation of smart water sensors has brought together plumbing expertise, behavioural change and school funding. Students now "say no" to excessive consumption, while management can track the reduction in bills, demonstrating that technology, habits and budget planning are all part of the same conversation. This illustrates a transdisciplinary approach involving different stakeholders and providing a comprehensive understanding of the system. Transdisciplinarity is not confined to technical fixes. In P04-LG, teachers are embedding "short, inquiry-based modules across science, art, and citizenship classes. At P02-LY, teachers are commended for enhanced student's ability to draw connections and understand diverse perspectives. The P03-LP recycling intervention involved coordination between university offices, city services, students, and cleaners, essentially on a campus-wide scale. The findings show how transdisciplinary knowledge and systems thinking can be developed through projects that link technology, behaviour, funding and education. Examples include solar panels, smart water sensors and cross-subject garden modules.

NEW COMPETENCES FOR Visions

- **Boundary-spanning leadership competence.** Participants repeatedly highlighted the importance of proactive leaders who can unite diverse stakeholder groups (students, staff, parents, community officials) behind a common vision. For instance, at P02-LR, a

continuous institutional support from school administration and municipal backing (e.g., hiring gardening experts, providing resources) was cited as crucial for sustained success.

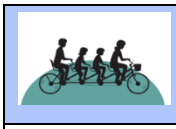
- **Political and cultural neutral framing competence**. Participants at P03-LO observed that some parents resisted sustainability initiatives perceived as political or outside traditional academics. This may suggest that educators and change leaders must frame sustainability in neutral, inclusive ways to avoid pushback. The ability to communicate the purpose and benefits of a project – aligning it with community values and educational goals – emerged as a vital competence to keep all actors on board.

- **Logistical micro-planning and governance competence.** Without a designated coordination group or maintenance plan, even the best vision can falter when key individuals leave or initial excitement wears off. To address this, participants suggested creating a clear maintenance and use plan to assign responsibilities and schedule follow-ups – essentially, competence in detailed project planning and institutionalising routines.

- **Capacity-building competence.** Participants realised that even well-meaning teachers, students, or janitors might lack specific knowledge or confidence – for example, how to compost, how to maintain a solar panel system, or how to incorporate new topics into lessons. The field evidence suggests an enabling factor: building everyone's skills ensures the vision does not collapse due to practical know-how gaps.

Action

The fourth dimension of the initial roadmap focuses on action and suggests three ways to promote sustainability in education: setting up **effective structures to support and guide change**; creating a thorough **strategy and action plan**, and ensuring there are **enough resources to enable and maintain the transformation.**

	**Individual competences in the initial roadmap Dimension 4. Action**
Structures for change	- Leadership: crucial role of principals and other staff - Leaders' knowledge, skills and attitudes to prioritize different values and goals of education - Leaders, teachers and students' skills in promoting ecological sustainability - Acknowledging or creating regulations
Creating strategy & action plan	- Knowledge about the environment and systems to create suitable strategies - Skills of teamwork to design of the most effective actions - Engagement of all actors in the planning work & learning process
Resources for change	- Personal resources define what kind of individual initiatives one can undertake - Knowing one's own potential and limits - Well-being, positive emotional atmosphere - Further training

We now present our evidence along these competences. While the data provides useful evidence to either support or refute most of the suggested competences, it is important to acknowledge that we could not find relevant examples for some of them. These are highlighted in grey in the above table.

Structures for change

Leadership role of principals & staff

Participants at P04-LT 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 P03-LO 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, the momentum suffered. For example, participants at P01-LA 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 – at P04-LT, staff suggested the principal should involve more teachers to distribute responsibilities, underlining that broad-based leadership strengthens sustainability efforts.

Thus, our evidence suggests that effective and visible leadership, such as principals actively supporting and coordinating sustainability efforts, was key to driving systemic change. In contrast, limited or isolated leadership weakened impact.

Leaders' knowledge, skills and attitudes to prioritize different values and goals of education

In some centres, this competence was clearly present: at P02-LQ, for instance, aligning the solar panel intervention with the school's green vision was seen as a success factor – the intervention was explicitly described as a replicable model fitting the school's sustainability goals. Likewise, at P03-LO the leadership's focus on long-term sustainable goals (e.g., integrating environmental topics into broader school interventions) demonstrated an ability to prioritise sustainability alongside other objectives. At P02-LW, role-players as teachers observed that sustainability had not been a main priority in the school's agenda, implying that leadership was more focused on other matters. Similarly, the P02-LR role-play found that sustainability had not been sufficiently prioritized in the school's strategic planning. Our findings therefore confirm that leaders' ability to prioritise sustainability alongside other educational goals was crucial to the success of interventions,

Leaders, teachers, and students skilled in promoting ecological sustainability

At P02-LQ, teachers leveraged new educational materials to impart sustainable knowledge, and as a result students gained skills for the environment and sustainability, including how to save and value resources. At P04-LT, some teachers took a strong initiative in encouraging recycling and environmental awareness at school, demonstrating pedagogical skill in promoting ecological values. Participants noted that such teacher leadership was crucial: it stimulated student interest and spread pro-environment messages effectively in the school community. Students themselves also developed notable skills to advocate for sustainability. In several cases, students became ambassadors of green practices – for instance, P04-LT students not only

learned about recycling at school but also actively influenced their families to adopt recycling and resource-saving measures at home. At P01-LA, students in school's environmental team gained confidence to discuss sustainability issues with peers and organise activities, thereby positively influencing attitudes in the wider society. In a minority of instances, teachers lacking interest or training failed to model eco-friendly behaviour, which undercut the promotion of sustainability (e.g., a few P04-LT teachers neglected recycling, sending a poor message to students).

Thus, the evidence suggests that positive change spread when leaders, teachers and students possessed the skills and commitment to promote ecological sustainability through teaching, leading by example and peer advocacy. In some cases, a lack of engagement or training weakened these efforts.

Acknowledging or creating regulations

Participants at P02-LY acknowledged a strong emphasis on integrating environmental protection regulations, efficient resource use and sustainability practices, describing lecture blocks that compared EU directives or the Sustainable Development Goals (SDGs) with national implementation gaps. Participants at P02-LW warned about the necessity for regular safety inspections (e.g., fire risks) for solar panel installations, listing check-up intervals and responsible departments. Participants at P03-LP observed that students raised critical questions about post-collection processing; prompting calls for clearer communication of recycling outcomes, recounting seminar sessions where learners asked facility managers whether separated fractions were later re-mixed.

Knowledge of environment & systems to create suitable strategies

For instance, participants at P02-LQ pointed out that limited technical knowledge among staff became a hurdle during the solar panel intervention – teachers did not fully understand the photovoltaic system, which restricted detailed discussions and planning around the panels' functionality. This knowledge gap meant the staff had to rely on external experts and could not maximise the educational value of the installation. Conversely, there were positive examples on how strong knowledge can facilitate strategic action. At P03-LO, teacher's role-players suggested to provide students with rich background knowledge on environmental issues (through videos, class materials, and discussions) to ensure they understood the significance of their tree-planting intervention. In higher education, too, participants from P02-LY role-play suggested to integrate sustainability science into a new course, raising awareness of students and responsibilities toward sustainability. At P02-LR, it was noted that the lessons and know-how from the water-saving intervention were not sufficiently disseminated beyond the small group of directly involved participants, which limited the broader impact on the school's practices.

Skills of teamwork to design of the most effective actions

In P02-LQ, the solar energy intervention benefited from unusually high levels of cooperation. Students, teachers, and administrators all took part in collaborative problem-solving, and this active participation across groups improved the outcomes of the intervention. Similarly, at P02-LW, where students installed water-saving sensors, teachers role-players reported that the intervention greatly enhanced students' ability to work together in a group to plan and carry out a challenging intervention. Students learned to coordinate roles, share tasks, and support each other through the process. Teamwork was suggested as not only make the immediate action more effective, but also built participants' confidence in working together to address sustainability issues. Across the different centres, when a team of different actors (students, staff, parents, experts) was formed and communicated well, the actions tended to run more smoothly. In contrast, a lack of teamwork or an uneven contribution often coincided with difficulties. One obstacle identified in P04-LT was an uneven distribution of tasks and responsibilities among the school team, partly due to different levels of interest among the staff.

Engagement of all actors in planning & learning

At P03-LO, for example, teachers deliberately involved students in the planning – assigning them clear environmental responsibilities and roles – which significantly as they suggested, it boosted the students' motivation and ownership of the intervention. In P02-LQ and P02-LW, the working groups for the interventions included teachers, students, and sometimes technical staff or external experts, ensuring that learning was shared and everyone's perspectives were considered during planning. At P04-LT, while in the principal role-player was supportive, it was noted that only a handful of teachers carried the effort – there was insufficient sensitization and engagement across the entire school community and a lack of widespread willingness among staff. The P04-LT role-play suggested that the principal should find ways to involve more teachers in future, highlighting a need to institutionalise broader engagement rather than rely on individual enthusiasm. Engaging all actors also extends beyond teachers and students. At some DS, parents and community members were brought into the dialogue, and this often amplified the intervention's effectiveness. For instance, in one school garden intervention (P04-LT), involving local families and even neighbours in planning volunteer days helped build community support and shared learning.

Resources ▸

Knowing personal resources, potential & limits

At P04-LT and P03-LO there was consensus that teachers have very little free time to dedicate to extra interventions beyond the regular curriculum. Participants at P01-LK observed that older students were often at the brink of their personal limits due to academic pressures; in fact, sustainability electives were a hard sell when preparing for graduation exams was the students' main priority and consumed most of their time and focus. The evidence indicates that teachers and students often faced time constraints and competing priorities, which affected their ability to engage in additional sustainability initiatives.

Maintaining well-being & positive emotional atmosphere

In P01-LA, organisers cleverly kept the mood positive by incorporating enjoyable elements into the campaign – one highlight was a vegan tasting day (with treats like chocolate cake and veggie balls) which many students found fun and memorable. At P04-LT, for instance, teachers noted that the students who took part in the recycling initiative did so with high enthusiasm and motivation, creating a positive vibe that boosted the intervention. At P03-LO, some students initially perceived the tree-planting activity as an imposed task or punishment rather than a positive learning experience, which led to low intrinsic motivation and even some resentment. This negative outlook among that subset of students resulted in only token participation. Teachers in that case had to work harder to frame the intervention in an inspiring way to win students over. Another issue that was noted was that stress and frustration were affecting wellbeing: for example, in the P01-LA role-play, tension arose when the cafeteria staff were dismissive of the students' feedback on the vegetarian options, treating the students as adversaries rather than partners. Our findings suggest that maintaining well-being and a positive emotional atmosphere is key to sustaining student engagement

NEW COMPETENCES FOR Action

The evidence collected tends to confirm and fill in the expected competence areas (leadership, role-play work, knowledge, personal well-being, etc.) rather than introduce brand-new categories. Nevertheless, participants did highlight certain practical skills and contextual factors that broaden our understanding of what it takes to implement sustainable actions

- **Communication infrastructure competence (application of leadership and teamwork)**. For example, at P04-LT the school principal's role-player used of robust communication channels and the leveraging of her formal authority were cited as key to the intervention's success. Having effective internal communication and clear authority structures is not a new competence per se (it is implicit in leadership and role-play work), but the emphasis on it shows an area of focus that the roadmap might not have explicitly mentioned.

- **Technical maintenance competence.** In the course of implementing innovative interventions, some schools discovered a need for very specific competences like the ability to maintain new equipment. For instance, in the P02-LW water saving intervention, technicians had to develop new skills to cope with the complex sensor technology maintenance (a point not originally identified in the planning). Again, this does not constitute a new broad competence area – it falls under technical and problem-solving skills but it was a concrete skill need that emerged only once the intervention was underway.

Conclusions

Two main conclusions emerge from the exploration of our empirical evidence on individual competences towards the ones initially suggested in the roadmap. On the one hand, the evidence conclusively confirms the relevance of the individual competences suggested in the initial roadmap. On the other, the evidence offers ways to strengthen the initial roadmap, whether by adding new individual competences or refining existing ones.

Next, we illustrate how the empirical evidence validates or expands upon the individual competences comprises in different steps in the initial roadmap.

→ ***ENGAGEMENT:***

The evidence largely supports the individual competences suggested in the initial roadmap, showing that intrinsic motivation, peer influence, and an emotional connection to nature are key drivers of engagement. Skills such as 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.

With regards to sustainability-related knowledge (e.g., ecological and systemic understanding), our findings confirm its relevance: students who first understand how a solar panel works or why a compost heap is important move from curiosity to advocacy. But information alone didn't go far unless someone had the interpersonal skills to translate it into everyday life and convene a comprehensive dialogue, such as the skills demonstrated by teachers who built youth parliaments, students who broadcast gardening news on school radio, and headmasters who led energy conservation into new projects.

Across all contexts, our evidence supports the core competences of the initial roadmap while emphasising their practical importance. Knowledge must be experiential and shared early; engagement skills must range from cross-boundary teamwork to meticulous micro planning; and participants must experience the satisfaction of being-heard.

- ***Strengthening the initial roadmap:***

*Our evidence shows that an **individual's personal passion and example** can, to some degree, substitute for formal knowledge in sparking engagement. **Motivation and empathy,** or the ability to connect sustainability to people's values, also emerged as critical factors in overcoming apathy among students. **Effective cooperation and detailed planning by leaders** were also crucial in stimulating engagement throughout the educational community in some DS.*

→ ***CONNECTIONS:***

The evidence largely supports the roadmap's competences by demonstrating the importance of systems thinking, interdisciplinary connections, and lifecycle awareness in sustainability education. Interventions showed successful integration of environmental, economic, and policy dimensions, though real challenges arose in practice, such as limited institutional support, inconsistent community engagement, or rigid academic structures. Difficulties like fragmented curricula, low student participation in sustainability electives, and infrastructural constraints affected the progress of the interventions. Critical reflection helped uncover false assumptions and highlighted the need for collaborative and scalable solutions embedded in school culture.

Identifying challenges and proposing solutions are also critical competences when establishing connections. Our participants identified various challenges to promoting sustainable behaviour, including individual, collective and technical-material factors that reduce motivation to participate in environmental activities. Building on this, they suggested specific actions, such as drawing up a written agreement to clarify who is responsible for garden tasks, making the space accessible to all, and sharing their project with other schools to increase its impact. Lasting solutions require structure, inclusion and collaboration.

Overall, these findings support the roadmap's emphasis on mutually reinforcing skills: the ability to recognise complexity; a commitment to interdisciplinary work; the capacity to identify unsustainable behaviours at an individual and contextual level; and knowledge of possible solutions. Each of these skills depends on strong collaboration, project management and social influence.

- ***Strengthening the initial roadmap:***

Our evidence suggests that teams with systems thinking skills can understand cause-and-effect chains and adapt to changing conditions, which confirms the importance of these skills in the roadmap. According to our evidence, effective collaboration and project management also transformed potential obstacles into enablers. Social skills such as storytelling, peer modelling and persuasive communication helped to spread the practices beyond the core groups. Finally, the evidence suggests a form of life-cycle thinking that strengthened the resilience of the interventions. For example, doubts about the future recycling of panels, concerns about maintaining the garden during holidays and questions about what happens to the sorted waste once the project ends show that the teams have a habit of looking forward and outwards. Behind these skills are competences that act as connective tissue.

→ ***VISIONS:***

In line with the initial roadmap, our evidence suggests that lasting change to a school's sustainability culture requires a shared vision. This vision should be promoted by leaders who prioritise environmental values in their daily decision-making processes and encourage everyone to envisage preferred and feasible futures. According to our findings, when school leaders and staff viewed projects as milestones in a broader journey, students felt empowered to take on the role of community ambassadors and believed that they could shape the future. Conversely, indifferent leadership and fragmented communication resulted in hesitation and cynicism among students, who doubted the impact of their efforts.

Our evidence also shows that these shared visions were only meaningful if accompanied by open reflection on how to realise them in daily practice. Debates about whether recycling habits should be taught at home or at school, and the emphasis placed on replicable models, show how schools are moving from ambition to action by testing their plans against real-world constraints. Without such critical planning, projects risked failing despite initial enthusiasm. It is acknowledged that joint visioning practices encourage willingness to act. When only a small group is involved in shaping the vision, momentum declines.

Our findings also indicate that creativity and transdisciplinary approaches integrating technical knowledge, behavioural change and community involvement are essential for developing

innovative and practical solutions to complex sustainability challenges. Nevertheless, according to our evidence, it is crucial to address challenging realities such as scepticism, limited resources, and systemic constraints to build resilience and maintain momentum.

Overall, our results suggest that lasting sustainability outcomes emerge from a combination of visionary leadership, collaborative action and practical

- ***Strengthening the initial roadmap:***

Cross-boundary leadership, *in which head teachers and project coordinators form alliances with city officials, contractors and families, ensures that the vision remains clear and shared beyond the school.* ***Political and cultural framing skills*** *translate this vision into a neutral community benefit, preventing resistance from staff or households who might otherwise see it as a personal agenda.* ***Logistical micro-planning*** *turns lofty goals into daily routines that survive staff turnover. Finally****, a capacity-building culture*** *broadens the circle of vision carriers. Caretakers are trained in waste handling, technicians in sensor maintenance and teachers in new pedagogical approaches. These individuals can spot gaps and convert them into opportunities for growth.*

→ ***ACTIONS***

As set out in the initial roadmap, committed, value-driven leadership is essential. Where principals and senior staff have made sustainability a visible part of the school's plans, interventions have gained legitimacy, resources, and morale. Leadership that remained personal rather than distributed, or that sent mixed signals, quickly lost traction. Staff and students recognised these inconsistencies and reduced their efforts accordingly. However, our findings suggest that leadership by principals and senior staff alone is insufficient; the skills and commitment of teachers and students are equally vital. Our interventions show that greater success was achieved when all educational actors — students, teachers, parents and external experts — were involved in the planning and learning processes. Interventions also benefited from teamwork and inclusive collaboration, enhancing problem-solving skills and confidence. Notably, this also required a solid grasp of environmental and systemic knowledge. Participants who understood how solar arrays interact with the grid or how municipal waste is handled after collection were able to design and present convincing, realistic plans.

