IMPROVING SOIL LITERACY IN EUROPEAN EDUCATION SYSTEMS

THE CHALLENGE OF SOIL LITERACY IN EUROPE

Context

Soil and the incredible biodiversity it contains are fundamental yet often overlooked resources in the fight against climate change and for improving environmental sustainability. Despite its crucial role, there is a widespread lack of awareness and understanding of soil's importance. This lack of "soil literacy" constitutes a significant obstacle to implementing effective sustainable land management policies.

The LOESS project (2023-2026), funded under the European Union's Mission "A Soil Deal for Europe," was created to address this challenge. With a collaborative approach involving 20 partners across 16 European countries, LOESS aims to improve the collective understanding of the importance of healthy soil through innovative education programmes and continuous training activities.

Soil health: an essential resource, increasingly at risk

A single teaspoon of soil contains more living organisms than there are people on Earth. This underground ecosystem processes nutrients, filters water and supports 95% of our food production. Yet we're losing 24 billion tons of fertile soil annually to erosion and degradation.

Soils store more carbon than the atmosphere and all vegetation combined – approximately 1,600 billion tons globally - making soil protection one of our most cost-effective climate solutions, as healthy soils can sequester 0.4% more carbon annually through improved farming practices.

Healthy soils with diverse microbial communities improve water retention by up to 187,000 litres per hectare, reducing flood risks and drought vulnerability while cutting agricultural irrigation costs by 30-50% in many regions.

Soils rich in organic matter and biodiversity produce 20-40% higher crop yields during extreme weather events compared to degraded soils, proving essential for food security in a changing climate. Despite this, awareness remains low. European education systems currently lack comprehensive soil-related curricula, leading to widespread soil illiteracy that undermines environmental sustainability, food security, and public health. This educational gap perpetuates a cycle where uninformed societal decisions accelerate soil degradation, while simultaneously weakening public support for protective policies and limiting the development of diverse, knowledgeable expertise across agricultural, environmental, and community sectors. Furthermore, existing soil policies often fail to integrate scientific research with traditional farming wisdom, local ecological knowledge, and practical field experience into coherent policy frameworks. This fragmented approach misses critical opportunities to build effective knowledge alliances that could translate diverse insights into evidence-based soil protection strategies, ultimately hindering the collaborative understanding needed to address soil degradation through inclusive, well-informed approaches that value both scientific findings and grassroots expertise.

The LOESS approach

The LOESS project addresses these issues through a comprehensive three-pronged approach: systematically cataloguing existing soil-related educational materials and programmes across Europe, assessing training needs within diverse educational contexts and demographic groups, and collaboratively engaging with diverse stakeholders.

The collaborative approach is key to the LOESS project and was therefore adopted from its inception, by establishing Communities of Practice (CoPs) in 15 European countries as knowledge-sharing networks that unite soil scientists, education professionals, policymakers, and community representatives. These CoPs served as essential partners for co-designing and co-analysing Europe's soil education landscape through ongoing dialogue and feedback loops.

Working with the CoPs, the project team conducted a comprehensive examination of soil education across four levels: primary, secondary, tertiary, and vocational education. This collaborative assessment examined multiple dimensions of soil education: learning objectives, teaching methods and activities, foundational concepts being taught, institutional partnerships, learning environments, and stakeholder desires and expectations for future development. Based on conversations within the CoPs, the project team developed a comprehensive co-research approach that included an extensive online survey of European educators to assess their soil-related knowledge, teaching confidence, and instructional methods, complemented by interviews, focus groups, and desk research examining existing teaching programmes, curricula, and educational materials. Results from all these research activities were subsequently shared and co-analysed with CoP members.

To ensure coherent analysis across national contexts, selected CoP members participated in cross-national alignment meetings, creating a European-level dialogue that complemented local conversations. This dual-level interaction enabled the identification of both common challenges and country-specific needs in soil education, revealing significant gaps in teacher preparation and public understanding of soil health.

