LOESS

LITERACY BOOST THROUGH AN OPERATIONAL EDUCATIONAL ECOSYSTEM OF SOCIETAL ACTORS ON SOIL HEALTH

CONTENT DEFINITION AND IMPLEMENTATION (WP3)

Deliverable D3.2 – Report on experiential learning modules for schools

PROJECT DETAILS		
	Project acronym LOESS	**Project title** Literacy boost through an Operational Educational Ecosystem of Societal actors on Soil health
	Call HORIZON-MISS-2022-SOIL-01-07	**Grant Agreement** n° 101112707
	Starting date 01/06/2023	**Project coordinator** Wissenschaftsladen Bonn
	Duration of project 36 months (3 years)	

DELIVERABLE DETAILS		
	Work package ID D3.2	**Expected date** 31/05/2025
	Work package title Content definition and Implementation	**Deliverable ID and title** Deliverable D3.2 – Report on experiential learning modules for schools
	Work package leader VA	**Deliverable description** Report on experimental learning modules for schools
	Nature [X] R Report / [ ] O – Other	**Author** Giuseppe Mossuti (EUN) Lucas Weinberg (UIBK) **Review** Ayfer Yilmaz (ANS)
	Submission date 31/05/2025	**Dissemination level** [X] P – Public [] CO – Confidential, only for members of the consortium (including the Commission Services)

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Deliverable 3.2

–

Report on experiential learning modules for schools

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

TABLE OF CONTENTS

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

1. Introduction

This document presents a set of educational resources developed to address soil health issues through an interdisciplinary STEM approach. The resources include:

- Four learning scenarios integrating various STEM subjects,
- A MOOC (Massive Open Online Course) on soil health,
- A blueprint showcasing exemplary sustainable practices in soil education, and
- A university-level course designed for biology and environmental science teacher students.

Each resource is described in detail, including its target audience, pedagogical approach, purpose, intended use, and expected learning outcomes. Links to all resources — developed under Task 3.2 — Co-design of Experimental Educational Modules for Schools, led by EUN — are provided within the text and listed in the annex.

In addition, this document outlines the piloting strategy for each educational resource, detailing the proposed timetable, the scope of the piloting activities, and the data collection methods to be employed.

The educational resources presented in this report have been designed based on the list of criteria, communication key messages and interaction elements presented in D3.6 — Draft content for teaching modules submitted in August 2024 (M15).

The established criteria, key messages and interaction elements are:

1. Promote complex forms of collaboration in soil education, involving teachers and students from multiple disciplines and multiple actors in society.
2. Favour outdoor forms of soil educational activities over indoor ones.
3. Design and carry out experiential hands-on activities, which cultivate caring dispositions and values.
4. Favour soil educational activities based on an ecological paradigm over those using a mechanistic one.
5. Strengthen the connection between Soil Deal mission goals, Sustainable Development Goals (SDGs) and soil education.
6. Recognise soil as a living system with cultural, social, and biological significance.
7. Integrate soil education into various subjects, providing practical, tactile experiences.
8. Integrate soil education into school curriculum.
9. Train teachers in soil education and provide well-organized, age-adjusted materials.
10. Provide tailored materials for soil education, including peer review and innovative pedagogies.
11. Integrate creativity and art into soil education.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

2. A Set of 4 Teaching Resources i.e. 4 Learning Scenarios

To support teaching and learning on soil health and soil ecosystem services, four STEM-integrated learning scenarios (LS) were developed. These scenarios, which target mostly at upper primary and secondary school students, are designed to be flexible and adaptable for other educational levels. Each scenario consists of a series of lessons that can be used in full or in part, allowing teachers to select the activities and content that best align with their curricular needs and educational objectives.

The four learning scenarios have preparation times ranging from 2 to 6 hours and teaching times ranging from approximately 3.5 to 6 hours, depending on the subject and implementation format.

2.1 Description of the 4 Learning Scenarios

In line with the objectives outlined in the Grant Agreement, the four LOESS learning scenarios promote interdisciplinary teaching by integrating two or more STEM subjects — specifically, geography, biology, physics, chemistry, and mathematics — into a cohesive learning experience. Two scenarios combine Biology and Geography, with one of them also incorporating Geology, while the other two integrate Biology, Mathematics, Chemistry, and Physics (see table below).