Nonetheless, limited time, academic pressures, and emotional fatigue posed real constraints for both students and staff and this is why well-being and emotional climate were as important as technical planning. Teachers and students who recognised their own limitations — such as juggling exams, heavy timetables or shift work — were better able to pace interventions and avoid burnout

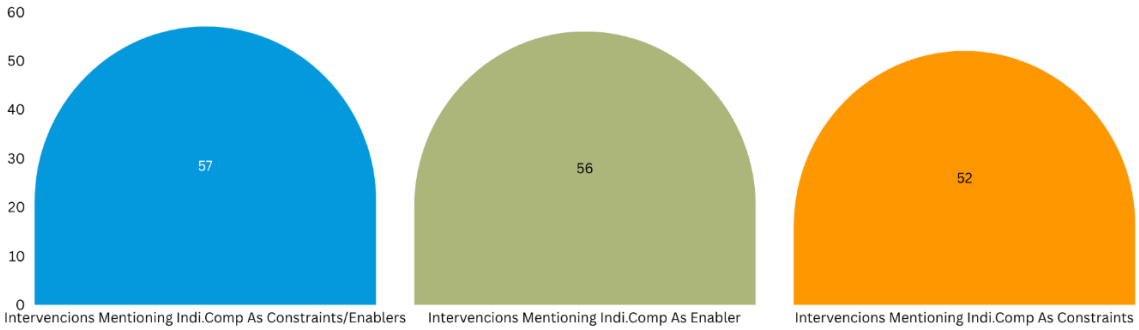
Together, the findings confirm the roadmap's emphasis on leadership, teamwork, systemic knowledge, and reflective practice. They also illustrate that these elements are only effective when integrated into a culture of shared responsibility, continuous learning, and visible, value-based action.

- ***Strengthening the initial roadmap:***

Some schools attributed their success to effective internal communication channels and clear leadership. Although these are general leadership skills, they became a specific focus during the interventions. Additionally, some projects revealed the need for specific technical skills, such as maintaining new equipment. These requirements were not anticipated initially, but emerged during the implementation process.

5.3. How does our evidence relate to the drivers/barriers suggested in the initial roadmap?

By monitoring the interventions, we also gathered data on the factors that enable or constrain their successful implementation. Our evidence indicates that individual competences were identified as a success factor in around 56 mentions, and as a failure factor in around 52 mentions. These references appear in most of the analysed interventions, highlighting the importance of individuals' competences in determining the outcome of sustainability initiatives.



→ **Interventions acknowledging individual competences either as enablers or constraints**: 57 out of 59 interventions (97%) include at least one reference to individual-level knowledge, skills, attitudes, or motivation in either their success or failure factors. This high prevalence indicates that human competences—beyond purely technical or structural conditions—are commonly viewed as pivotal.

→ **Individual competences acknowledged as enablers**: 56 interventions (95%) explicitly mention one or more individual competences (e.g., skills, knowledge, motivation, leadership) as part of the conditions for success. Having the right attitudes and capabilities was noted as a driver of positive outcomes.

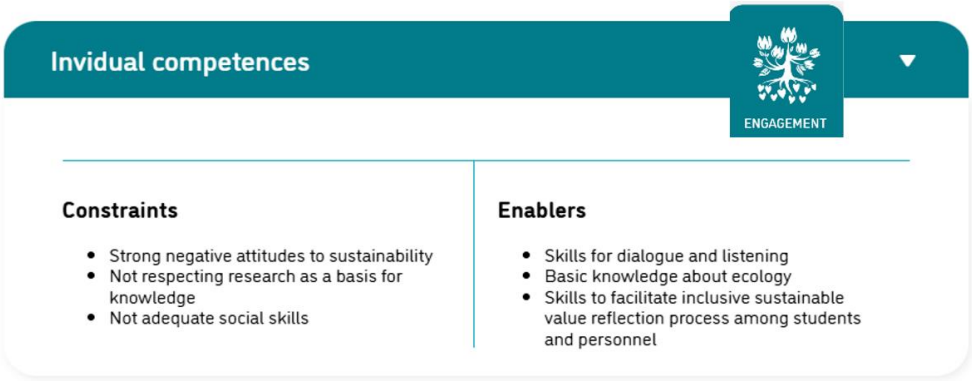
→ **Individual competences acknowledged as constraints**: 52 interventions (88%) identify a gap or shortfall in individual competences—such as lack of motivation, negative attitudes, or insufficient skills—as contributing to failure or underperformance. These deficits can undermine otherwise well-funded or well-structured sustainability efforts.

→ **Individual competences not acknowledge either as enablers or constraints**: Only 2 interventions (3%) do not make any clear reference to individual competences in either their success or failure factors. In these cases, the text emphasised external and structural drivers (e.g., resources, institutional support, technical infrastructure) without highlighting personal skills or attitudes.

Next, we provide a more detailed description of our findings on how individual competences act as enablers or constraints in practice. We achieve this by comparing our findings on drivers/barriers with the suggested enablers and constraints in the initial roadmap. To this end, we examine how our evidence verifies, refines or expands the initial roadmap, detailing any new enablers and/or constraints that emerged during the interventions.

Engagement

The individual competences identified in the initial roadmap as enablers and constraints in the **Engagement** dimension are reflected in this table.



We now present our evidence relating to these constrains and enablers.

Skills for dialog and listening

In the context of an awareness raising intervention it was deemed important that participants were able to "*organize events, design spaces, and engage with diverse stakeholders"*. Likewise, *"skills to collaborate, communicate and reflect critically"* are mentioned, indicating the need for interpersonal skills to facilitate meetings, discussions, and teamwork.

Basic knowledge about ecology

The importance of a *'basic understanding of water conservation and sustainable practices'* is emphasised in the context of water-saving interventions, while the mastery of energy concepts is highlighted in relation to an *'understanding of renewable energy and its benefits'*. Similarly, an understanding of decarbonisation and climate change (*"understanding of energy efficiency, decarbonisation and climate change mitigation*) is emphasised, indicating that participants must be familiar with the relevant scientific and environmental fundamentals. Also, the absence of certain knowledge is explicitly acknowledged as a limitation. In one intervention, for example, the 'lack of knowledge about the impact of the loss of biodiversity' was identified as a risk factor. If those involved do not understand the importance of biodiversity, they will hardly support measures to protect it.

Skills to facilitate inclusive sustainable value reflection process among students and personnel

"*Fostering a culture of collaboration among students, teachers, and environmental and architectural experts*" to ensure *"informed and shared decision-making"* was acknowledged as critical for the success of one intervention. Collaboration is seen not as a one-off effort but as a

collective norm—a competence shared at the group level. Several quotes reinforce this idea of widespread collaboration: *"engage and involve teachers, students, parents, and administrative staff in the planning and decision-making process to build a sense of ownership".* Similarly, *"good communication between all the institutions is the first step"* refers to inter-institutional projects where smooth communication between entities is fundamental.

(in) Adequate social skills

One intervention recommended the use of bidirectional communication and the involvement of certain stakeholders, such as parents and teachers, in order to work together to implement a sustainable food intervention: *"There are teachers and parents on the dining hall committee. Involve them more... Move forward in a co-design format"*. The evidence also shows that a failure to communicate and approach sustainability with different stakeholders effectively can lead to failure. *"People do not know about the campaigns"* because *"communication does not work well enough".* The ability to communicate, inform, listen and provide feedback to all participants is an essential competence. In practice, this involves designing awareness campaigns, which requires a wide range of social skills, and ensuring that everyone understands their roles and the messages they need to convey.

(Strong) negative attitudes to sustainability: Several quotes highlight that sustainability is often seen as "extra," "boring," or misaligned with the school's core mission. Such framing fosters apathy: *"if sustainability is considered as extra, not relevant,"* or *"not fun or inspiring,"* engagement declines. Cultural resistance further amplifies this gap: *"failure to establish sustainability as a core value*" or *"lack of engagement from the school community*" repeatedly obstructs change. Institutional actors, including coordinators, often resist curriculum reforms or waste initiatives, viewing them as burdensome or misaligned with priorities. As one quote puts it: *"there was a great deal of resistance from the institution*."

NEW CONSTRAINS AND ENABLERS FOR Engagement

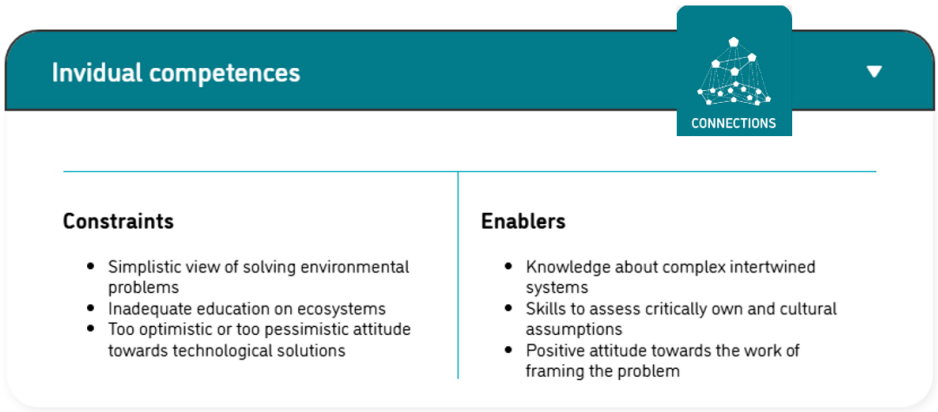
Next, we present further evidence from our interventions that somehow expand the knowledge, skills and attitudes considered in the initial roadmap.

- **Analytical reasoning and data literacy as pillars of evidence-based action:** In data-rich environments, the success of sustainability projects often pivots on actors' ability to interpret numbers meaningfully. Beyond mere collection, data literacy includes validating sources, deriving insights, and grounding decisions in evidence. One project lamented "*poor data collection, analysis, and management practices*," pointing to the risk of data misuse. Others recognised the need for training in the *"ability to interpret and analyse consumption data"* and the importance of "*maintenance protocols*" to ensure sensor reliability. These competences enable actors to monitor progress, detect anomalies, and justify decisions, keeping interventions credible and adaptable.
- **Motivational leadership to maintain collective momentum:** Leadership in sustainability contexts is not solely about knowledge**,** authority or decision-making—it involves the emotional and motivational work of keeping groups committed over time. One school's

monitors the effectiveness of communication activities "*linking feedback collection to ongoing improvement"*. Likewise, pupils' engagement is explicitly acknowledged as a valuable input. These references point to leadership as an **affective competence:** the capacity to cultivate belonging, purpose, and resilience. Especially when enthusiasm dips or results lag, motivational leadership becomes essential to sustaining participation and progress.

Connections

The individual competences identified in the initial roadmap as enablers and constraints in the **Connections** dimension are reflected in this table.



We now present our evidence relating to these constrains and enablers.

Knowledge about complex intertwined systems

One intervention stressed the need for "*managing and coping with the complexity*", signalling that actors must be comfortable tracing knock-on effects across ecological, social, and technical layers. Another highlighted that participants deliberately merged "*diverse perspectives within the group to address technical, environmental, and societal aspects of solar energy adoption*." In another intervention, students are recognised as possessing the *"basic elements for the sustainable technologies"* and having experience in critical thinking and problem-solving approaches. This enables them to connect classroom theory with real-world feedback.

Skills to assess critically own and cultural assumptions

Some interventions worked to shift everyday norms: "*cultivating a sense of environmental responsibility and waste separation as a norm within the school community*," or fostering a "*community-wide mind-set that values cycling as a sustainable and healthy mode of transportation*." In another intervention, students were invited to review data and "*assess the operation of these devices*," forcing them to question default practices. Such reflection helps actors notice blind spots; for instance, the cultural belief that biking is unfashionable or unsafe.

Positive attitude towards the work of framing the problem:

"Adaptability to changes" was listed among the desirable competences in one of the interventions. In another, those involved (designers/architects, researchers, etc.) were expected to have an open mind, "*ready to communicate the viewpoints of their disciplines about green transition, open to different views, and prepared to negotiate the interdisciplinary goals (…) accepting their own learning process."* Momentum increases when participants regard framing and re-framing as worthwhile in itself. Leadership reinforced this stance: "[the team] *should monitor the effectiveness of communication activities, gather feedback from participants,"* treating evaluation as a continuous, constructive exercise.

Inadequate education on technical ecosystems

In interventions with technical components, specific competences were required to analyse data and manage information. One case explicitly cites the necessity of *"Ability to interpret and analyse consumption data, apply mathematical and scientific concepts,"* referring to the students having skills in energy consumption data analysis. The lack of such skills can undermine the results: inadequate practices such as *"Poor data collection, analysis, and management"* were warned as a risk that *"could undermine… outcomes."*

Too optimistic or too pessimistic attitude towards technological solutions

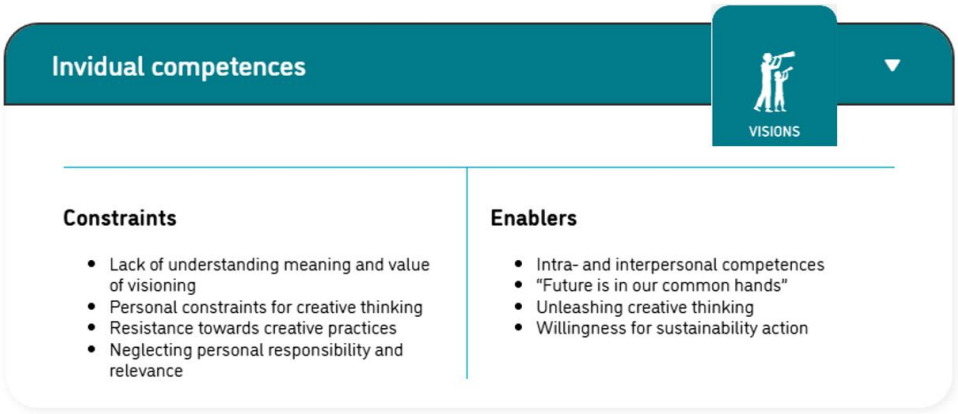
Several interventions warn that skewed expectations about technology—whether techno-utopian or techno-fatalistic—can derail progress. Interventions dealing with the installation of solar panels feared "*rapid advancements in solar technology could make current systems outdated sooner than expected*," revealing paralysis born of assumed obsolescence.

NEW CONSTRAINS AND ENABLERS FOR Connections

Beyond the ones in the initial version, we could not find any further relevant drivers and/or barriers for this dimension of the roadmap.

Visions

The individual competences identified in the initial roadmap as enablers and constraints in the **Visions** dimension are reflected in this table.



We now present our evidence relating to these constrains and enablers.

Intra- and interpersonal competences

Students and teachers who "*collaborate to plan and implement sustainability exercises*" or show "*proactive attitudes*" demonstrate the interpersonal and organisational skills needed for sustainability interventions to succeed. One quote highlights the "*skills to collaborate, communicate and reflect critically*," while others point to pedagogical agency—e.g., "*teachers acquire skills to use ECF4CLIM tools as pedagogical materials and to envision a sustainable future*." These competences are important in ensuring that sustainability does not remain abstract but is instead enacted through everyday decisions.

Future-oriented vision and competences anchored in institutional commitment ("Future in our common hands")

On the individual level, through our interventions pupils and teachers are acquiring different knowledge for the future like "*knowledge about photovoltaic technology systems*," and teachers gain "*skills to use ECF4CLIM tools as pedagogical materials and to envision a sustainable future*." These competences indicate not only technical understanding but also anticipatory thinking—essential for linking pedagogy to long-term sustainability goals. This is bolstered by **normative leadership:** "*the decision of the vice rector that the curricula for 2024–2027 are to be drafted so that all future graduates will have necessary understanding for the promotion and development of sustainability*."

Unleashing creativity thinking

For example, in the context of a just transition and climate education, the need for *"critical thinking skills to analyse complex societal and environmental challenges and propose solutions"* was highlighted. Likewise, creativity was valued for visualizing ideas and designing proposals (in an intervention on solar energy, the ability to *"think creatively and visualize ideas through drawings"* was requested). Higher-order thinking competences (analysing, questioning assumptions, imagining alternatives) are considered important in practice, especially in interventions aimed at solving complex problems where simply following instructions is not enough.

Willingness for sustainability action

The reports from interventions emphasize the need to maintain high interest: *"Pupils' motivation and willingness to learn and put into practice the knowledge acquired"* was essential in educational activities (visits, gardening, etc.). On the contrary, the lack of motivation is directly identified as a cause of problems. In one high school, the risk was observed that students might show apathy and consider the actions *"irrelevant"* on a personal level. Even designated figures for leadership, such as student environmental coordinators, can falter: the *"lack of motivation of environmental coordinators"* is mentioned when the program is long, as they may *"neglect their functions"*. High motivation acts as a driver, while demotivation or negative attitudes (disinterest, scepticism, considering the project *"boring"* or extra-curricular) act as a true brake.

Neglecting personal responsibilities and relevance

Quotes such as *"teachers are not interested in facilitating the discussions*," "*the assessment of the intervention does not interest anybody*," and "*the city traffic office is not interested in cooperation*" highlight how actors actively disengage. This denial is often justified by overload: "*there is not enough time and energy to take these steps*," and *"students cannot invest their scarce time*." Even when support is provided: "*ECF4CLIM has provided time resources"*—questions remain about continuity. The lack of ownership and prioritisation leads to implementation gaps, where *"no suitable time [is] found for the meetings"* and roles remain unclear— *"who should do what?"* Without a clear sense of shared responsibility, sustainability becomes marginal, vulnerable to institutional habits and perceived as external to core educational duties.