Building on these collaborative findings, LOESS is developing innovative teaching resources and learning tools, emphasising experiential approaches such as hands-on community activities, augmented reality applications for visualising soil processes, and participatory mapping exercises. These interactive

LOESS: Main activities

- **Mapping of existing soil-related materials and education programmes and identification of educational needs.**
- **Development of a toolkit for soil education and training materials and resources** based on existing good examples, as well as new resources developed by LOESS.
- **Engagement and connection of stakeholders in communities of practice** in 15 European countries.
- The **co-creation and piloting of new courses, teaching modules, educational materials and learning tools** for soil education for use in primary and secondary schools, universities and vocational colleges.
- **Hands-on engagement activities related to soil education** through community projects involving students and local communities; the development of an augmented reality app; and crowdmapping to identify, visualise and address local soil problems.
- **Campaigns and dissemination activities** aimed at schools, universities, decision makers and members of the public.
- **Engagement with policy makers and lobbying** to communicate the advantages of integrating soil-related activities into formal education.

methodologies were selected based on CoP insights and evidence-based educational best practices.

KEY FINDINGS

The research uncovered a significant gap between current soil teaching methods and stakeholder expectations across Europe. This disconnect not only undermines existing soil protection efforts but also highlights clear opportunities for transformative educational change. The findings demand urgent, coordinated action to bridge these gaps and unlock Europe's potential for comprehensive soil literacy.

Key challenges identified include:

Increase "soil health" in educational offerings. Integrating "soil health" into educational curricula across Europe is essential. Current educational programmes that address soil often limit their focus to basic facts, neglecting both soil health assessment and a systems-based understanding of soil functions and their societal relevance. Closing this gap is crucial to equip future generations with the knowledge needed to maintain healthy soils, which is essential for sustainable land use and environmental conservation. Incorporating soil health into the curriculum, we can cultivate a deeper understanding of its significance and ensure a more sustainable future.

Shift the educational paradigm. Instead of adding isolated topics to already overcrowded curricula, we must fundamentally rethink our educational paradigm itself. The traditional approach of fragmenting knowledge into isolated subjects—where soil science competes for limited time alongside countless other topics—fails to reflect the interconnected reality of our world. Soil should be taught as part of interconnected themes—such as climate regulation, biodiversity, and cultural relevance—across various subjects. This approach fosters holistic understanding and better prepares students for complex environmental challenges.

Rethink learning approaches and environments. Current approaches in schools and universities mostly centre on delivering facts and technical skills. However, education should also foster responsible behaviour and support the development of values. Today, learning largely happens indoors – too often disconnected from real-world soil and environmental contexts. Students may memorise soil chemistry formulas without ever feeling soil texture or learn about biodiversity without witnessing the complex life beneath their feet.

Research evidence consistently shows that this disconnection from nature weakens the emotional bonds and personal commitment essential for genuine environmental stewardship and lasting behavioural change. Our findings confirm that it is essential to challenge this norm by integrating more outdoor, experiential learning opportunities in settings such as gardens and forests. These environments enrich the educational experience, foster a profound appreciation for nature and promoting holistic cognitive and emotional growth. By adopting this approach, we can inspire new generations of well-informed learners who are deeply attuned to environmental stewardship and active participation.

Harness the power of collaboration. Our findings demonstrate the transformative potential of collaboration when not only teachers and students, but also farmers, economic actors, and policymakers come together. By broadening our collaborative efforts to include these key groups, we bring a wide array of expertise and viewpoints, driving mutual learning and extensive social acceptance of pathways to innovation and progress based on reciprocal understanding and consensual target setting. This inclusive approach crucial to develop sustainable solutions to the complex challenges that we face today.

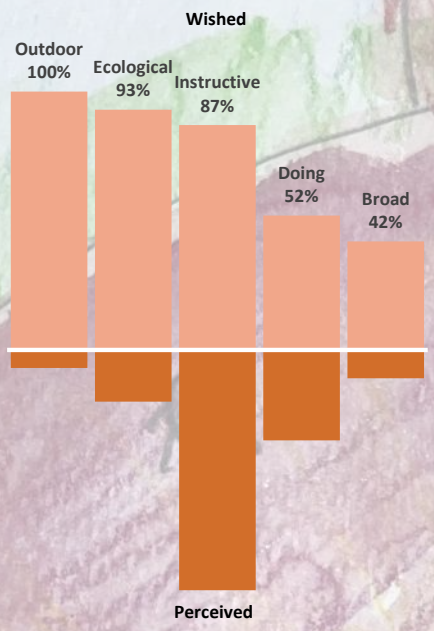
Support educator awareness and training. Current soil education faces a systemic challenge: educators lack access to adequate training resources and comprehensive knowledge about critical soil topics, such as pollution sources and mitigation strategies, ecosystem service indicators, and the drivers of soil degradation. This ongoing knowledge gap – not a temporary deficiency but a persistent structural issue – prevents the effective teaching of soil health concepts that are fundamental to environmental literacy.

Educational systems must provide sustained institutional support, including professional development and concrete teaching materials, to empower educators in delivering effective soil

Bridging the Gap to Reimagine Soil Health Education

Discrepancies in Soil Health Education

Our study reveals a **broad divergence between current perceptions and the envisioned future of soil health education across all dimensions examined**.



Learning Environments

Current education mostly takes place indoors, while there's a strong wish to move toward **more outdoor and field-based learning**.

Educational Approach

Participants would like to see a shift in mindset: Away from fragmented, mechanical teaching, towards **more ecological and holistic ways of thinking and learning**.

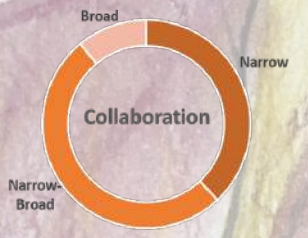
Learning Methods

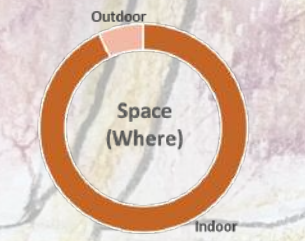
There is a strong call for **greater emphasis on experiential learning and extensive collaboration across disciplines**. These methods are still rare but seen as key for meaningful soil education.

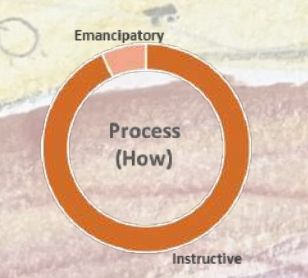
Teaching Style

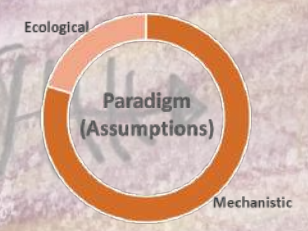
While a shift toward **more student-centred learning** is desired, a balance remains between aspiration and the current instruction-oriented style.

Perceived









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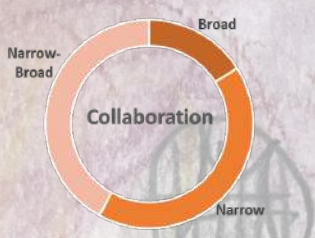
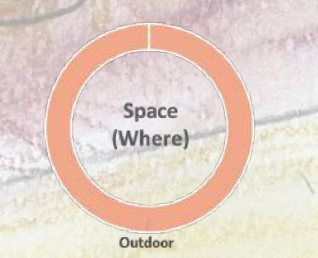
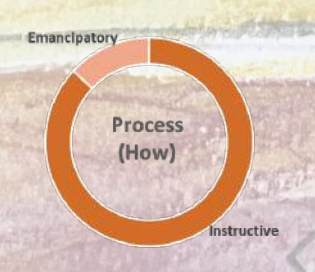
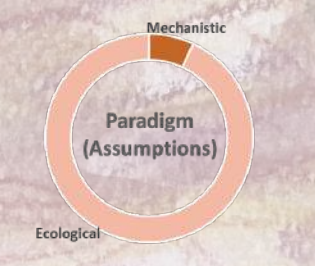








health education. Addressing these challenges requires coordinated efforts across education, policy, and resource allocation to inspire informed soil stewardship and protect this critical environmental resource.