NEW CONSTRAINS AND ENABLERS FOR Visions

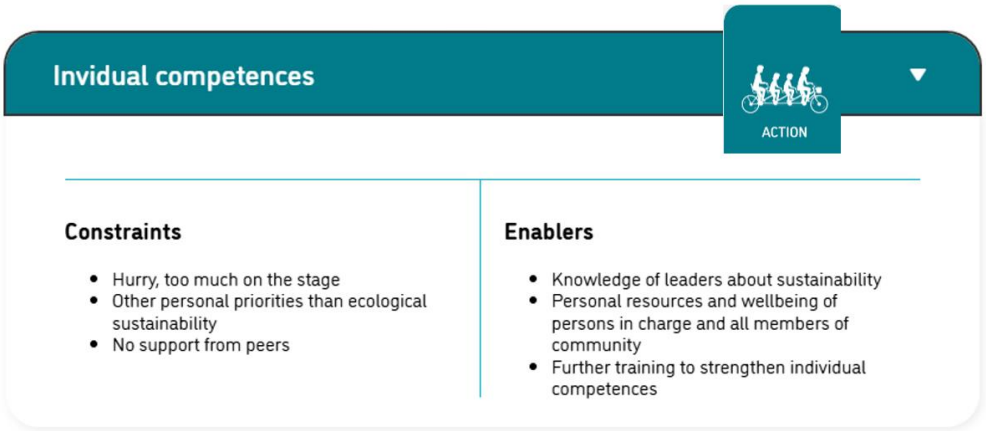
Next, we present further evidence from our interventions that somehow expand the knowledge, skills and attitudes considered in the initial roadmap.

- **Resilience and adaptability in uncertain environments:** 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."*

- **Learning and innovation capacity:** competence to learn new things and handle uncertainty. In some interventions, participants had to assimilate novel technologies or approaches. It is mentioned that those involved should be able to *"handle new technology or methods, [and] creatively address challenges,"* which implies flexibility in adopting unknown tools (for example, sensors, applications, innovative materials) and in overcoming unexpected challenges in a creative way. This technical adaptability goes hand in hand with critical thinking: whoever can continuously learn and reinvent their approach will contribute to the smoother execution of the intervention. Conversely, although it is not frequently stated, the lack of adaptability underlies many failures – as mentioned, resistance to change is a symptom of the absence of this competency.

Action

The individual competences identified in the initial roadmap as enablers and constraints in the **Action** dimension are reflected in this table.



We now present our evidence relating to these constrains and enablers.

Personal resources and wellbeing of persons in charge and all members of community

One example describes how *"headmaster [is] supporting and networking to organise the system, [e.g.] buying and ordering functional recycling bins…"* – illustrating a headmaster who provides resources and coordinates the logistical implementation (in this case, to improve recycling in the school). Likewise, *"teachers and headmaster allocating time for sustainability education"* evidences leadership by integrating sustainability into the academic planning (dedicating time in teachers' meetings, etc.). Distributed leadership is also valued: the quote *"leadership skills of the headmaster and leader teachers to promote positive attitudes…"* indicates that not only the headmaster but also leading teachers capable of motivating colleagues and students are crucial. In university contexts, the role of central administration supporting projects is mentioned.

Further training to strengthen individual competences

For example, in a sustainable mobility program, it was necessary to have trainers with experience in cycling: *"competent instructors with the necessary expertise to teach bicycle riding effectively and safely."* In another case, the implementation of energy improvements in a school building required that teachers and staff acquire *"skills for more sustainable control of the climatisation system"*. Beyond generic skills, each intervention may demand specific technical competences (cycling pedagogy, management of air conditioning systems, computer knowledge, etc.), without which the practical measures could not be executed correctly.

Overload and time pressure (Hurry, too much on the stage)

Sustainability initiatives often fail due to individuals' limited capacity to manage time within overloaded school environments. The competence to prioritise tasks, coordinate schedules, and balance roles is crucial when *"there is not enough time and energy to take these steps"* or when *"students cannot invest their scarce time in the team meetings*." Repeated quotes highlight time pressure as a key constraint: "*No time and no interest*," "*lack of time to do everything*," and "*teachers prioritise other things*." Even with support—e.g., "ECF4CLIM has provided time resources as monetary compensation"—long-term continuity is uncertain without internal time-management skills. Projects suffer when scheduling misaligns with school rhythms: "*everything was installed, but the involvement of students and teachers was not taken into account.*"

NEW CONSTRAINS AND ENABLERS FOR Action

Next, we present further evidence from our interventions that somehow expand the knowledge, skills and attitudes considered in the initial roadmap.

- **Clear communication and outreach as 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 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.

- **Digital and technical fluency to sustain operational capacity:** Digital tools—from communication systems to environmental sensors—are indispensable to modern sustainability practice. However, projects falter when actors lack technical fluency. Several statements identified barriers: "*technical competences for communication"* or "*technical constraints of communication*." 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 on which project success depends.

- **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 infrastructures (bicycle parking areas). Other cases mention collaborations with companies or external suppliers (*"external contractors or suppliers"* for sustainable technology). Interventions that managed to involve municipalities, organizations, or external experts expanded their impact, whereas where this collaboration was lacking (for example, 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 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.

Conclusions

Two main conclusions emerge from the exploration of our empirical evidence on drivers and barriers towards the ones initially suggested in the roadmap. On the one hand, the evidence

conclusively confirms the relevance of the individual competences suggested in the initial roadmap. On the other, the evidence offers ways to strengthen the initial roadmap, whether by adding new enablers and/or constrains or refining existing ones.

Next, we illustrate how the empirical evidence validates or expands upon the individual competences comprises in different steps in the initial roadmap

Engagement

Our findings show that several key factors help or hinder engagement with sustainability, as noted in the original roadmap. A strong understanding of basic ecological ideas—like saving water, using renewable energy, cutting carbon emissions, and protecting biodiversity—is essential. The evidence also shows how important is that participants know how to guide open and inclusive conversations about sustainability values. This means being able to work well with others, communicate clearly, and think critically together. Good communication and listening skills are especially important in our interventions. They help bring different people into the conversation, support better decision-making, and make everyone feel responsible for the outcomes. On the other hand, we identified real challenges. Negative attitudes, cultural resistance, and slow-moving institutions can block progress. When sustainability was seen as unimportant or separate from the school's main goals, fewer people got involved and the impact is limited.

NEW

- *Analytical reasoning and data literacy as pillars of evidence-based action*
- *Motivational leadership to maintain collective momentum*

Connections

Our findings highlight key factors that constrain or enable sustainability efforts, as described in the original roadmap. Skills like understanding data and using math or science are very important in our interventions; when these are missing, it can hurt the success of a project. Just as important are positive attitudes, such as being open to change and seeing sustainability challenges in flexible ways. The evidence suggests that people who can look at problems from different angles are better at dealing with the complex nature of sustainability. Our examples indicate that a good understanding of how environmental, social, and technical systems are connected also helps participants think critically and solve problems more effectively. Finally, we also found evidence that having realistic expectations about technology helps avoid relying too much—or too little—on tech solutions, and this could lead to smarter and more balanced planning.

NEW

Beyond the ones in the initial version, we could not find any further relevant drivers and/or barriers for this dimension of the roadmap.

Vision

Our findings support the constrain and enablers suggested in the initial roadmap. Data from our interventions show how the ability to imagine a better future—and the personal attitudes that support it—can either help or block progress toward sustainability. First, *intrinsic personal motivation* is key. According to our evidence, when students and coordinators are genuinely interested and willing to apply what they learn, they put in the time and energy needed. But when people see the actions as unimportant, interest fades quickly. Second, *creative and critical thinking* are essential in our interventions. Projects that encouraged participants to analyse problems and come up with their own ideas showed that real change requires more than just following instructions—it needs thoughtful, imaginative solutions. Third, *personal and social skills* like taking initiative, working well with others, communicating clearly, and reflecting on actions helped turn ideas into real changes in daily life. On the other hand, when people avoid taking responsibility—like teachers not supporting group discussions—plans often stall. Finally, our evidence suggests that a *clear vision for the future* that's supported by the institution makes a big difference. For example, a university leader decided to include sustainability in all future courses, showing how strong leadership and individual effort can work together to make lasting change

NEW

- *Resilience and adaptability in uncertain environments*
- *Learning and Innovation Capacity*

Action

Our evidence clarifies *why* several enablers and constraints flagged in the original roadmap are decisive once plans move to implementation. First, the presence of informed and committed leadership is indispensable; projects thrive when a head teacher, university administrator, or student champion *"embodies environmental leadership,"* secures resources, and keeps momentum alive. Second, the availability of practical support—time allocations, budget lines, and physical infrastructure—translates vision into operational reality; examples range from headmasters ordering functional recycling bins to teachers carving out classroom time for sustainability lessons. Yet our cases show that these gains evaporate without peer endorsement: passive or absent leaders ("functions neglect of the sustainable development department's head") leave teams directionless. Third, targeted *skills training* is often mandatory: competent cycling instructors or staff able to manage advanced HVAC systems illustrate that context specific know how matters. Finally, chronic *overload and time pressure* remain the most pervasive constraint; without personal time management competences and clear scheduling, even well-resourced projects stall.

NEW

- *Clear communication and outreach as enablers of sustainability*
- *Digital and technical fluency to sustain operational capacity*
- *Cooperation and negotiation skills*
- *Organisational and project management skills to turn visions into reality*

5.4. Are individual competences actor-dependent?

This section aims to identify the different individual competences exhibited by each actor. As described in the 'Methodology' section, during Session 5 of the SCTs and SCCs, every DS collaborated with the research team to pick one or two interventions for detailed scrutiny. Participants then took part in a role-play designed to prompt reflection and group discussion about how those interventions affected sustainability competences at their respective sites. By assigning each person a distinct role, the exercise not only surfaced concrete insights into the constraints and opportunities encountered but also guaranteed that every viewpoint was voiced.

The findings that follow derive from structured observational and data-recording protocols applied throughout the role-plays. During and after each SCT/SCC5 session at all DS locations, research teams used the task leader's template and their comprehensive field notes to compile reports. Because the role-play concentrated on a limited number of interventions, the evidence relates solely to those selected, rather than the full suite of interventions at each site. All participant identities have been protected through pseudonymisation codes. It's also important to note that all the results mentioned in the next section come from the role play, and not directly from activities at the DS.

An illustrative table with examples and evidence gathered from the role-play is attached at the beginning of each section.

The table below summarizes the kinds of individual competences that, according to our empirical evidence, proved particularly relevant **for students** within our educational communities.

Individual competences	Evidence from our role-play	Illustrative quotes
Technical skills with renewable-energy technologies	Installing or maintaining solar panels or water-saving sensors	In P02-LQ, the solar-panel project led to enhanced student technical skills … they could now explain how photovoltaic energy works."
Project-planning and organisational ability	Scheduling garden tasks, mapping tree-maintenance rosters, or coordinating peer teams	"…the same school (P02-LQ) also practised scheduling tasks and planning the installation timeline for the panels."
Pro-active resource-saving attitudes & behaviours	Advocating recycling at home or reducing on-campus energy use	"Pupils reported adopting more proactive attitudes towards saving resources after the project."
Hands-on sustainability practice	Gardening, tree care, school-garden upkeep	"At P04-LG, many students gladly took on daily garden tasks such as watering and weeding."
Sense of ownership & stewardship responsibility	Gardening, tree care, school garden upkeep	"P03-LF students assumed full responsibility for watering and caring for the newly planted trees."
Critical thinking & evidence-based decision-making	Analysing real world problems and justifying solutions with data	"A sustainability course at P02-LY equipped older students with critical-thinking and decision-making skills through real-world problem solving."
Creative problem-solving & event organisation	Radio school campaigns, recycling fairs, etc.	"P01-LA pupils created an eco-team and even organised a vegan tasting event to promote plant-based diets."

Communication / ambassadorial outreach	Influencing families, running radio spots, mascots, etc.	"P04-LT students effectively influenced their families' recycling and resource-use habits."
Peer motivation & leadership	Student clubs, teams	"The student-led eco-team became a hub of peer motivation that mobilised classmates for green actions."

According to our evidence, first, a subset of students across the participating educational communities developed **hands-on familiarity with small-scale renewable-energy and efficiency technologies**: assisting in mounting photovoltaic modules, helping install water-saving irrigation sensors in school gardens, checking basic connections, and learning to recognise malfunctions so they could suggest simple fixes. Second, students strengthened **project-planning, organisational and team work competences** as they devised rotation rosters for garden maintenance, mapped tree-watering and pruning calendars, allocated shared tools, and coordinated peer crews during community action days— practicing how to estimate time, plan steps, and work together to complete tasks. Third, our findings suggest that many of our students showed shifts in **pro-environmental attitudes, norms, and everyday resource-saving behaviours.** They advocated for waste separation at home, modelled reduced energy and water use on campus and started encouraging their classmates and family members to do the same. Fourth, several interventions embedded **practical ecological maintenance competences**— students prepared beds, composted organics, sowed and transplanted seedlings, watered newly planted trees through vulnerable establishment periods, managed irrigation, and even ran plant-based (vegan) tasting activities that linked food choices to ecological footprints.

Fifth, the results suggest that, through the activities and participatory process, some students developed a strong **sense of care and responsibility in managing shared resources**: Young people who had planted or 'adopted' trees or garden areas took responsibility for them. They set up watering groups during hot weather, reminded others to turn off the hose properly and cleared up litter, showing that they were becoming guardians of the space. Sixth, structured reflection cycles—most explicitly documented in the Romanian university role-play but evident elsewhere—supported **critical, analytical, and evidence-based decision-making competences.** Students compared growth, water-use, or waste-volume data, debated intervention options, and justified preferred actions using observed evidence rather than opinion alone. Seventh, across sites some of our students exercised **creative problem-solving, innovation, and event-organisation competences**: they created sustainability segments for the school radio, used mascots to tell stories to younger students, organized low-cost recycling fairs, and reused discarded materials to make signs and learning tools—helping boost participation when interest dropped. Eighth, according to our evidence some students cultivated **communication, advocacy and community-influencing competences**: pupils facilitated class workshops, demonstrated sorting to families, co-presented at parent meetings, produced age-appropriate materials (posters, short skits), and extended discussion into neighbourhood networks. Ninth, the spontaneous formation (or teacher-supported continuation) of student-led sustainability clubs—such as eco-teams—illustrates **peer motivation, youth leadership, and sustained collective agency competences**: motivated small groups brought their peers together, kept track of tasks outside of class time, involved younger students and kept thing going during school breaks, showing early signs of self-organisation.

Overall, the findings suggest that **students' capacity to make a difference** is most powerfully activated when experiential stewardship leads to personal attachment. When students feel responsible for a living system or shared resource, they willingly mobilise their technical know-how, organisational planning, critical analysis, creativity, and communication skills to protect and improve it—and these competences reinforce one another in a positive feedback loop that extends from the school site into households and local communities.

The table below summarizes the kinds of individual competences that proved particularly relevant **for teachers** within our educational communities according to our empirical evidence.

Individual competences	Evidence from our role-play	Illustrative quotes
Integrating sustainability into the curriculum	Embedding climate, recycling or gardening themes in lessons	"In P01-LA, a few highly motivated teachers laced climate and recycling themes into their lesson plans
Creating bespoke teaching materials & units	Tailoring worksheets, experiments and field tasks to local contexts	"At P03-LO, proactive teachers prepared bespoke environmental worksheets to bolster student awareness."
Modelling sustainable behaviour	Separating waste correctly, tending the school garden, or hosting vegetarian tasting	"Dedicated teachers became positive role models, openly practising what they preached—separating waste, tending the garden."
Leading extracurricular / project-based learning	Garden clubs, recycling markets, tree-planting campaigns or "climate-radio" broadcasts	"Teachers of P04-LG drove success by holding outdoor lessons in the garden and motivating pupils to join garden clubs."
Managing technical interventions	Scheduling contractor visits for solar-panel installations, arranging tool logistics or supervising sensor deployment	"In P02-LQ, teachers guided students through the solar-panel installation, helping them diagnose practical problems."
Peer inspiration & collegial leadership	Mentoring hesitant colleagues or sharing lessons	"Motivated staff shared ideas and mentored hesitant colleagues, whereas others 'showed little motivation', exposing a leadership gap."
Subject-matter expertise in sustainability tech	From photovoltaic basics to horticultural care	"Some teachers of P03-LO felt unable to explain how the new panels worked—highlighting the need for stronger technical expertise."

Our findings indicate that teachers emerged as pivotal "competence multipliers." Where individual educators excelled, they integrated **sustainability into the curriculum**, embedding climate, recycling or gardening themes in everyday maths, language and science lessons rather than treating them as add-ons. Many went further by **creating targeted teaching materials** and full learning units on environmental topics, tailoring worksheets, experiments and field tasks to local contexts. According to our evidence, such attention to detail in the curriculum supported students' understanding of the subject matter and its civic relevance. In parallel, **effective teachers modelled sustainable behaviour**—separating waste correctly, tending the school garden, or hosting vegetarian tasting evenings—thereby turning abstract messages into visible daily routines. Our findings suggest that these role-model actions are especially influential in socialising younger students into new norms.

Beyond the classroom, leading teachers organised and steered **extracurricular or project-based learning activities**: garden clubs, recycling markets, tree-planting campaigns and "climate-radio"

broadcasts. Such initiatives not only multiplied practice hours but also displayed real-world applications of curricular content. We found that that success often depended on teachers' capacity for **project-management and organisational guidance** of technical interventions—for example scheduling contractor visits for solar-panel installations, arranging tool logistics, or supervising sensor deployment. It seems that when this skill was present, new technologies were successfully introduced and used as hands-on learning tools. When it wasn't, the equipment and learning opportunities were underused. An additional amplifier was **peer inspiration** and collegial leadership. Motivated teachers mentored hesitant colleagues, shared lesson plans and co-taught workshops, gradually normalising green pedagogy across departments. Finally, the most impactful staff demonstrated solid **subject-matter expertise** in sustainability technologies—from photovoltaic basics to horticultural care—allowing them to answer probing student questions and link hands-on tasks to underlying science. Conversely, competence gaps in these seven areas (especially time pressures, uneven technical know-how, or limited willingness to model behaviours) regularly stalled project momentum and created a two-tier faculty where a few enthusiasts carried the burden.