Main challenges and needs for effective soil health education policies

Our findings underscore the necessity to address specific needs at the micro- and macro-levels to induce significant changes in soil health education. Therefore, a sustainable future for agricultural practices and environmental stewardship should be ensured.

Micro-level needs (individual educators and classrooms)

Improved teacher education

- In-depth understanding of soil health subjects (e.g. pollution sources, ecosystem services, and degradation indicators). This would allow teachers to answer student questions confidently and teach with scientific accuracy
- Teaching skills for outdoor, hands-on, and system-based educational methods. This would result in higher student engagement compared to traditional classroom approaches

Teaching materials and resources

- High-quality and accessible educational resources on soil health. This could significantly reduce teacher preparation time while ensuring consistency across schools
- Equipment and tools for hands-on soil observation and investigation (e.g., soil test kits, microscopes, pH meters), that would enable students to transform abstract concepts into tangible experiences

Awareness building

- Increase educators' awareness about the urgent need to protect and improve soil health (for instance through professional development workshops and the creation of soil-literate educators' networks)
- Enhance the communication of soil health relevance across diverse educational contexts, thereby connecting soil education to climate action, food security, and biodiversity (making it relevant across all subject areas)

Macro-level needs (system-wide changes)

Curriculum revision

- Integration of soil health topics within formal curricula at primary, secondary, and tertiary levels, which would ensure that 15 million European students receive systematic soil education by 2030 while preparing future professionals with foundational soil literacy
- Alignment of curricula with Sustainable Development Goals, particularly SDG 15 (Life on Land), and the eight specific objectives of the EU Mission Soil, such as reducing soil erosion, increasing soil organic matter, and preventing soil contamination. This would contribute measurably to EU environmental targets while creating environmentally literate citizens equipped to address concrete soil challenges

LOESS by established Communities of Practice (CoPs) in
that unite soil scientists, education professiona

Assessment reform

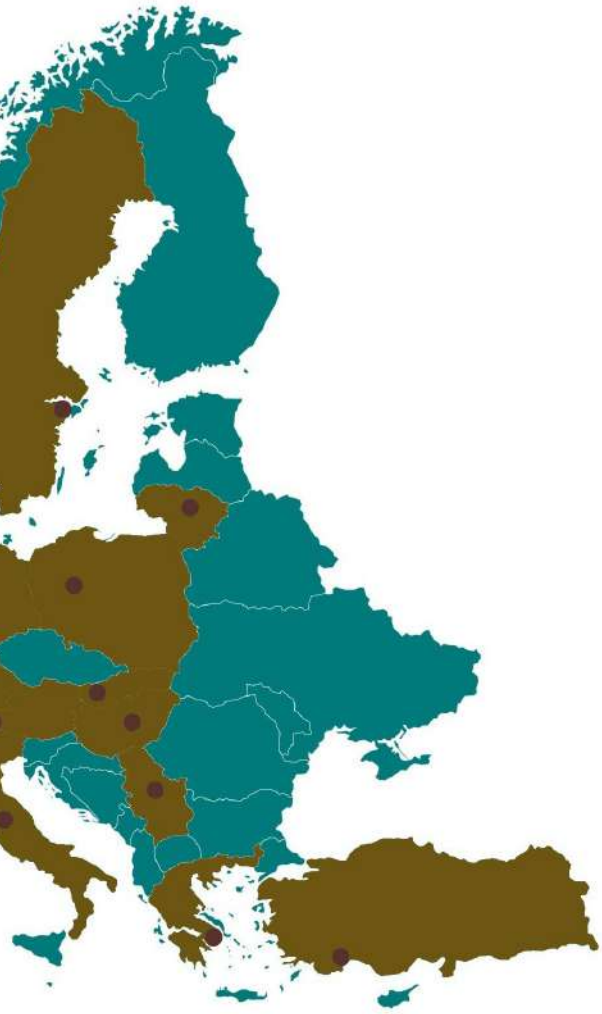
- Revision of educational goals and performance assessment criteria to include environmental stewardship competencies. This would produce graduates equipped with both knowledge and values needed for sustainable careers–
- Development of evaluation methods that balance knowledge, skills, and values through practical assessments (e.g. considering real-world problem-solving abilities rather than just memorised facts)

Transdisciplinary collaboration

- Dedicated programmes and funding for cross-sector partnerships (for example multi annual funding programmes aimed at connecting schools with local farmers, environmental organisations, and research institutions)
- Frameworks to connect educational institutions with community stakeholders, thus way providing students with real-world learning opportunities while addressing local soil challenges

LOESS Project has received funding from the European Union

N 15 European countries as knowledge-sharing networks
LS, policymakers, and community representatives



Policy support

- Educational policy reforms to facilitate innovative teaching approaches, including outdoor learning standards. This would remove regulatory barriers that currently prevent most schools from conducting regular outdoor education
- Administrative support for outdoor and experiential learning initiatives, thereby enabling schools to access natural learning environments safely and effectively

Recommendations for regional and local decision makers

Addressing these challenges requires a long-term, coordinated effort involving all stakeholders — not just a few determined individuals. Collective action at every level is essential to bring about meaningful and lasting change.

We strongly encourage regional and local decision makers and stakeholders to contemplate and discuss the following recommendations, designed to address the needs identified above, to drive concerted deliberations. These form the basis for coordinated deliberations that aim to meet current needs while laying the groundwork for sustainable progress and community well-being.

We appreciate that public administrations, along with profit and nonprofit organisations, as well as various groups and communities, face constraints of time, economic and human resources. At the same time, demands for restructuring and urgent action continue to grow. Therefore, we emphasise the necessity for coordinated efforts that generate synergies to optimise the use of existing resources.

To ensure the feasibility of the following recommendations, we propose that they be considered with a comprehensive understanding of current resources and opportunities. Each recommendation highlights the importance of connecting with and building upon existing structures and initiatives. While not exhaustive, this approach aims to encourage practical and sustainable implementation adapted to diverse regional realities.

We encourage consideration of these recommendations in light of potential developments that align with existing policies and actions. This approach emphasises the integration of innovative operational methods, rather than simply disrupting effective existing practices and adding the burden of new initiatives.

For regional councillors/ministers for agriculture, environment, and education (maximizing efficiency within existing policy frameworks)

Integrate soil health across policy domains building on current inter-departmental coordination

- Establish cross-departmental working groups on soil literacy by expanding existing environmental or agricultural working groups rather than creating entirely new structures
- Develop regional soil health education strategies aligning environmental, agricultural, land use, and urban planning objectives to address soil challenges in both rural and urban contexts within current regional development and sustainability planning processes

Create regional funding mechanisms, optimizing available resources

- Allocate dedicated budget lines for soil education initiatives by rearticulating and/or reallocating portions of existing environmental or educational budgets rather than requiring new funding sources
- Leverage European Structural Funds to support educational infrastructure for soil literacy through existing EU funding applications and regional development programmes already being pursued

Establish regional centres of excellence utilizing current institutional capacity

- Support the development and expansion of existing educational and environmental centres to include specialised soil health education programs. Creating new centres where gaps exist, by providing modest enhancement funding rather than major capital investments
- Foster research-practice partnerships between universities/research centres and schools through existing university outreach programs and established school-research collaboration frameworks