Teachers are *competence multipliers* when they integrate sustainability themes across subjects and pair this pedagogical integration into the curriculum with strong planning. By organising and supervising locally grounded, hands-on activities—gardens, recycling drives, tree-planting, "climate-radio" broadcasts—and managing the logistics that link classrooms to sensors, solar visits and other equipment, they convert technical-material assets into everyday learning tools. Visible role-modelling of correct practices turns lessons into daily routines and socialises younger students into shared norms, an effect amplified when motivated teachers mentor colleagues and share materials across departments. Where this integration-plus-organisation competence is weak, sustainability stays peripheral and equipment is underused.

The table below summarizes the kinds of individual competences that proved particularly relevant **for school and university leaders** within our educational communities according to our empirical evidence.

Individual competences	Evidence from our role-play	Illustrative quotes
Strategic vision & long-term integration	Embedding garden work or teacher training in annual plans	"Strong leadership was a cornerstone: the principal of P02-LR championed the water-saving intervention and tied the results to broader school goals."
Resource mobilisation & funding	Tapping municipal grants or specialist contractors	"The principal of P03-LO proactively sought municipal help to hire gardening specialists and secure maintenance resources."
Stakeholder coordination & networking	Building strong partnerships between teachers, parents or city services	"At P04-LG, the school management involved the municipality in discussing infrastructure improvements for the garden."
Leading by example & personal engagement	Principals watering trees or attending eco-club meetings	"The deputy headmaster of P01-LA personally attended student meetings, signalling top-level commitment."
Policy-setting & responsibility allocation	Creating duty rosters or maintenance contracts	"At P03-LF, the principal created a clear responsibility matrix between students, staff and the contracted gardening company."

Project planning & operational management	Scheduling panel installers, synchronising bin deliveries or supervising maintenance cycles	"At P04-LT, headmaster's careful planning 'facilitated the smooth implementation' of recycling and renewable-energy projects."
Financial / administrative balancing	Reconciling green ambitions with hard budgets	"The management of P03-LP warned that more recycling bins meant extra collection rounds and staff time the budget had to absorb."
Bureaucratic navigation & regulatory compliance	Handling permits or inspectorate paperwork to link projects to "green school" accreditations	"The principal of P02-LW underestimated the red tape involved in becoming a registered solar-energy producer."
Culture-building & community motivation	assemblies, newsletters or celebration events	"Expectation-setting by the principal of P03-LF helped create an emerging norm of caring for campus greenery."

Our findings suggest that school and university leaders acted as institutional keystones, and that their influence can be read through several intertwined competences. Successful principals and rectors articulated a **strategic vision** that wove sustainability into the organisation's long-term identity – for example, principal of P03-LO explicitly embedded garden work and teacher training in the annual plan, ensuring the project would outlive any single cohort. Second, they showed skilful **resource mobilisation and external fund-seeking**, tapping municipal grants or specialist contractors so that initiatives such as P04-LT's solar-plus-recycling package could proceed without draining core budgets. Third, many leaders excelled in **stakeholder coordination and networking**, forging working triangles among teachers, parents and city services (e.g., local waste authority collaborating with P03-LP). Fourth, according to our evidence, the most credible managers led by example through visible **personal engagement**: principals who watered trees or attended eco-club meetings legitimated the work. Fifth, they **set clear policies** and assigned responsibilities by creating duty rosters or maintenance contracts, so everyone knew who did what. This helped keep the tree-planting project at P03-LF on track. Sixth, **robust project-planning** and operational management kept technical roll-outs on schedule – scheduling panel installers, synchronising bin deliveries, and supervising maintenance cycles. Seventh, our data indicates that administrators had to perform constant **financial and administrative balancing**, reconciling green ambitions with hard budgets; the P03-LP Rectorate openly calculated the added cost of extra waste-collection rounds before approving campus-wide recycling. Eighth, they practised **bureaucratic navigation** and regulatory compliance, handling permits or inspectorate paperwork that linked projects to national "green school" accreditation. Finally, visionary heads invested in culture-building and **whole-community motivation,** normalising eco-habits through assemblies, newsletters and celebration events that reinforced norms beyond one-off campaigns.

Our evidence suggests that where these competences were weak, progress stalled. Budget strains or cautious leadership sometimes dampened momentum (e.g., a P01-LA principal's fuel-hungry "turbo" car undercutting his message, or P03-LO leaders hesitating for fear of parental backlash). Overall, the cases show that administrators who combine strategic vision with practical project governance can transform scattered eco-initiatives into resilient, institution-wide change.

The table below summarizes the kinds of individual competences that proved particularly relevant **for parents & community** within our educational communities according to our empirical evidence.

Individual competences	Evidence from our role-play	Illustrative quotes
Reinforcing children's green habits at home	Internalising children's lessons, adapting domestic routines or offering material resources to school initiatives	"P02-LR parents fixed leaks and adopted water-saving practices after listening to their children."
Providing hands-on help & material resources	Donating tools, seedlings or time	"P04-LG parents volunteered weekend labour and donated seedlings for the school garden."
Co-creating awareness activities	Designing joint recycling contests, parent–student workshops, and feedback surveys	"At P03-LO, parents proposed home recycling challenges and parent-student workshops."
Positive attitudinal support & moral encouragement	praising vegan tasting stands, displaying garden photos or expressing pride	"P01-LA families expressed pride in their children's eco-club work and vegetarian food campaign."
Community engagement & problem-solving partnership	integrating projects into broader community networks	"Parents acted as partners, offering ideas and collaborating on project improvements alongside staff."

We found that parents proved to be the decisive bridge—or, at times, the missing link—between school-based learning and everyday household practice. When fully engaged, they first **reinforced sustainability habits at home** by internalising their children's lessons and adapting domestic routines: families fixed leaking taps, sorted recyclables correctly, and installed water-saving devices after students demonstrated the benefits. They simultaneously offered **hands-on help and material resources** to school initiatives or weekend labour that kept gardens thriving and technical roll-outs on schedule.

A second layer of influence emerged as parents **co-created awareness activities** with teachers and pupils, designing joint recycling contests or participating in parent–student workshops, and feedback surveys. Our data indicates that their **positive attitudinal support** and encouragement—publicly praising vegan tasting stands, displaying garden photos, or simply expressing pride—enhanced children's self-efficacy and maintained peer enthusiasm. The most proactive families even extended their engagement beyond the school gate, collaborating with staff to lobby municipalities, tweak infrastructure, and tackle emerging problems collaboratively.

However, the role-plays also revealed that indifference or resistance from sizeable parent groups can dilute progress; some ignored recycling instructions, mocked campaigns as "nonsense," or questioned the feasibility of school gardens, sending conflicting signals that eroded the pupils' growing competences. Thus, our evidence suggests that the above-mentioned complementary competences must be cultivated across the whole parent body, not just among an enthusiastic minority. The data suggests that structured engagement strategies, such as recurring feedback loops, skill-sharing workshops and explicit invitations to contribute labour or ideas, are essential for transforming classroom-based sustainability learning into long-lasting, community-wide ecological change.

The table below summarizes the kinds of individual competences that proved particularly relevant **for technical staff** within our educational communities according to our empirical evidence.

Individual competences	Ideas from our role-play	Illustrative quotes
Continuous monitoring & gentle enforcement of sustainability rules	Support staff conducted daily campus rounds to remind and correct pupils who forgot to separate waste or transplant seedlings.	"Support staff at P04-LG were on campus daily, correcting pupils who forgot to separate waste or trampled seedlings."
Modelling correct environmental behaviour	Properly using bins or picking up litter	"One janitor made a point of using the appropriate bins and picking up litter, visibly setting the norm."
Practical horticultural / maintenance skills	Suitably watering or caring for plants and trees	"The P03-LF cleaning crew, after brief training, took genuine pride in maintaining the new trees."
On-site mentoring & guidance for students and teachers	The P03-LF janitor provided hands-on mentoring—explaining how to water saplings properly and warning pupils not to pull on branches	"The P03-LF janitor explained how to water saplings properly and warned pupils not to pull on branches."
Technical troubleshooting & joint problem-solving of installations	Collaborating with teachers and students to diagnose glitches and refine installation plans	The facility manager of P02-LQ joined planning meetings and helped troubleshoot the solar-panel installation."
Interdisciplinary collaboration with teaching staff & students	Attending planning meetings or ensuring that operational realities matched curricular ambitions	"Technicians worked alongside teachers and students, letting pupils see interdisciplinary teamwork in action."
Operational initiative & ideas to improve waste-sorting systems	Janitor schemes of waste gathering based on their own experience considering the peculiarities of each school.	"Once recognised, the janitor of P03-LO suggested extra recycling points and organised bin logistics."
Adaptability & willingness to adjust daily routines for sustainability	A P04-LT caretaker proactively reconfigured his workflow—setting up separate bins on every floor to improve waste sorting	"A P04-LT caretaker was 'keen to adjust his routines'—for example, setting up separate bins on every floor."

Our analysis reveals that non-teaching personnel, such as janitors, groundskeepers, cleaners and cafeteria workers, can play a key role in determining the success of sustainability projects in daily practice. First, their constant presence enabled **continuous monitoring and gentle enforcement of sustainability rules**: at P04-LG, a janitor corrected pupils who forgot to separate waste or trampled seedlings, protecting the garden when teachers were absent. Second, by consistently using the correct bins, watering plants on schedule or picking up litter, they **modelled visible pro-environmental behaviour** that set everyday norms for students. Third, our data indicates that some demonstrated practical **horticultural and maintenance skills**—for example, P03-LF cleaning crew learned proper tree-care techniques and took pride in nurturing the new saplings. Fourth, these staff became informal coaches, offering **on-site mentoring and guidance**; the janitor of P03-LF showed pupils how to water correctly and warned them not to hang on branches. Fifth, technicians brought **technical troubleshooting and joint problem-solving capacity**, collaborating with teachers and students to diagnose solar-panel glitches and refine installation plans. Sixth, effective technical staff embraced **interdisciplinary collaboration**

with teaching teams, attending planning meetings and ensuring that operational realities matched curricular ambitions. Seventh, several displayed **operational initiatives**, proposing improvements to waste-sorting systems or suggesting additional recycling points once they felt recognised and incentivised, as happened after leadership introduced small rewards for janitors. Finally, according to our evidence, the most committed workers showed **adaptability and a willingness to adjust daily routines**—a caretaker reorganised his cleaning rounds to accommodate extra recycling bins once expectations were clarified.

Yet competence gaps and unclear role definitions often undermined interventions. In many schools, new tasks such as holiday watering or rooftop panel cleaning were assigned to no one, leaving even willing staff uncertain and frustrated; workload increases without compensation, and lack of training —for instance, cleaners unprepared for safe panel maintenance at P02-LQ— raised occasional disengagement. These shortfalls reveal that technical staff can be decisive allies only when management provides explicit task allocation, training, and recognition.

The table below summarizes the kinds of individual competences that proved particularly relevant **for external stakeholders** within our educational communities according to our empirical evidence.

Individual competences	Evidence from our role-play	Illustrative quotes
Technical expertise & reliable work	Professional installation of solar panels, renewable-energy gear, tree planting	"A specialist solar contractor in P02-LQ installed the panels on schedule and to a high standard."
Specialist scientific / horticultural know-how & innovative ideas	Hardy-plant selection, UV-lamp growing, street-greening concepts	"Experts proposed UV grow lights and NGO advised on drought-resistant plants, broadening the scope of the project."
Infrastructure & policy alignment with local authorities	Providing recycling logistics, cafeteria food reforms or, municipal waste-collection compatibility	The local municipality ensured recycling facilities and pushed for sustainable food options in cafeterias." (P01-LA)
Resource mobilisation & co-financing	Municipal or programme funding, tools or maintenance services	"Municipal backing granted schools access to waste-collection services and small grants they could not raise alone."
Civic-engagement platforms for students	Youth Parliaments or public sustainability forums	"Local authorities created a 'Youth Parliament' on sustainability, giving pupils a public voice." (P04-LT)
Accreditation / endorsement linking to wider "green school" standards	Provide accreditation to the schools that fulfil some green-school requirements	"County school Inspectorates linked school projects to the national 'green-school' accreditation programme."
Constructive external feedback & critical reflection	Highlighting curriculum integration gaps or maintenance risks	"An NGO in P02-LW praised student enthusiasm but warned that without deeper curricular integration the gains could fade."
Reliable coordination & on-time delivery	Meeting deadlines, clear communication, fulfilling contractual duties	"External providers of P04-LT 'adhered to strict timelines and quality benchmarks', giving the school a reliable outcome."

Our findings suggest that external contractors, municipal bodies, civil-society organisations and research institutes can act as catalytic "outsiders. Their **technical expertise and reliable work** were highly appreciated: in P02-LQ a specialist solar firm delivered fault-free panels on schedule,

P04-LT's providers met exacting benchmarks for both PV and recycling systems, turning schools into live demonstrations of clean technology. Complementing this, research centres and NGOs injected **specialist scientific- or horticultural-know-how** and innovative ideas—from hardy-plant palettes to ultraviolet grow-lights and street-greening concepts—that, according to our evidence, encouraged the educational community to think creatively beyond their usual routines.

Our analysis also shows that where municipal authorities cooperated, partners' secured **infrastructure and policy alignment with local services.** P01-LA's city waste authority coordinated changes in cafeteria practices with bin placement, while city council adjusted its waste collection system so that the P03-LP program aligned with the city's waste streams. In some cases, this came pushed with **resource mobilisation and co-financing**, supplying extra trucks, maintenance crews or small grants schools could not raise alone. Some actors went further by creating **civic-engagement platforms for students**—P04-LT's Youth Parliament on Sustainability gave pupils a public voice and embedded classroom learning in community dialogue. Education authorities added accreditation and endorsement linking projects to wider "green school" standards: the County school inspectorate in P02-LQ and P02-LW tied interventions to the national programme, lending legitimacy and nudging curricular uptake. According to our evidence, partners also supplied **constructive external feedback and critical reflection.** NGOs in P02-LW, for example, warned that solar-panel gains could fade without deeper curriculum integration, spotlighting maintenance and pedagogic risks insiders had overlooked. Finally, the best teamwork depended on **good coordination and timely work**. However, when city bureaucracy delayed garden approvals or waste companies mixed sorted and regular trash, trust and student motivation dropped.

In conclusion, our findings suggest that external partners amplify school sustainability when a few competences—workmanship, specialised knowledge, infrastructural alignment, resourcing, civic platforms, formal endorsement, critical feedback and dependable coordination—are present; gaps in any can erode the value of the others and stall momentum.

Conclusions

Our evidence suggests that, across the six actor groups, one individual competence emerges as the 'hinge competence' that unlocks the others.

- For **students:** *personal sense of ownership and environmental stewardship*. When pupils felt responsible for "their" garden beds, solar panels or recycling stations, they spontaneously mobilised peer leadership, refined technical skills and carried the message home, converting an individual disposition into collective norm-setting and hands-on care of material infrastructures.
- Among **teachers:** *ability to weave sustainability organically into the taught curriculum***.** Educators who redesigned lesson plans, experiments and assessments around climate themes created a shared pedagogical framework that other staff could adopt, transforming isolated enthusiasts into a learning community and ensuring that expensive technical equipment—whether photovoltaic kits or moisture sensors—became integral teaching tools rather than idle demonstration pieces.

- For **school and university leaders:** *strategic vision coupled with resource mobilisation***.** Principals and rectors who shared a clear, long-term vision for sustainability—and backed it up with funding, schedules, and policies—helped create a strong support system. This support made it easier for teachers to try new ideas in the curriculum and for students to take care of the environment using working, well-maintained technologies.
- For **parents and the wider community***: habit reinforcement at home*. When families started using water-saving devices or sorting waste—encouraged by their children—they connected what students learned in class with real life at home. This made school projects feel more meaningful to everyone and helped support more technical improvements like adding more recycling stations or smart irrigation systems.
- For **technical staff:** *continuous monitoring and gentle enforcement*. Janitors and caretakers who quietly fixed things like wrong bin use or overwatering helped protect important equipment and showed others the right way to do things. Their careful work supported the culture that students and teachers were trying to create and helped turn technical knowledge into everyday habits
- Finally, for **external stakeholders:** *specialised technical expertise delivered on time and to specification*. High-quality installations by contractors or evidence-based advice from research institutes lent credibility to the entire initiative, reassured school leaders about future maintenance burdens.

Taken together, and in line with our analytical framework, these findings may suggest a three-layer coupling. First, each actor's key competences can initiate change at the *individual* level. Second, that competence catalyses *collective* capacities—shared norms, peer support networks and coordinated routines. Third, collective capacity is what ultimately safeguards and extracts pedagogical value from the *technical-material* layer of sensors, panels, gardens and bins. In addition, where any hinge-competence was weak, the chain broke: material assets languished and collective enthusiasm dissipated. Therefore, in terms of practical implications, our suggestion is that capacity-building programmes pay special attention to these actor-specific hinge-competences and on designing deliberate hand-offs between the individual, collective and material domains.