For decision makers in the domain of training and education at national and regional level (integrating with ongoing educational reforms)

Reform professional development programmes within current teacher training structures

- Integrate soil health modules into teacher training curricula during scheduled curriculum reviews and updates rather than requiring immediate overhauls
- Create continuing professional development programmes, workshops, and certification courses focused on innovative soil education methods by incorporating soil content into existing environmental education and outdoor learning training programs

Update curriculum guidelines through established curriculum development processes

- Review and revise curriculum frameworks to include soil health topics during regular curriculum review cycles to minimise disruption and additional costs
- Develop assessment guidelines that value practical and experiential learning about soil by adapting existing competency-based assessment frameworks rather than creating entirely new evaluation systems

Support educational innovation using available regulatory and funding mechanisms

- Create flexible regulatory frameworks supporting outdoor learning activities by modifying existing health and safety guidelines rather than developing new regulatory structures
- Establish innovation grants for schools implementing soil literacy programmes by dedicating portions of existing educational innovation funds or EU education program allocations

For local authorities (Mayors and Councillors)

Develop local soil education initiatives leveraging existing resources and partnerships to minimize municipal costs

- Create municipal soil education programmes linked to local environmental challenges using existing park staff and volunteer networks
- Establish community science initiatives focused on soil health monitoring through partnerships with local schools and environmental groups that provide expertise and equipment

Repurpose public spaces for soil education utilizing available municipal land at minimal additional cost

- Transform suitable public lands into educational soil gardens through community volunteer programs and donated materials
- Create demonstration sites showcasing sustainable soil management practices in collaboration with local agricultural colleges or environmental organisations that provide technical expertise

Foster local education networks building cost-effective partnerships

- Facilitate cooperation between schools, farmers, landowners, foresters, landscape architects, gardeners, and environmental organisations through regular networking events hosted in municipal facilities

- Support community-based learning activities around local soil issues by providing venue space and promotional support rather than direct funding

For school principals and education coordinators

Redesign learning environments building on existing outdoor education initiatives

- Enhance existing school gardens or outdoor classrooms to create dedicated outdoor learning spaces focused on soil education.
- Establish school gardens with dedicated soil monitoring stations that complement current biodiversity and sustainability projects, demonstrating measurable environmental impact to students and parents

Build local partnerships strengthening community connections schools value

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- Develop formal collaborations with local environmental organisations that schools may already work with for existing nature or sustainability programmes
- Create internship opportunities with farms, environmental agencies, and green businesses to support career education goals and community engagement objectives already prioritised by schools

Adapt school schedules integrating with established outdoor learning practices

- Restructure timetables to accommodate field-based soil education activities within existing outdoor education time slots that many schools already allocate for environmental learning
- Create dedicated project weeks focusing on soil health as part of established cross-curricular projects or environmental weeks that schools commonly organise to meet sustainability education requirements

For managers of protected areas and environmental centres (enhancing existing programs within current operational capacity)

Develop specialised soil educational programmes building on established visitor engagement activities

- Create immersive soil education experiences for schools and the general public by incorporating soil components into existing guided tours, nature programmes, and educational workshops that centres already offer
- Adapt existing signage, brochures, and digital materials to highlight soil ecosystem services instead of creating new materials

Train environmental educators supporting professional development of existing staff

- Enhance soil health knowledge among employed environmental educators through targeted professional development sessions integrated into existing staff training schedules
- Create professional networks to share soil education best practices among environmental education professionals already working in centres, facilitating peer-to-peer learning through existing inter-centre collaboration networks

Establish demonstration sites utilising available land and minimal additional resources

- Create educational installations showcasing soil profiles and soil functions within existing nature trails and demonstration areas, using low-cost materials and volunteer support
- Develop comparative plots demonstrating different soil management practices by designating small sections of current grounds for soil education, and ensuring maintenance within existing groundskeeping routines