5.5. Evidence of change

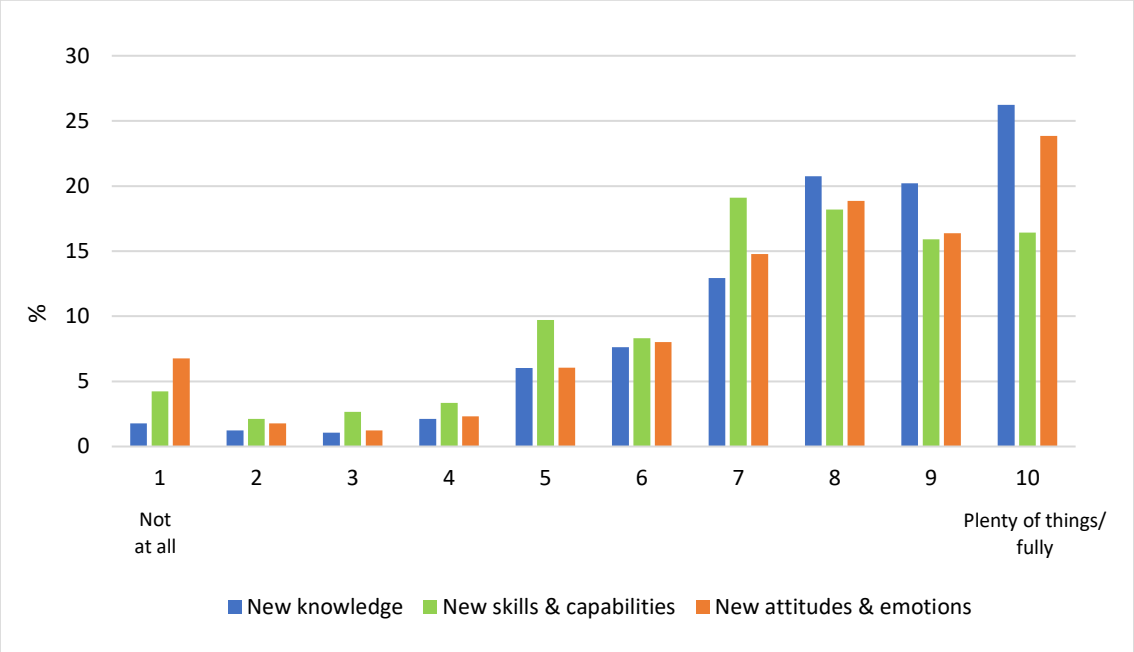
This section aims to analyse and explore how individual competences have evolved throughout the project, based on the results from the intervention evaluations (using short surveys and deliberative workshops) and the interviews with key actors in the different DS. In particular, it focuses on changes in participants' knowledge, skills and capabilities and attitudes and emotions towards sustainability over time.

Short Survey & Deliberative Workshops

To assess the impact of the interventions on participants' sustainability competences, they were encouraged to reflect on how the interventions could had contributed to their acquisition of new knowledge, skills and attitudes through short surveys and deliberative workshops. Once the

intervention had finished, participants were invited to complete a short survey individually and/or join a group deliberative workshop. This section integrates findings from both methods.

The majority of participants in our interventions reported positive outcomes across all dimensions, indicating the perceived overall effectiveness of the specific intervention. In terms of acquiring **new knowledge**, 88% of respondents scored 6 or higher (on a scale from 1 to 10, where 1 means 'not at all' and 10 means 'plenty of things/fully'), suggesting that participants felt that the interventions were well designed and enabled them to learn something new. Regarding **new skills and capabilities**, 77% of respondents gave positive ratings (scores between 6 and 10), reflecting the perceived success of the interventions in enhancing ones' own skills and capabilities. Finally, in terms of **new attitudes and emotions**, 82% of participants scored 6 or higher, suggesting that they perceived the interventions as having changed their views on sustainability.



When asked about the **new knowledge** participants declared they had learned, they highlighted the following aspects:

- **Technical knowledge**. Participants felt that they had acquired a broad range of technical knowledge. This included insights into electricity generation and the functioning of solar panels (*"I know more about how solar energy works")*. Others highlighted their understanding of the *"technical aspects of water sensors"* and the recycling process *("how recycling works", "the glass is not crystal").* Some participants also mentioned gaining knowledge about the natural environment, citing topics such as different "*types of plants, types of rocks"* as well as animal life *("things about the bees" or "how chickens live")*.
- **Sustainability knowledge**. Participants also felt that they had developed a deeper understanding of what sustainability means and how to promote it. As one participant

expressed, they gained *"more knowledge about sustainability"* and now understand *"what sustainability really is"* and *"how to contribute to the improvements of sustainability."* They explored concepts such as ecological footprints, circular economy processes (*"life cycle assessment of technologies")* and the environmental costs. In this regard, p*articipants* recognize the importance of actions such as waste separation and recycling for the environment. The role of renewable energies was also emphasized (*"I consolidated my understanding of how solar power can help the planet"). Thus, they highlighted their understanding on* how everyday actions can impact the environment and the importance of protecting it *("to protect as much as possible the environment").*

- **Eco-systemic thinking.** Participants declared they gained understanding on the interconnections between various systems and actors. Participants expressed *"the importance of multiple actors in sustainability"* or *"the importance of involving the whole community".* Participants also developed a broader awareness of how individual behaviours are embedded in wider energy, environment and society systems. From their narratives, this helped them to move beyond a narrow view of sustainability. *"*[I see] *a clearer understanding of the links between electricity and sustainability performances."*

When asked to reflect on the **new skills and capabilities** they might have acquired through the interventions, participants highlighted the following

- **Practical implementation skills:** Participants considered that they had developed hands-on abilities such as planting (*"I have learned how to plant")*, installing sensors *("how to install sensors")*, making compost ("*how to make compost"),* waste management *("better waste sorting"*) and identifying healthy food (*"distinguish one good egg from another")*.
- **Analytical skills:** Participants also felt they gained analytical skills such as estimating energy and water needs ("*how to estimate the electricity needs"; "to calculate water consumption and costs")*, applying cost models, or interpreting environmental datasets.
- **Digital and data-handling skills:** Participants reported developing a range of digital and data-related skills, including working with specialized software such as GIS software, sensor programming, and advanced spreadsheet functions. Examples include: *"I have learned to use a new software tool, PVGI"; "learning how to use QGIS on my own"; "I have learned how to use Excel."*
- **Communication skills.** Participants believed that they had acquired the practical skills needed to convey and advocate ideas effectively. This includes: simplifying technical concepts through visuals *("to explain in images how solar panels work"; "using drawings to create discussions")*; presenting benefits to family members *("how to present to my colleagues, family and friends some messages on green energy"; "how to transfer the experience from the school to home")*; as well as best communication strategies (*"how to communicate our ideas and results"; "communication about sustainable food transition goals").*
- **Interpersonal and collaborative skills.** Participants also reported developing interpersonal and teamwork competences, including working with others (*"the*

importance of common working (groups) for the success"; "how to collaborate in a group"), and co-designing solutions ("*to learn together by exchanging different views on the same idea"; "greater appreciation for teamwork and participatory design processes").*

- **Environmental decision-making skills.** Participants felt that they had also acquired environmental decision-making skills *("how to solve environmental problems at the local level")*. After the interventions they considered they are able to apply sustainability indicators *("use the indicators for sustainability"; "use the circular economy indicators"),* to choose healthy and local products *("I choose local products of sustainable origin"; "decide which eggs are healthiest using the code on the shell")*, and to practice responsible consumption *("responsible food consumption and recycling"; "increased responsibility for environment")*, among others.

Finally, after the interventions, participants declared they had experienced **new attitudes and emotions**:

- **Eco-responsibility**. Participants expressed increased eco-responsible behaviours and practices, expressing both a sense of duty and greater confidence to act: *"be more ecological"*. They highlighted specific actions, including water conservation, waste reduction, use of sustainable transportation, and care for plants and animals *("to treat animals with care"; "learning to take care of the planet").* They began to recognize personal habits as key leverage points for environmental change. As some participants expressed, *"you have to recycle and reuse clothes"; "you have to waste a lot of water"; "we must stop polluting."* In this regard, participants felt that they were much more responsible after the interventions: *"thanks to this it has made me aware of recycling waste in a more responsible way"; "it has helped me improve responsibility"; "more aware on the impact of daily actions".*

- **Changes in behaviour and mind-set:** Many participants reported a shift in mind-set, recognising that small actions -such as saving water or reusing items- can contribute to significant environmental improvements. As some expressed: *"the value of small changes"; "the importance of our actions on the environment"; "the impact of daily actions".* They also acknowledged the value of long-term individual commitment to sustainability, learning *"how to change daily behaviours".*

- **Curiosity and openness.** Participants expressed a growing interest in exploring new perspectives, alongside a strong motivation to act for sustainability. This was reflected in comments such as *"found new perspectives to look on the reality"* and *"promoting the sharing of knowledge and perspectives was reinforced".* Many also reported feeling "*more motivations to act for sustainability"* and "*motivation to advocate for more sustainable practices."* As one participant mentioned, "*curiosity motivate to participate".*

- **Optimism and hope.** After the interventions, **s**ome participants felt optimistic and hopeful for the future. As they point out: *"more hopeful about the future"; "hope is essential"; "excited to see we can do valuable actions"* and recognize *"the importance of*

sustainability in the future" and the need to "*change the future".* As one participant reflects, *"the world is not ready yet, but we should be happy with the small victories..."*

Some participants felt that **they had not learnt anything new from the interventions**. In these instances, they were invited to explain why.

- **Prior knowledge and lack of novelty:** For some participants, interventions may not have introduced concepts or ideas that were new to them. Those with a strong background in sustainability or related topics might have found the material redundant or not tailored to their level of expertise. This could have contributed to their perception that they did not gain additional knowledge: *"my parents taught me to plant"; "it's my work area"; "I already work in the environmental field"*. They also noted that the content overlapped with that of previous lessons. *"because we'd already done this in our school"; "I have already done it in the 3rd year"*
- **Limited clarity or complexity of content:** Some participants also mentioned the complexity and lack of clarity of the materials presented during the interventions. As some participants mentioned, *"it was all very complicated"; "she explains it very quickly"; "I do not understand"*.
- **Pre-existing convictions.** Participants who entered the activity with strong pro-sustainability attitudes experienced reinforcement. *"I have a robust vision on sustainability"; "I was already very aware"; "I already had a good vision of sustainability"; "my vision didn't change because I already thought sustainably"; "I already had a vision about the importance of sustainability, which this activity reinforced".* In contrast, a small group of participants were sceptical. As one participant said, *"for me there is no such thing as climate change"* while another states that *"there are more relevant things."*
- **Lack of hands-on practice.** Some participants also mentioned the lack of hands-on practice. Skill learning stalled at the informational level, with no opportunity to perform the tasks. As they noted, *"the sessions were mostly theoretical […] no practical spaces that gave the possibility to learn"; "they have only explained how the machines and the process work […] we haven't done anything manual"*.
- **Limited personal involvement.** Some participants remained observers rather than active participants, and the time dedicated to activities was too brief to consolidate meaningful learning: *"I wasn't actively involved for a long time"; "we have only looked."*
- **Unclear relevance and low engagement.** A few participants reported low levels of engagement, finding the activities uninteresting or lacking personal relevance. This led to boredom, reduced motivation, and limited commitment. Some comments reflected a failure to perceive the value of the activities in terms of skill-building or personal growth: *"I didn't find it fun"* or *"it is only a plant".* Others expressed disinterest in passive formats: *"quite boring to sit and watch videos".*

Interviews

As describe in the 'Methodology' section, to deepen understanding of individual competences and encourage further reflection within our educational communities, we designed an interview protocol for use with selected representatives from each DS who had been involved in the project from the outset. As also mentioned earlier, to capture age-specific perspectives, we designed two interview protocols: one for primary school students and another for secondary and university students, teachers, administrative staff, and other members of the educational community. This section presents the findings from each group separately.

Kids

Knowledge gains

Across the interviews, answers reveal repeated references to **new facts or clearer distinctions** that students now apply in everyday life. One student, for instance, explains, *"when I was younger I confused plastic with glass and now I separate them"* illustrating an explicit gain in technical recycling knowledge. Several students speak of fresh insight into resource use. A student reports, *"I started to look at energy not only as a service but as a resource that we must take care not to waste"* while another notes that *"now I think more about where electricity comes from".*

Even briefer answers still contain evidence of **conceptual advances.** One student states *"we became more knowledgeable about the topics and more careful, for example with recycling",* and another observes simply *"I think it improved",* a concise but direct acknowledgment of learning. Where knowledge fuels sustainable thinking, it is voiced through causal reflections such as a student's statement that schoolmates now consider "*what exactly happens when you throw trash on the street",* signalling a growing grasp of knock-on effects. Even those who perceive limited change in practice recognise fresh information: One student concedes that "*more information has become available, which has had an impact on decisions and ways of thought".*

Skill and capability gains

Practical implementation skills surface whenever students describe concrete sustainable actions they now perform. A student describes nurse-like care for plants: "*when a plant is sick … she brings it back with care",* demonstrating hands-on competence. Similarly, another student highlights routine waste sorting: "*now when I have trash… I dispose of it in a recycling container when I can*". Traditional household skills are refined, too. One student says "*not leaving lights on. Not letting the tap run*".

Analytical and problem-solving abilities emerge in longer reflections. One student describes learning *"how to deal with complicated elements, how to manage the challenges that arise in an activity or project",* while another links new reasoning to health and collective confidence: *"now I realize how important it is to protect nature … we are healthier and more confident in what we can do together*".

The capacity for **communication and advocacy** is equally evident. One student says she *"talk[s] to my family about what we can do",* while another stresses persuasion: "*I try to convince others of the changes in caring for the environment".*

Attitude and emotion shifts

Most students report a heightened **sustainable mind-set**. A typical comment from a student is that their classmates "*think twice before acting",* echoing another's view that peers are *"more aware, and you can see it every day at school*". Eco-responsibility often blends with **optimism.** A student notes that even limited progress counts: "*even if only a few changed, that's already good".* Personal commitment is evident in phrases such as *"after the recycling competition I improved how I recycle"* or *"I do not waste as much, and I try to convince others"*. Curiosity and openness resonate through students who wanted still more engagement; for instance, a student concedes behaviour has not shifted yet but acknowledges a readiness*: "maybe we know a little more"*. Another student is more explicit in their optimism, assuring us that the class is *"more determined to do [eco-tasks] every day".*

Barriers and limitations to change

Yet several excerpts highlight constraints. One student frankly states that "*the behaviour hasn't changed*" among classmates, and another judges that personal improvement in recycling owes more to external factors than to the project (*"there are other reasons for that").* Lack of broad participation recurs: a student observes *"those involved became more aware, the others didn't",* a theme echoed by another, who laments classmates *"aren't interested*" because they were *not involved*. Prior knowledge forms a ceiling for one interviewee who insists "*I have always acted sustainably and had that mind-set",* limiting perceived personal gain. A subtler limitation is uncertainty: a student admits it is "*hard to think of an example*" of changed practice *"despite greater information"*, hinting that knowledge alone did not automatically translate into action.

Adults

Knowledge gains

Broader and clearer understanding of sustainability: Many participants reported that their conceptual understanding of sustainability had expanded throughout the project. Several interviewees initially had a narrow or confused notion of sustainability, often equating it only with recycling or other isolated actions, and later developed a more nuanced grasp of the concept. For instance, one teacher confessed that *"before I didn't really know what it was… I mixed it up with recycling, the SDGs, more mixed and abstract concepts*", but after the project *"now [she] understands it more as respecting the environment and surroundings, altering them as little as possible"*. In some cases, participants learned new frameworks and terminology that helped clarify sustainability. A university teacher highlighted that the project *"introduced GreenComp as a central framework… a useful tool when trying to understand the entirety of sustainability pedagogy",* suggesting that exposure to structured sustainability competences enriched his knowledge base.

Holistic and systemic perspectives: A strong theme was the evolution from fragmented views to a more eco-systemic understanding of sustainability. Participants came to recognize the interconnections between different dimensions (environmental, economic, and social) and the need for collective action. One student described how his perspective *"shifted understanding from individual actions to systemic thinking involving tech, policy, and collective behaviour"*, moving beyond a focus on personal eco-habits to see the bigger picture. Another student

confessed that *"at the beginning, I was convinced that the promotion of sustainability can only be done institutionally… Now I am aware that I can promote sustainable behaviour".* Teachers echoed this broadened outlook. A Romanian teacher who initially saw sustainability merely as a school management issue came to view it "*as a collective responsibility requiring individual action*".

Technical and practical knowledge: Alongside conceptual gains, participants acquired concrete knowledge about environmental topics and practical solutions. Through hands-on activities and project experiences, they learned specifics about waste, water, energy, and other sustainability issues. For instance, one student reported, "*we realized that 'recycling, reuse, regeneration' is not an advertising slogan, it is a daily action, a normality in which to live. I learned that every drop of water is important. [And] that reducing the carbon footprint can be done… through lower consumption*". Others mentioned learning about sustainable technologies and practices. Several participants were impressed by demonstrations such as visits to recycling facilities or eco-sites; one teacher described a recycling plant visit as "*impressive how everything was recycled",* an experience that stuck with students and *"promoted a change of behaviour at home"*.

Skill & capability gains

Problem-solving and practical implementation skills: A number of participants, especially students, developed new skills and confidence in practical problem-solving through their project activities. The hands-on projects and collaborative tasks taught them how to plan and execute sustainability initiatives. One student reflected, *"in my case, I managed to learn how to approach a practical activity, how to find solutions…*". Another student reported that participation "*broadened my knowledge of reference projects and sustainable building techniques"*. Teachers and staff members also observed an increase in participants' practical skills.

Communication, collaboration and advocacy: The collaborative nature of the project and its emphasis on community involvement, helped to strengthen participants' interpersonal and communication skills. Several interviewees mentioned that the ECF4CLIM project created platforms for discussion, debate, and sharing ideas, thereby improving their teamwork and advocacy skills for sustainability. A teacher explained that "*it allowed more debate and genuine involvement. It increased knowledge and the ability to share it".* This highlights how students and teachers learned to articulate their ideas and educate others by participating in workshops, meetings, and campaigns. A university researcher similarly noted that his understanding of *"the centrality of collective competences has been strengthened",* recognizing that working together and pooling skills is critical. Some participants became more proactive in engaging others: for example, a teacher said, *"I keep the conversation going about sustainability and moderation"* in daily life, and another shared how he now raises awareness in both home and school settings.

Attitude & emotion shifts

Adoption of eco-responsible behaviours: A major outcome across interviews is the shift in attitudes leading to tangible behaviour changes. Many participants became more environmentally responsible in their daily habits, reporting that they now act in greener ways and pay closer attention to their environmental impact. For example, one teacher noted, "*I reuse materials, avoid wasting resources, and encourage students to adopt similar behaviours"*. Others

mentioned specific lifestyle changes: *"I started recycling more,"* confessed one school administrator plainly, while a student volunteered, "*I eat more vegetarian food. I avoid fast fashion more"*. These concrete examples (choosing sustainable diets, reducing consumption of cheap clothing, diligently sorting waste) demonstrate that the project successfully translated knowledge into practice.

Increased environmental awareness and mind-set change: Participants frequently used phrases like "*more conscious*," *"more aware",* and "*becoming aware"*. For instance, a teacher remarked that *"people have become aware, the term sustainability has been internalized*" within the school community. Such testimony suggests that sustainability is no longer seen as an external concept or obligation, but rather as a normal part of their thinking and identity. Students echoed this sentiment, expressing that sustainability is now "*a familiar and natural part of everyday life"*. One student reflected that previously sustainability wasn't talked about much, but *"now it has become visible"* and integrated into daily routines. Another interviewee shared that, after the project, "*I know more now. A more diverse picture [of sustainability*]", and realised that one doesn't have to be "too radical", indicating a more informed and balanced mind-set toward sustainable living.

Optimism, enthusiasm and emotional investment (with some challenges): Educators observed a surge of enthusiasm among students, which in turn inspired the wider community. *"I would highlight the motivation of the children... they came with a lot of enthusiasm... they knew that they were going to be listened to, that they were going to learn,"* noted one Spanish teacher. Seeing youth so eager gave some participants optimism about the future. There is also evidence of growing hope and determination to tackle environmental challenges together. *"We are in this together,"* affirmed a teacher who hoped the project helped colleagues overcome their reluctance to address difficult issues openly. At the same time, not all emotional shifts were uniformly positive. A few participants admitted to feelings of frustration or scepticism alongside their commitment. For example, one school principal described becoming *"disenchanted"* upon realizing that despite his own efforts (like diligently separating waste), others in his community were not doing the same, which he found discouraging. However, importantly, he did not give up; *"despite the disenchantment he continues forward"*.

Barriers and limitations to change

While the overall impact was positive, the interviews also shed light on several barriers and limitations that affected participants' experiences and the degree of change. These range from personal factors (like prior knowledge or scepticism) to external constraints (such as structural challenges in schools).

Pre-existing high awareness meant that some participants felt the initiative merely confirmed what they already practised. "*Personally, I was already very aware of sustainability issues, so my understanding didn't change",* admitted one teacher, and a researcher agreed the activities "*did not change [my views], as my perception was already very high due to my profession"*. Scepticism and resistance surfaced mainly among veteran staff. One secretary argued "*we put the emphasis on sustainability as if it were something new and it is not. It's nothing new. ... All this fervour for going green ... is all very well, but let's not go crazy"*. He added, *"I am sceptical",* warning that *"so much emphasis can be a boomerang*" if people feel pressured.

Complexity of the task dampened enthusiasm for harder issues. A Finnish teacher observed, *"It's great to have technical solutions, but food and mobility are difficult to solve*". Another researcher felt "*the complexity and challenge of promoting sustainability has [only] increased*".

Resource and institutional gaps limited continuity. The principal of one school "*misses that it should be moved into the teachers' timetable and that there should be resources... That it should not have to be taken out of class time. Not voluntarism".* A school leader concluded that "*a method involving action and participation is always more effective but requires resources*", highlighting the need for systemic backing.

Insufficient hands-on continuity left learning fragile. A manager realised, "*I now see that understanding sustainability comes through practice. Seeing to learn.*" The project "*demonstrated the value of hands-on, campus-based initiatives"*, yet participants lacked time to reinforce new routines, so sustained, practice-rich follow-up is required.

Additional emerging themes

Youth empowerment and intergenerational dynamics emerged strongly. Teachers repeatedly contrasted adult caution with children's motivation: *"Perhaps for adults it's harder to leave our comfort zone; … the children came with a lot of enthusiasm… they knew they would be listened to, that they would learn"*. Students took that energy home, reminding parents to recycle or save energy, and their "little voice" rippled back through classes. Rather than resisting this imbalance, educators welcomed it, drawing motivation from their pupils' passion and recognising that empowered youth can catalyse wider community change when their ideas are respected. A parallel thread was the demand for continuity and integration. Participants warned that **progress will fade without institutional follow-through.** "*School could evolve significantly if student/teacher engagement and sustainability integration continue,"* one student predicted.

Conclusions

Our findings suggest that the ECF4CLIM project has generated a platform that enables the development of individual competences. Most participants reported learning something new (88% for knowledge, 77% for skills, 82% for attitudes), and were able to specify what they had learnt: from understanding electricity generation or life cycle assessment to mastering practical tasks such as installing sensors, composting, or using new software. Perhaps the most striking change was the shift from "recycling equals sustainability" to a broader, sustainable systemic awareness that links personal choices to energy, food, and community dynamics. Along with this growth in knowledge, there was also a rise in care for the environment. Students now *"think twice before acting"*, teachers consciously reuse materials, and several interviewees speak of hope and motivation rather than fatigue. These changes demonstrate that knowledge has evolved into skills and, most importantly, the confidence to advocate and collaborate.

Nevertheless, change was uneven. A minority felt they "learnt nothing new" because the material repeated what they already knew, or because explanations were rushed and practical time was short. Previous beliefs -both pro-sustainability and sceptical- sometimes acted as a philtre, and experienced staff occasionally expressed "green fatigue". Structural limitations, such as voluntary after-hours activities, a lack of resources and a lack of follow-up, hindered the transition from classroom learning to a sustained routine. Some students remained mere

observers, and more challenging areas, such as nutrition and mobility, remained out of reach. These absences are significant and demonstrate that information alone is insufficient without relevance, time and institutional support.

When the results are examined through the analytical lens of the project, it becomes clear why the successes and the gaps coexist. At the individual level, new facts, skills and feelings promoted self-efficacy - the sense that "my small actions count"-. At the collective level, workshops, debates and children's influence on adults fostered a common purpose, but they needed broader participation to avoid "we changed, they didn't" divides. At the technical/material level, learners gained practical skills and insight into technologies that paved the way, but without sustained access to tools, time and infrastructure, these skills risk remaining hidden. In short, meaningful change occurs when personal insight is supported by others and backed by material resources: if one part is weak, progress stalls. Our findings therefore suggest both the power of aligning the three spheres and the fragility of change when that alignment is incomplete. This is a useful reminder that future endeavours must weave individual motivation, collective structures and technical resources into the same net if sustainable habits are to endure.

5.6. A reflection on gender

This section aims to shed light on the gender variable by analysing the gender-specific findings from the short survey and the interviews, taking into account the limitations of data collection at our DS, as outlined in the 'Methodology' section.

Short surveys, conducted after each intervention, and the individual interviews, conducted at the end of the interventions and the participatory process, recorded the gender of respondents, enabling gender-specific analysis. However, the findings from the SCT and SCC sessions do not allow us to identify any gender differences. Data collection from these sessions was primarily based on observation logs completed by the researchers in real time during the sessions. Although these logs recorded the gender of the participants, it was not possible to analyse individuals' arguments by gender. This would have required the recording, transcription and discourse analysis of all group discussions, which was beyond the scope of this project. Detailed transcripts were not included in the project budget, and not all research teams possess the requisite skills for discourse analysis.

Short surveys

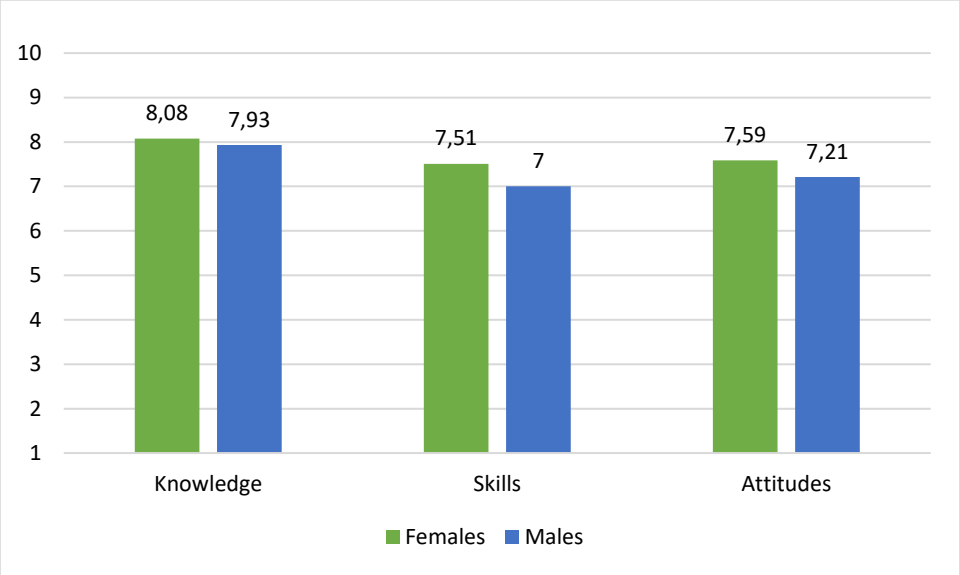
Of the 490 individuals who responded to the short survey and reported their gender, 254 identified as female and 236 as male. The following table presents the participants' profiles, categorised by their self-identified gender.

Profile	Female	Male
Student	195	211
Teacher	25	5
Staff	10	1
Other	3	2
No answer	21	17

Total	**254**	**236**

The short survey allows for the exploration of gender differences in participants' perceptions of acquiring new knowledge, skills, and attitudes.

Overall, the self-reported levels of **new knowledge**, **new skills**, and **new attitudes** were **high**, given that the scale ranged from 1 to 10, where 1 means 'not at all' and 10 means 'very much. The mean scores for both males and females in all three areas were above 7, indicating a **generally positive learning outcome**. The next figure illustrates the self-reported levels of new knowledge, new skills, and new attitudes.



- → For **new knowledge,** both genders reported high scores, with no statistically significant difference. This suggests a comparable self-perception of learning across genders.
- → For **new skills,** however, females reported significantly higher scores, indicating that they may have perceived a greater gain in individual competences for sustainability.
- → For **new attitudes,** females also scored significantly higher, suggesting a stronger impact in terms of mind-set change.

In sum, participants rated their learning experience positively across all areas. Females scored significantly higher than males in new **skills** and **attitudes**, while no significant difference was found in new **knowledge** scores.

Interviews

The interview sample consisted of 44 individuals (29 women, 14 men and one person who identified as 'other'), occupying various roles such as students, teachers, researchers and staff. It includes students from secondary and university level education. Female respondents were particularly prevalent among teachers and support staff, while the majority of male respondents

were students. The following table shows the representation of the sample by profile and self-identified gender.

Profile	Female	Male
Teachers	17	3
Students	4	7
Researchers	4	1
School administration	3	0
Leadership/management	1	3

When participants described the **outcomes of the ECF4CLIM project**, they consistently highlighted the language of learning and awareness as central. As one male teacher who was satisfied with the impact in his classroom observed, it "*improved student attitudes and awareness of their role in environmental protection,"* while a female colleague celebrated the "*increased recycling efficiency, better visibility of environmental issues, and student activism."* Project members repeatedly linked these gains to enhanced individual sustainability competences—not only students' pro-environmental attitudes and awareness but also their practical skills for integrating sustainability into everyday routines. Together, these reflections suggest that ECF4CLIM succeeded in making sustainability both tangible and skill-based: learners emerged not merely more informed but better equipped to translate awareness into action.

When considering possible gender-specific nuances in how these competences were framed, we should also consider role responsibilities. Women, especially those responsible for day-to-day pedagogy, tended to anchor their reports in concrete behavioural changes and curriculum routines: new recycling stations, cloth lunch bags, lesson plans that integrate environmental issues into normal lessons. Men in leadership or research positions were interested in the structural horizons opened up by the project. One male principal spoke of laying *"the basis for possible improvements in future school building designs",* and several male interviewees referred to future projects and grant opportunities. This contrast shows that reported outcomes reflect not only gender but also the distinct educational roles each actor inhabits.

Regarding **unexpected effects of the project**, overall, both men and women noticed a surprising level of social involvement—more than they had expected. They saw more participation from students' families, local partners, and even classmates who were not usually involved. One female teacher was amazed by "*the strong involvement of students and families in the waste separation contest,"* while a male teacher said the project "*sparked interest among students who weren't involved before and encouraged teamwork across different roles."*

As for gender, female teachers often framed their surprise in relational terms: *"the greater cohesion of the group of students involved"* and *"an empowerment of the school community, particularly among students"*, showing that they care about the relationships and community involved in learning. Some male students and a handful of male teachers, by contrast, either down-played surprises or dismissed them entirely: "*no unexpected elements*" and "*there were no unexpected effects*.

Respondents' reflections on **understanding sustainability** also show a mix of shared ideas and subtle differences. Women repeatedly described a movement from a narrow ecological focus toward a holistic vision encompassing social justice and economic viability: "*I used to think mainly about the ecological side, but now I see that economic, societal and social sustainability go hand-in-hand".* A male colleague, meanwhile, located his learning in the technical lexicon of climate science: *"I now better understand concepts such as sustainability, greenhouse-gas emissions, energy waste, etc."*

Respondents of every gender reported adopting **new habits or deepening existing ones:** riding public transport, cutting meat consumption, separating waste, lobbying for greener procurement. "*Sustainability has become part of everyday life at school, and my worldview has broadened*". Echoing him, a female student noted: "*I eat more vegetarian food. I avoid fast fashion more"*. A female teacher added the collective dimension: *"Community and personal awareness improved through practical activities like tree planting"*, while a male manager catalogued individual lifestyle tweaks: "*I recycle better, conserve water and electricity, and plant trees"*. The overlap is extensive enough that role and context, rather than gender alone, appear decisive.

A woman working in administration and a man coordinating research both invoked **resource constraints and institutional inertia**; a female student and a male student alike cited budget-friendly steps such as reusing notebooks. Gender inflects these stories, but it does not dictate them.

Looking forward, hopes and cautions take centre stage. Many women voice measured optimism, confident that the "*ongoing integration of sustainability into school culture"* will last if momentum is nourished. They lay out practical continuities—retaining recycling points, embedding environmental themes across subjects, maintaining student eco-clubs. Men's views are more varied: several are equally hopeful, affirming that the sustainability team *"will become permanent"*, yet leadership voices introduce structural warnings. One male principal reminds us that progress "*depends on who is in the leadership*", while another flags legal and budgetary hurdles.

That recognition becomes explicit when they were questioned about **enabling conditions**. Women focus more on time, recognition, and support from leadership: dedicated hours for project work, curriculum space, material resources, and leadership endorsement. "*Support from management, time allocated in the school schedule and material resources",* one female educator specifies. Men, too, cite funding and formal structures, sometimes pushing the lens outward to regional or European funding streams. "*We need projects with funding, so that sustainable measures are concrete and the results visible",* a male teacher insists. On both sides, students confess to overload but promise continued engagement "*as much as time allows*". The narrative centres on a common dilemma: passion is abundant, but capacity (whether measured in euros, hours or political will) is scarce. Where gender priorities differ, they are mirrored in professional realities: teachers call for a reduced timetable, managers demand a budget line.

Limitations and conclusions

Our analysis faces several limitations. The sample is small and uneven (70% women), coming from multiple countries (Spain, Portugal, Finland, Romania) with different languages and school systems. Translations and cultural framing may affect responses. The available gender categories are binary plus one "other", so nuanced identities are underrepresented. Because many female respondents were teachers and many male respondents were students, some apparent gender differences may reflect *role or context* (as noted above). For instance, a female teacher's emphasis on community projects could reflect the school culture at her site more than a "women's perspective". Similarly, comments about national policies (e.g., references to national education legislation) are specific to the site in question and are not necessarily inherently gendered.

Also, and according to the literature, gender per se is unlikely to account for the patterns we observe. A recent meta-analysis of 53 studies found only a small average female advantage in pro-environmental attitudes ($d \approx 0.28$) that tends to disappear once education and age are controlled for (Gökmen, 2021). Subsequent syntheses and large-scale surveys confirm that the gap is statistically reliable yet modest (Nagy, 2024; Xia & Li, 2023) and varies substantially across countries: it widens in societies with traditional gender-role norms and narrows—or even reverses—where egalitarian norms prevail (Zelezny et al., 2000). Other studies also report the same pattern and note that these gaps are steadily decreasing as climate anxiety becomes more common (Berland & Leroutier, 2025; Pinho, 2025).

Consistent with earlier studies, our evidence suggests gender as a context-dependent moderator rather than a primary cause of environmental attitudes and behaviours. Therefore, any apparent gender patterns in our data should be interpreted with caution, bearing in mind broader socio-cultural factors. In our data, both men and women reported similar awareness gains and motivation to act. As just mentioned, any patterns should be interpreted cautiously: for example, while women often talked about empathy and care for community, this may align with social role expectations rather than innate gender traits. We have deliberately avoided stereotypes (e.g., "women are caring, men are disinterested") and instead highlighted themes as they co-occur with gender and other identities.

5.7. How effective is the hybrid participatory approach?

Drawing on data from SCT6 and interviews with key actors, this section examines, how effective the hybrid participatory approach was in fostering self-reflection and deliberation on individual competences.

SCT6

The aim of SCT6 was to evaluate the ECF4CLIM project as a whole. Participants reflected on and deliberated about the project's outcomes and processes. Part of the SCT6 discussion focused on evaluating the effectiveness of our hybrid participatory approach, particularly whether it succeeded in enhancing self-reflection and deliberation on sustainability competences, including individual competences. The most salient findings are presented below.

Overall, participants emphasise the importance of joint discussions and reflections about sustainability such as of getting to know other people's opinions. When asked about **concrete contributions** of the hybrid participatory approach, participants referred to the following ideas:

- The establishment of **new interpersonal relationships** with other students and teachers was one of the main contributions highlighted by participants. This has fostered a culture of co-learning, in which students and educators engage in mutual exchange and learning. Furthermore, the hybrid participatory process has enabled participants to share experiences with other DS and individuals from outside their own school.
- The hybrid participatory approach has also strengthened collaboration by **promoting teamwork** through joint planning, decision-making, implementation, and monitoring. As a result, relationships among participants have become more balanced and respectful.
- The participatory process has fostered **inclusive and empowering participation**. Students, teachers and staff have all played an equal role, giving everyone a voice and encouraging active participation and involvement.
- Another key contribution that was highlighted was **active and engaging learning**. The hybrid participatory approach enhanced motivation, responsibility and engagement. Learning became more meaningful and dynamic, fostering a long-term commitment to sustainability.
- The participatory format also contributed to fostering a more integrated and holistic **understanding of sustainability** among participants. Sustainability became a more visible and frequently discussed topic in schools. The project's approach broadened participants' perspectives on sustainability and enhanced their awareness of others' efforts in this area. They came to understand how small initiatives can contribute to broader environmental goals, making their actions feel both relevant and impactful.
- Participants, particularly students, **developed critical thinking, problem-solving skills, an appreciation for different perspectives.** They also improved their communication skills and acquired practical knowledge. From a pedagogical standpoint, the process helped to bridge the gap between theoretical learning and real-world application. Projects and activities were closely linked to real-life issues, enabling students to connect classroom theory with practical experience.