Building territorial partnerships for soil literacy (leveraging established regional cooperation frameworks)

To maximise impact, regional and local stakeholders should develop integrated approaches through territorial partnerships:

Create local soil education consortia within existing partnership structures

- Bring together educational institutions, environmental organisations, agricultural stakeholders, and local authorities through established regional environmental councils, sustainability networks, or existing multi-stakeholder platforms
- Pool existing materials, expertise, and communication channels to develop shared resources and coordinated educational campaigns instead of creating new ones from scratch

Establish "soil literacy territories" integrating with current territorial designations

- Designate geographic areas for intensive soil education activities within existing protected areas, biosphere reserves, or sustainable development zones to avoid creating new administrative boundaries
- Coordinate existing school partnership programs with public education offerings to integrate formal and informal learning

Develop multi-stakeholder knowledge networks building on established research-practice partnerships

LOESS TEACHING AND LEARNING RESOURCES

LOESS has collaboratively developed several teaching and learning resources. Some of them are already available on the project's website, while others are still being finalised and will be available soon.

COMPLETED RESOURCES

CROWDMAPPING TOOL An interactive platform that enables users from schools, universities, and the wider public to identify local soil -related issues.

MOOC (MASSIVE OPEN ONLINE COURSE) Designed to offer professional development for teachers and to provide an introduction to innovative methods to integrate soil health into classroom teaching.

FOUR LEARNING SCENARIOS aimed at STEM educators teaching in schools incorporating to help soil topics into their teaching. These learning scenarios follow the BSCS 5E Instructional Model and integrate innovative pedagogical approaches.

COMMUNITY ENGAGED RESEARCH AND LEARNING MODULE FOR LECTURERS: a structured digital educational programme that helps university educators enhance their teaching through focused content, collaborative activities, and guided practice.

GLOSSARY: a list of key terms and corresponding definitions related to soil available in eight languages. The glossary is regularly updated to ensure accuracy and relevance.

AUGMENTED REALITY (AR) APPLICATION: an interactive digital tool that uses virtual 3D models, animations, and simulations onto the real world to help users explore and understand soil ecosystem services in a playful way.

COMING SOON

A BLUEPRINT outlining sustainable practices for educational settings, including school gardens, school practicals, "Guardians of the Soil Microverse," and tea bag experiments. It includes a framework for soil Education Measures. The blueprint will be integrated into the European Atlas of Soil Education and Training.

TRAINING MODULES FOR STUDENTS BY STUDENTS: collaborative educational resources in which students contribute to the development of instructional content for their peers. These co-created modules aim to foster both subject expertise and essential soft skills through practical engagement with real-world issues.

EUROPEAN ATLAS OF SOIL EDUCATION AND TRAINING: best practices and tools developed and tested through project activities, including the Augmented Reality (AR) tool.

- Connect scientific expertise with educational practice and local knowledge through existing university partnerships, agricultural extension networks, and established community engagement mechanisms
- Use existing meeting structures, digital platforms, and events for ongoing knowledge exchange and co-creation

Link soil education to territorial development integrating with ongoing planning processes

- Integrate soil literacy objectives into regional development plans during scheduled updates of environmental strategies, educational plans, and sustainable development frameworks.
- Align education programmes with conservation projects, agricultural initiatives, and climate adaptation measures already supported by funding to create synergies.

CONCLUSIONS

Improving soil literacy across European education systems requires coordinated action at multiple levels of governance. Regional and local policy and decision-makers play a crucial role in creating enabling conditions for innovative soil education approaches that connect knowledge acquisition with experiential learning and value development.

By implementing the recommendations outlined in this policy brief, decision makers can contribute significantly to the objectives of the EU Mission "A Soil Deal for Europe" while enhancing educational quality and environmental stewardship in their territories. The LOESS project offers valuable resources, case studies, and partnership opportunities to support such efforts.

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For more information: www.loess-project.eu
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