While the participatory approach brought many benefits, it also presented some **challenges**. The high number of meetings and the significant time and dedication required often made it difficult or impossible to implement the process as expected or initially planned. In some DS, participants faced time constraints due to already busy schedules, leaving limited room for additional activities such as this project. Furthermore, the gradual time constraints over the sessions emerged as a notable issue, especially in universities.

Interviews

The effectiveness of the hybrid participatory process in encouraging self-reflection and deliberation on individual competences was also explored through personal interviews with

selected key actors in all our DS. These interviews provided a deeper insight into the experiences of those involved in the project from the outset.

To capture age-specific perspectives, we designed two interview protocols: one for primary school students and another for secondary and university students, teachers, administrative staff, and other members of the educational community. This section presents the findings from each group separately.

Kids

Students from different countries said that the most positive aspect of the participatory process was **the freedom to speak openly**. Comments such as: *"I could participate whenever I wanted"* (P02-LQ), *"we always had the freedom to participate whenever we wanted"* (P04-LG), and *"I liked giving ideas for the school and what we could do to improve it"* (P03-LO) illustrate the psychological safety of the process. Students could test arguments, negotiate solutions, and develop self-efficacy. In line with this, satisfaction deepened when students held formal roles. One female student said that *"feeling in control and having a say in decisions is great"* (P04-LG), and another boy student in Portugal stated that *"what I liked most was being able to speak up"* (P04-LT).

The importance of **teamwork and collaboration** was also highlighted by primary students. In this context, dialogue became a learning outcome in its own right. A Portuguese girl remarked that group work *"was a way to understand classmates' opinions"* (P04-LT), while a Spanish boy found that group debates generated *"more ideas and better ones"* (P03-LO).

Students noted that some of the **tools and methods** used in the participatory approach encouraged greater engagement and commitment than others. Hands-on activities and those with interactive elements made students more enthusiastic (*"poster boards and sticky notes … a fun way to interact";* P04-LT), while purely seated discussions often "*got a bit boring"* (P01-LA). Even hands-on activities encouraged quieter students to contribute, whereas monotonous repetition *("having to recall the project ID over and over";* P03-LO) tired them.

Finally, primary school students also mentioned some **challenges** that arose during the process: scheduling conflicts (*"sometimes I haven't been able to join meetings because of exams,"* P01-LA) and uneven flow of information *("I didn't always know when meetings would take place";* P04-LG). In addition, students emphasised the challenge of the diversity of the participants in the meetings. Students who had participated in heterogeneous groups felt that the meetings allowed them "*to discuss and exchange many opinions"* (P02-LQ), while a girl from Portugal regretted that *"no more students from other grades and classes had taken part"* (P04-LG).

Adults

One of the first points raised by the adult participants was that the participatory process **had given the students a voice**, making them feel that their ideas were important and motivating them greatly. In words of one Spanish teacher "*they came in with great enthusiasm, knowing they would be listened to and that they were going to learn; they realise the value of their ideas".* (P03-LO)

Similarly, adults mentioned that the participatory process fostered participants' interest and **encouraged reflection and awareness**. One Spanish teacher emphasised that *"listening to children helps you think the things better"* (P03-LO) and another Spanish teacher pointed out that *"each meeting brought something, for me, that served as a wake-up call".* (P03-LO) This teacher also talked about how motivation and enthusiasm are contagious: "*if you see the students getting excited and responding positively, you feel even more motivated yourself. It's like a boomerang. It's a kind of positive contagion."* (P03-LO)

Furthermore, they also mentioned that the **experience had exceeded their initial expectations**. A Romanian teacher reflected that *"the expectations have been met, and the process has enriched both students and teachers"* (P02-LY) while Portuguese teacher admitted that *"the result was very positive engagement and reflection, exceeding my expectations"* (P04-LG). Another Romanian teacher noted that *"student interest exceeded expectations, promoting lasting sustainable habits"* (P02-LQ), while an administrative staff member was pleased that *"the voluntary participation of students, other classes, and newly arrived teachers was unexpected and very positive"* (P04-LT). This sense of surprise was also expressed by a Romanian student who said *"we didn't expect to end up discussing so openly within a group"* (P02-LR).

Another recurring theme among adult participants was **collaboration.** A Portuguese teacher said that the project *"promoted collaboration with external stakeholders such as the parish council and the city hall"* (P04-LT). Similar experience was reported in Romania, where a teacher noted that *"the town council supplied compost bins and even joined us for the neighbourhood clean-up day"* (P02-LQ), while another teacher mentioned that engineers from the local university *"co-taught a session on renewable energy"* (P02-LY). A **supportive culture** was also important. One Finnish teacher credited *"an enthusiastic team to work with"* (P01-LA), while another teacher welcomed the new wave of parent volunteers (P02-LR).

The participatory process has enabled **long-term thinking** about the future and the integration of sustainability in the schools. A teacher argued that *"the key is to maintain awareness, secure resources, and integrate sustainability into annual activity plans"* (P04-LT). A Portuguese researcher favoured *"deeper institutionalisation, urging that sustainability indicators be embedded in performance reviews"* (P04-LE). In Finland, high school student suggested continuity rituals such as *"an annual story about Earth Hour"* (P01-LA). In this sense, *"future involvement depends on visible student roles, staff support, and minimal resources to execute ideas"* observed a student in Romania (P02-LY).

Nevertheless, adult participants mentioned that they still faced **time and resources constraints**. A Finnish teacher admitted that *"there have always been more ideas than resources to implement things"* (P01-LA). A university researcher warned that *"when resources are lacking … sustainability will not improve significantly"* (P01-LS), and a leader in Romania cautioned that future success depends on *"a strategy, resources, and ongoing training"* (P02-LQ). In this sense, a Spanish teacher stated that *"creating committees and structures is difficult due to lack of time, teachers are very busy, students have exams. Without these spaces, we are confined to repeating what we have always done — we simply do not innovate"* (P03-LO).

Conclusions

Data from SCT6 meetings and interviews with key actors have enabled us to evaluate the effectiveness of the hybrid participatory approach in encouraging self-reflection and deliberation on individual competences. These findings can clearly be related to the individual competences of the roadmap.

Strengthening of relationships and fostering a culture of collaboration: The participatory process fostered the creation of new interpersonal relationships among students, teachers, and staff, as well as between different schools and external stakeholders. These interactions cultivated a culture of co-learning based on mutual respect, dialogue, teamwork and collaboration. This evidence relates to the engagement and action dimensions of the initial roadmap.

Inclusive and empowering participation: One of the most notable achievements was the active and equitable involvement of all participants. The participatory approach gave students of various ages a voice, and they especially valued the freedom to express their ideas, as well as the feeling of being heard and having influence over school decision-making processes. These findings align with the dimensions of engagement and action set out in the initial roadmap.

Meaningful learning and skills development: The methodology promoted dynamic, motivating, and real-world-connected learning. This increased engagement, particularly with regard to sustainability. Participants, particularly students, developed key competences such as critical thinking, problem solving, teamwork, effective communication and the ability to apply theory to practice. This evidence reflects individual competences from all the dimensions of the initial roadmap.

Increased awareness and commitment to sustainability: The process fostered a more integrated and holistic understanding of sustainability, embedding it as a frequent and visible topic in school life. Activities enhanced participants' awareness, encouraging the development of long-term sustainable habits and mind-sets. This is linked to the individual competences specified in the initial roadmap. Engagement, connections and visions dimensions of the roadmap are linked to this evidence.

Positive impact on educators and staff: Adult participants recognised the value that the process added to their professional and personal development. Many highlighted the motivational effect of student enthusiasm, improved pedagogical reflection and the generation of innovative ideas. For many, the experience exceeded their initial expectations and promoted shared learning. These findings align with engagement and action dimensions of the roadmap.

Challenges and limitations: Despite the benefits, significant challenges emerged, including time constraints, limited resources and difficulties in maintaining participation over time. To ensure an effective participatory process and significant improvements in school sustainability, it is essential to guarantee the availability of minimum resources and to create institutional mechanisms that formally embed sustainability and participation in school structures. Notably, the participants emphasised the importance of long-term thinking and the **stability** of such participatory processes.

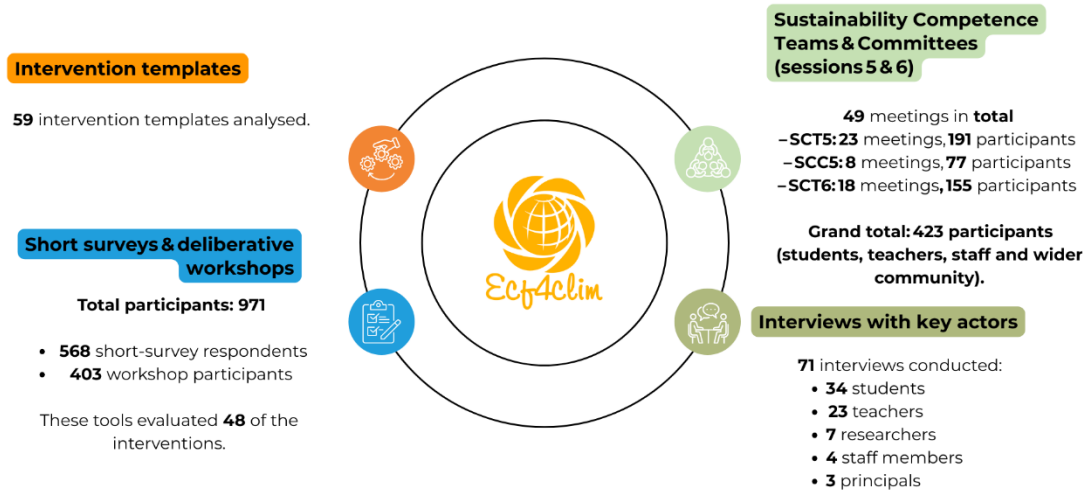
6. CONCLUSIONS

We now present the conclusions drawn in relation to each of the objectives of this systematic and comprehensive evaluation of individual competences at our schools and universities.

→ **Objective 1: Explore the status of individual competences at our demonstration sites at the current stage of the project.**

The evidence gathered through our innovative hybrid participatory approach provides a solid basis for exploring individual competences in our Demonstration Sites. Students, teachers, staff and other representatives from our educational communities actively engaged in our participatory process. Through their reflections and deliberations, they created a detailed portrayal of how individual competences work in the daily lives of schools and universities.

These methods were designed to encourage our educational communities to critically reflect on their sustainability competences and how these evolve through engagement with the project. Some methods, such as surveys and workshops, prompted reflection on each intervention at the very end. Others (SCT/SCC) encouraged deliberation on specific interventions from design to implementation. Still others (interviews) stimulated reflection on the project as a whole just before its conclusion. As shown in the figure below, we have analysed the individual competences of a variety of educational actors involved in 59 interventions using short surveys (n=568), deliberative workshops (n=403), SCT and SCC meetings (n=423), and interviews n=71).



The resulting solid and robust database has allowed us to identify the critical knowledge, skills and attitudes that underpin the desired transformational change towards sustainability and to understand their nature and operational dynamics as either enablers or barriers. In addition, we have been able to specify the singularities of individual competences for each type of actor within our educational communities: students, teachers, non-teaching staff, and other relevant external stakeholders. These findings represent a significant advance in conceptualising individual competences for sustainability in an educational context and they allow us to operationalise and validate our initial roadmap. Identifying the specific characteristics of the

individual competences of each educational actor is a notable achievement in relation to GreenComp and the initial roadmap.

→ **Objective 2: Generate empirical evidence to validate the initial roadmap by considering both the originally suggested individual competences and their potential roles as constraints and/or enablers**.

Our comprehensive analysis of the individual competences for sustainability across selected educational institution indicates that the initial roadmap has a great capacity to promote critical knowledge, skills and attitudes. Our evidence supports, in practice, the relevance of most of the initial competences suggested in the initial roadmap.

In terms of knowledge, for example, having a **basic factual understanding of sustainability issues** proved essential across contexts. Teachers and students at multiple sites noted that shared baseline knowledge – about water conservation, renewable energy, waste cycles, etc. – provided a necessary foundation for engagement. Conversely, **knowledge gaps** were indeed limiting. Overall, the evidence reinforces that cognitive competences (knowing *what* and *why*) are fundamental drivers of change, whereas ignorance or misinformation can function as concrete barriers.

Regarding skills, communication and **dialogue** skills emerged as critical, echoing their prominence in the initial roadmap. Many interventions succeeded or struggled based on participants' ability to communicate effectively and inclusively. Role-play reflections frequently stressed that clear **interpersonal and facilitation skills** were needed to spark and sustain others' interest. In practice, this meant teachers and student leaders who could organise events, listen to diverse opinions and coordinate group decisions. These findings validate the roadmap's call for dialogue and listening skills to promote stakeholder engagement. Importantly, the evidence adds nuance by showing **what happens when such skills are lacking**: several interventions that faltered cited poor communication as a root cause.

In terms of **attitudes and motivations,** our evidence also confirmed the initial roadmap, with important refinements. Many interventions illustrated that *positive attitudes*, intrinsic motivation, and a sense of ownership are powerful enablers. However, the evidence also nuanced **the role of motivation**: it showed that motivation is not static or uniform – it can be reinforced or eroded by context. Some students initially keen on climate action lost interest when they perceived the tasks as *"irrelevant"* or too disconnected from their personal lives. The presence of *strong negative attitudes* – for instance, outright resistance among staff who saw green initiatives as outside their job – was repeatedly observed to obstruct progress. It became clear that the competence to **remain motivated (and to motivate others)** in the face of boredom or resistance is a key enabler, whereas widespread apathy is a fundamental barrier.

Many **new or more specific individual competences** emerged from the interventions, suggesting ways to strengthen the knowledge, skills and attitudes considered in the initial roadmap. These additions often build on the originally proposed individual competences but provide sharper focus or new angles.

→ In the **ENGAGEMENT** dimension, data-intensive projects revealed a need for **analytical reasoning and data literacy.** Participants had to learn to interpret energy usage data and

validate technical information to make informed decisions. The evidence shows that, in practice, critical thinking translates into very concrete data-handling skills when working with smart meters, sensors or audits. Another clear addition was the importance of **motivational leadership** – the capacity of certain individuals (teachers, student leaders) to keep the group's spirit high and nurture a collective sense of purpose. Field evidence underscores the emotional and inspirational dimension of leadership: successful leaders were not only organising tasks but also cultivating enthusiasm and resilience over time. **Individual's personal passion and example**, **motivation and empathy**, and **effective collaboration and detail planning** also emerged as relevant additions to the ENGAGMENT dimension in the initial roadmap.

- In the **CONNECTIONS** dimension, other competences that emerged include **social influence and advocacy skills** – such as students devising creative campaigns to engage the wider community. Similarly, **project management and organisational skills** were emphasised repeatedly – from drafting maintenance plans for school gardens to scheduling project meetings around exams. The initial roadmap proposal mentioned planning; the evidence elevates it as a competence on its own, given how often lack of planning nearly derailed projects. Our evidence also suggests that **systems thinking and complexity competences** as well as **lifecycle thinking across levels** are to be considered.

- In the **VISIONS** dimension, participants highlighted a **boundary-spanning leadership competence**, whereby effective leaders formed alliances beyond the school (with city officials, suppliers, families) to secure broad support for the vision. Additionally, as interventions progressed, teams realised the importance of **resilience and adaptability** in the face of unexpected changes. Staff turnover, technical problems or shifting regulations were common; participants who could adjust plans and troubleshoot on the process (for example, reassigning roles when a champion teacher left) kept the momentum, whereas rigid plans faltered. Finally, our findings show that, to encourage VISIONS, **political and cultural neutral framing, logistics micro-planning**, **governance and capacity building** should also be considered.

- In the **ACTION** dimension, a recurrent practical need was **technical and maintenance know-how**. Several interventions discovered that without individuals capable of maintaining new equipment (be it solar panels, sensors, or simply managing a compost system), the technical gains could quickly be lost. According to our evidence, **communication and outreach**, **digital and technical fluency, cooperation and negotiation** skills and **organizational and project management** skills constitute core elements for ACTION.

The table below summarises the main contributions to the initial roadmap that emerged from our empirical evidence. In our view, none of these expansions contradicts the initial roadmap. Rather, they refine it by showing which competences require further emphasis or a broader definition.

Roadmap dimension	Evidence VS initially suggested individual competences (participatory approach)	Evidence VS initially suggested drivers & barriers (intervention templates)

	Individual's personal passion and example. Motivation and empathy. Effective cooperation and detailed planning.	Analytical reasoning and data literacy as pillars of evidence-based action. Motivational leadership to maintain collective momentum.
	Systems thinking and complexity. Collaboration and project-management. Social-influence. Lifecycle thinking across levels.	-
	Boundary-spanning leadership. Political and cultural neutral framing. Logistical micro-planning and governance. Capacity-building.	Resilience and adaptability in uncertain environments. Learning and innovation capacity.
	Communication infrastructure. Technical maintenance competence.	Clear communication and outreach. Digital and technical fluency to sustain operational capacity. Cooperation and negotiation skills. Organizational and project management skills to turn visions into reality.

Beyond ratifying or expanding the initial roadmap, our analysis highlights the **importance of anticipating and addressing common barriers when designing** sustainability initiatives. Educational practitioners can use the evidence presented here as a checklist of pros and sorts when planning new interventions. For instance, knowing that "lack of time" and "overloaded curriculum" are frequent barriers, a school planning a new project might integrate it into existing subjects rather than adding extra work, or schedule it in a low-stress period of the school year. Recognising that "lack of student interest" can be a barrier, teachers might co-create projects with students to tap into their intrinsic motivations, or use gamification and creative elements to make it fun. Understanding that technical maintenance often gets overlooked, the planning should assign clear responsibility and training for equipment upkeep from the start. Essentially, the practical implication is to adopt a **preventative approach**: assume that barriers *will* arise in the known categories (time, interest, knowledge, collaboration, etc.) and build in mitigations from the beginning. In doing so, educators turn the act of planning into an exercise in competence-building itself – engaging participants in foresight, shared problem-solving, and adaptive thinking.

→ **Objective 3: Promote self-reflection and deliberation on individual competences for sustainability and on their roles within our educational communities.**

The **hybrid participatory approach** adopted in ECF4CLIM (involving students, teachers, staff and external actors in joint planning, decision-making and evaluation) was widely credited with positive outcomes. Participants emphasized that regular "joint discussions and reflections about sustainability" were extremely valuable. Through the SCTs and SCCs, new *interpersonal relationships* formed between students and teachers, creating a "**culture of co-learning**" rather than top-down instruction. Students were empowered to share experiences not only within their school but also with other demonstration sites, broadening their perspective and motivation. The process deliberately gave **equal voice** to all roles and everyone was encouraged to speak up and contribute. Teachers noted that hearing students' ideas "helps you think things through better" as an adult, providing a sort of "wake-up call" and inspiration. Likewise, students were thrilled to have "the freedom to speak openly" whenever they wanted in meetings. Such

openness cultivated **self-efficacy** and satisfaction. Many students also highlighted that working in teams with diverse participants was a learning experience in itself, understanding classmates' opinions and generating "more and better ideas" through group debate. In essence, the participatory process modelled the very competences of collaboration, critical thinking, and communication that the project hoped to instil. It turned learning into an active, dialogic experience rather than a passive one, effectively bridging the gap between theory and real-world application.

However, these benefits came with **significant challenges,** chiefly related to the sustainability of the participatory model. Teachers and students frequently mentioned the **strain of time and workload**. Especially in later stages, tight schedules in schools (and even more so in universities) meant some participants could not attend all sessions or had to rush through them. Some regretted that not more students or grades could join due to these practical limits. Adult participants similarly observed that while student engagement exceeded their expectations, keeping it up required integrating it into normal routines. For spreading beyond the initial core group and achieving broader, lasting participation, schools might need structural adjustments. Indeed, the **call for institutionalization** is a recurring theme: educators argued that for these initiatives not to remain one-off experiments, they should be backed by policy. Making participatory sustainability projects a part of the curriculum, or an official program with allotted hours and resources, would prevent reliance on personal sacrifice – for example, by **recognizing teacher time on sustainability projects as part of their workload**.

Similarly, institutional support could mean establishing permanent **student "green councils" or committees** in schools that have a voice in school decisions (e.g., on energy use, cafeteria menus, etc.). Our findings show that when given such opportunities, students can be formidable change agents who even influence their families and communities (a "positive contagion" effect). In practical terms, this could involve **dedicated coordination staff or working groups** for sustainability at the school, regular inter-departmental meetings to integrate climate action into all subjects, and partnerships with local environmental agencies to support projects. It also requires resources: from modest funds for intervention materials to training for teachers in facilitation techniques. The evidence is clear that the educational community values the participatory approach. Thus, formalizing it is an investment in educational quality as well as climate action. Without such structure, as participants warned, progress remains fragile and dependent on a few champions.

→ Final reflection on our evidence and the ECF4CLIM analytical framework

A pivotal finding of our analysis is that individual competences often **mediate the interactions between the personal, collective, and technical-material spheres** of change. Our empirical evidence shows that 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 where all three spheres overlap, all rooted in the observed dynamics at the demonstration sites.

Individual ↔ Collective: One clear linkage between 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 was when some teachers neglected recycling, showing how one person's behaviour 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. 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) took a decision to upgrade the garden school to a more context and sustainable based garden (technical), but crucially, they also adapted the school's schedules of care (collective rules). 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., infrastructure of their installations to make activities with students). Whether these external resources ultimately became available usually hinged on collective-level agreements—such as school-municipality accords—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 dimensions more tangible, we present a fictional—but evidence-grounded—vignette: a school-garden initiative synthesized 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, 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 over 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**. In 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 to maintain it or teach students how to use it (individual gap). Food waste piled up, and eventually the machine was abandoned.

In **conclusion,** examining the linkages between spheres illuminates *why* individual competences are so pivotal. They function as integration points: a teacher's leadership links an environmental policy (collective) to actual classroom projects with solar panels (technical); a student's enthusiasm and knowledge links a new piece of equipment (technical) to a change in school norms (collective). Our evidence thus suggests that fostering these mediating individual competences (communication, leadership, technical literacy, adaptability, etc.) is not only about personal development but also about systemically aligning educational environments and tools with sustainability goals. When the spheres remain disjointed – say, when there is advanced equipment but no training, or passionate individuals but no institutional recognition – progress

stalls. Therefore, it is crucial a **holistic approach that connects individual, collective, and technical aspects**. For practitioners, this means when introducing a new practice or technology, simultaneously consider the required individual competences and the needed institutional support.

7. DISCUSSION & PRACTICAL IMPLICATIONS

In terms of the practical implications of our comprehensive analysis of individual competences for sustainability across selected educational institutions, we would like to emphasise the following achievements:

- A **solid and robust database on individual competences** for sustainability across a variety of EU educational communities, ready for further exploitation in future research.
- An **efficient hybrid, participatory approach** that can be implemented to promote sustainability competences within educational communities.
- A **validated analytical framework** for conceptualising sustainability competences that could be useful for future research within educational communities.

Furthermore, our results allow us to provide a series of **specific recommendations for all members of the educational community** who wish to further understand and enhance sustainability competences.

- **Education authorities and policymakers:** Curricula should be revised to include interdisciplinary climate and sustainability content at all levels, and timetables should carve out space for project-based learning and eco-club activities. Our evidence shows that making time for these initiatives during the school day (rather than as extracurricular extras) is key to their continuity. Ministries, regional and local education authorities can support this by issuing guidelines that every school develop a sustainability action plan and by recognizing teacher involvement in such projects as part of their professional duties. Providing modest dedicated funding to schools for sustainability projects (for example, via annual grants or inclusion in school budgets) will address resource gaps that were identified as barriers. Policymakers should also facilitate networks among schools – much as ECF4CLIM did – so that they can share experiences and maintain momentum together. The fact that some students in our project connected their efforts to global goals (SDGs) shows the value of linking local action to broader policy frameworks; education authorities can encourage this by highlighting how school projects contribute to national climate commitments, thereby validating and motivating school communities.
- **School leaders and administrators:** Headmasters and school management play a pivotal role in enabling or hindering these transformations. Principals should actively champion sustainability initiatives, for instance by establishing a cross-role "sustainability committees" in the school that includes students, teachers, and support staff. They should work to institutionalize the participatory process – for example, scheduling regular assemblies or meetings where students can voice ideas (echoing the safe space that students appreciated in the project) and ensuring decisions from these forums feed into school policy. Additionally, school leaders should actively seek resources and partnerships: whether

installing infrastructure like water-saving devices or solar panels (and planning for their maintenance), or collaborating with local government for support (since lack of broader municipal engagement was noted as a limitation in one case). By publicly recognizing and rewarding the efforts of teachers and students in sustainability (e.g., in school newsletters, events, or awards), principals can strengthen the culture of sustainability and signal that it is a core value, not an "extra" – countering the attitude that such efforts are outside the school's main mission.

→ **Teachers and educators:** Teachers are at the frontline of cultivating competences and need support to continue the pedagogical innovations trailed in ECF4CLIM. Practically, teachers should integrate sustainability topics into their regular teaching, leveraging the fact that many sustainability issues naturally cut across subjects (science, civics, economics, literature, etc.). Our findings show that students respond well to lessons that link theory to real-world practice – for instance, analysing energy data in math class or discussing climate justice in social studies. Teachers might need training to feel comfortable with this interdisciplinary approach, so professional development focused on Education for Sustainable Development competences would be beneficial. Another recommendation is for teachers to adopt a facilitative role that empowers students – acting as guides or co-learners rather than sole knowledge-holders. The success of the participatory workshops, where educators often stepped back and let students lead discussions or experiments, indicates that giving students responsibility can increase their engagement and confidence. Teachers can encourage the formation of student eco-clubs and support them by providing guidance without taking control. In terms of daily practice, teachers should continue modelling the behaviours and attitudes they want to see: many already started reusing materials, conserving energy, and bringing sustainability examples into class. By consistently doing so, teachers normalize sustainable behaviour. Finally, educators can act as bridges to the community since our results showed that family and community involvement amplified the impact (e.g., waste contests that engaged families led to unexpectedly strong participation).

→ **Students and student leaders:** The youth in this project demonstrated that they can be effective champions of sustainability when given the chance. Students should be encouraged to take initiative in their schools – whether by forming clubs, proposing ideas to school management, or organizing awareness campaigns among peers. We recommend that students continue the practices that worked well in ECF4CLIM: for example, peer education (students teaching students) through creative means like school radio shows, theatre sketches, or friendly competitions. Students should also harness social media and digital skills (many learned to use data and software in the project) to spread messages beyond their schools and connect with youth in other regions for a broader movement. Crucially, students should seek dialogue with their teachers and principals – our findings suggest that many adults are very open to listening (the participatory meetings showed teachers genuinely considering student input and even being surprised by how much they learned from students). By voicing their needs (like asking for a say in school decisions on recycling systems or energy use) and offering to help lead solutions, students can push schools to institutionalize their engagement.

- **Technical staff and support personnel:** Often overlooked in school innovation, technical and administrative staff proved in this project that they too are key actors. The janitors, gardeners, IT staff, and administrative personnel should be included in sustainability training and dialogues, since they manage many of the material aspects (energy systems, waste handling, purchasing) that sustainability efforts involve. We recommend schools facilitate regular meetings between technical staff and teachers/students on sustainability committees to co-design solutions (e.g., optimizing heating settings, or setting up compost systems). Additionally, administrative staff can help by aligning school policies with sustainability goals – for example, adjusting procurement to buy eco-friendly supplies or setting rules that reinforce the behaviours students are learning (such as paper recycling protocols or turning off lights after class

Students and educators, when equipped with knowledge, skills, and motivation, and supported by their peers and environment, can indeed become agents of change. Importantly, we also saw why some changes took root while others remained tentative – reinforcing the idea that individual, collective, and technical factors must progress in unison. Where a piece was missing (say, enthusiastic individuals but no institutional follow-up, or new equipment but little engagement), the change was fragile. A major takeaway is that educational transformation for sustainability is **not automatic nor effortless**: it requires intentional cultivation of competences and careful attention to context and constraints. This final reflection also validates much of the project's initial roadmap while highlighting needed adjustments – especially the imperative of formalizing support for participatory, cross-cutting approaches in schools.

There are, of course, **limitations to our findings.** The interventions were relatively short-term and varied widely across sites, so some impacts may be temporary or context-dependent. Our evaluation relied on self-reported data and observations in a project setting; true long-term behavioural change could only be confirmed with follow-up studies months or years down the line. We also faced methodological constraints, such as difficulty in capturing gender dynamics in group discussions, and not every potential competence or driver was observable in each setting. For instance, some roadmap competences remained "greyed out" due to lack of evidence, which could be due to the specific focus of chosen interventions rather than their irrelevance. Future research should investigate these less observed areas – for example, how to better foster critical thinking against prevailing unsustainable norms, or how to engage those who are initially indifferent or resistant. We also recommend further exploring the gender dimensions of competence development – our data hinted at differences in experience and emphasis between male and female participants; understanding these could help tailor interventions that are inclusive and effective for all genders.

In conclusion, the experience of ECF4CLIM demonstrates that with the right mix of **empowering pedagogy, supportive community, and enabling resources**, schools can become living laboratories of climate action and sustainability learning. The transformation roadmap largely held true, but its realization depends on addressing practical barriers and actively involving the whole institution.

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9. ANNEXES

ANNEX A

Short survey

Date:

Individual Competences

- **Taking part in this activity has been:**

  1 ----------10

  1: Fully negative (useless, boring, …)/ 10: Fully positive (meaningful, interesting, ….)

- **Have you learned something (new knowledge)?**

  1 ----------10

  1: Not at all/ 10: Plenty of things

  If you have learned something, can you briefly explain what (3 issues maximum)?

  -
  -
  -

  If you have not, can you briefly explain why (3 issues maximum)?

  -
  -
  -

- **Have you acquired new skills (new skills & capabilities)?**

  1 ----------10

  1: Not at all/ 10: Plenty of things

  If you have learned something, can you briefly explain what (3 issues maximum)?

  -
  -
  -

  If you have not, can you briefly explain why (3 issues maximum)?

  -
  -
  -

- **Has your view on sustainability changed (new attitudes & emotions)?**

  1 ---------- 10

  1: Not at all/10: Fully

  If yes, can you briefly explain in which ways (3 issues maximum)?

  -
  -

-

If not, can you briefly explain why (3 issues maximum)?

-
-
-

- **Have your habits and behaviour changed (new actions)? / Do you plan to change your habits and behaviours after this experience?** (Depending on the time frame of the intervention)

1 ---------- 10

1: Not at all/ 10: Fully

If yes, can you briefly explain how (3 issues maximum)?

-
-
-

If not, can you briefly explain why (3 issues maximum)?

-
-
-

- **Any other issue you may want to raise concerning the intervention?**

Collective competences

- Have you seen that the role or activities of institutions in constraining and facilitating action towards sustainability have changed during the intervention?

If yes, can you briefly explain how, e.g., via examples (3 issues maximum)?

-
-
-

If no, can you briefly explain why (3 issues maximum)?

-
-
-

ANNEX B

Interview guide for kids

0a. Date: _____

0b. Gender:

- Male
- Female
- Other (non-binary, etc.)
- Prefer not to say

0c. Demonstration Site: _____

Questions:

1. [Engagement: Have you enjoyed your participation in the ECF4CLIM project? Have you been able to participate whenever you wanted?
2. [Engagement Have you enjoyed participating in the project together with your schoolmates?
3. [Expectation] What did you like the most? What, if anything, did you like the least? Could you provide some examples?
4. [Expectation] Would you have liked something else to happen? Was there something you expected to happen but that didn't? Could you provide an example?
5. [Environmental performance] Do you think the project has brought environmental benefits for your school? What kind of benefits? Could you provide examples?
6. [Environmental performance] If new devices or equipment have been installed (solar panels, sensors, new waste bins, etc.), do you think they've been useful for the school? In what way? Could you provide an example?
7. [Individual competences] Do you think your schoolmates are more aware of environmental issues now, thanks to the ECF4CLIM project? Do you think their behaviour has changed in any way? Could you explain how?
8. [Individual competences] Do you think your ways of thinking (e.g., knowledge, skills, and attitudes) or behaviour have changed in any way, as a result of the ECF4CLIM project? Could you provide an example?
9. [Collective competences] Do you think the project and the “interventions” carried out as part of it have produced lasting changes in the teaching or other activities at the school? What kind of changes? Could you provide an example?

10. [Collective competences] Do you think what you learned at school as a result of this project will have impacts elsewhere (e.g., among your family members, neighbours, friends; in your municipality)? Could you provide an example?

Interview guide for adults

Interviewee profile:

0a. Date: _____

0b. Profile:

- Student
- Teacher
- Staff
- Leadership and management

0c. Gender:

- Male
- Female
- Other (no binary, etc.)
- Prefer not to say

Questions:

1. How did you get involved in the ECF4CLIM project (hereafter "the project")? What motivated you to participate in it? Which factors facilitated the most your involvement in the project?
2. Has the project succeeded in involving the educational community? Who has been more and who less involved? How would you explain the differences between groups and individuals in their degree of engagement in the project?
3. What do you think are the main results of the project? Have these results met the expectations you had at the beginning? How, if in any manner, have your expectations have evolved throughout the process?
4. What unexpected effects has the project generated? Have they shaped the implementation of the interventions in your school/university?
5. Do you think the project has brought environmental benefits for your school/university? What kind of benefits?
6. If new devices or equipment have been installed, do you think they have been useful in reducing the environmental impacts of the school/university infrastructure?
7. If new devices or equipment have been installed, do you think they have helped to promote the individual and/or collective sustainability competences among students, teachers and staff? How have the devices/equipment been used?

8. To what extent do you think the project has contributed to improving the knowledge, understanding, and awareness of the educational community on sustainability issues? In your case, how has it changed your understanding of the topic?
9. Do you think your understanding of sustainability (and of the ways of fostering sustainability) has changed because of your participation in the project? How did you understand it at the beginning and how do you understand it now?
10. What new norms (incl. formal or informal social norms), rules or guidelines for sustainability have been implemented in your school, and to what extent would you say the "sustainability culture" of your school has changed?
11. To what extent do you think the project has contributed to generating new organisational structures (offices, committees, commissions, networks, etc.) designed to favour sustainability?
12. To what extent do you think the project has helped to improve academic teaching plans or educational curricula (introducing sustainability topics in courses)? If changes have been introduced, do you think they will be last over time?
13. To what extent do you think the project has pushed the school/university to allocate more resources (financial, human, time, etc.) to promoting sustainability?
14. To what extent do you think the project has helped to improve the visibility of data and information on environmental impacts and sustainability at the school/university?
15. Would you say that, thanks to the project, environmental awareness among the educational community has improved? Has your own awareness has increased? In what way?
16. How has your participation in the project influenced your behaviours? Can you describe any concrete examples of such changes?
17. How do you think the school will evolve in relation to sustainability? Which factors do you think will determine whether the achieved improvements will last over time? Why?
18. What conditions should be in place to spur you, personally, to actively engage in future interventions towards sustainability at your school?
19. Do you have further plans, individually or collectively, to promote sustainability at your school? Can you please describe these plans?
20. Do you plan to do something related to sustainability outside the school (at home, in your neighbourhood, in the municipality, etc.)? How, if in any manner, has your participation in the project influenced your attitudes or plans in this regard?