Title of the LS	Target audience	Subjects covered
The life beneath our feet	11-16-year-old students	Biology, Chemistry, Mathematics and Physics
Soil detectives	14-16-year-old students	Biology, Geography, Geology
Exploring soils	11- 13-year-old students	Biology, Chemistry, Mathematics and Physics
Save our soils	15-18-year-old students	Biology, Geography

Table 1: key elements of the 4 LOESS learning scenarios

These ready-to-use resources aim to increase students' understanding of key concepts such as soil functions, degradation, erosion, and texture. They also demonstrate how soil-related topics connect to the Sustainable Development Goals (SDGs), offering concrete examples of how to embed these themes into national curricula.

Target audience and intended learning outcomes

The learning scenarios are primarily designed for upper primary and secondary school students (ages 11–18), but their flexible structure allows adaptation to a wide range of age groups and educational settings. They are particularly suited for teachers aiming to foster

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

interdisciplinary, STEM-based learning within formal education, and can be used across various national curricula.

To support educators, each scenario includes practical implementation guidance, as well as suggestions for adapting content to meet specific curricular standards, local contexts, and the diverse needs of learners. The scenarios also demonstrate how to meaningfully connect soil health topics to the Sustainable Development Goals (SDGs), encouraging alignment with broader educational priorities.

The intended learning outcomes focus on developing students' critical thinking, scientific literacy, and digital competencies in the context of soil health and environmental sustainability. Students are encouraged to:

- Engage in interdisciplinary learning by integrating concepts from geography, biology, and environmental science.
- Collaborate on projects that promote teamwork, shared responsibility, and communication skills.
- Conduct scientific investigations, analyse soil health using digital tools (e.g., GIS), and represent data through visual storytelling and mathematical formats.
- Understand the role of soil in key global challenges, such as food production, climate change, land degradation, and sustainable agriculture.
- Explore the impact of human activity on soil ecosystems and evaluate strategies for soil conservation and sustainable land management.

Pedagogical approach

To achieve these learning outcomes, the learning scenarios employ a combination of inquiry-based science education (IBSE), project-based learning (PBL), and interdisciplinary teaching strategies, supported by collaborative, hands-on activities both in and outside the classroom.

This pedagogical approach encourages student-led exploration, real-world problem-solving, and the use of digital tools and data to foster critical thinking, scientific literacy, and systems thinking in the context of soil health and sustainability. As such, the scenarios equip students with the knowledge and skills to become informed, responsible, and active participants in addressing real-world environmental issues.

Purpose and intended use

The four learning scenarios are designed to support educators in teaching soil health through an interdisciplinary STEM approach. Each scenario integrates at least two STEM disciplines and is framed around real-world environmental challenges, helping students connect scientific concepts to practical, meaningful contexts.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The primary purpose of these scenarios is to foster student engagement, critical thinking, and hands-on learning through the use of innovative pedagogical methods. These include inquiry-based science education (IBSE), project-based learning (PBL), and a balanced mix of indoor and outdoor activities. The structure of the scenarios allows for flexible implementation and easy customization to suit different classroom needs, local contexts, and curricula.

Designed for use in formal school settings — primarily upper primary and secondary classrooms or laboratories — the scenarios offer a diverse range of activities, such as lab experiments, field observations, and interactive classroom tasks. They are intended to be integrated into regular school instruction but can also support extracurricular or project-based learning.

Accessibility, inclusion, and gender responsiveness were key considerations during development. Where relevant, the scenarios use gender-neutral language and highlight diverse role models, including female soil scientists, ecologists, and farmers from underrepresented backgrounds to promote equitable representation in STEM education.

Originally developed in English, the learning scenarios have been professionally translated into 12 additional languages. All 13 language versions are available on the LOESS website under the "Resources – Learning Scenarios" tab. Additionally, direct links to each language version of the 4 learning scenarios — *Soil Detectives, The Life Beneath Our Feet, Save Our Soils, and Exploring Soils* — are provided below and in the annex.

- Soil detectives
- The life beneath our feet
- Save our soils
- Exploring soils

Development process

The four learning scenarios were co-created by eight teachers, working in four interdisciplinary teams. These educators were selected through the Scientix® network, which brings together over 1,500 teachers with diverse subject expertise and pedagogical experience across Europe. Selection criteria included demonstrated interest in the LOESS project, subject-matter expertise, prior experience with international co-creation initiatives, and the ability to collaboratively teach the same cohort of students.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Each team consisted of two teachers from the same school who taught different subjects but had access to the same group of students. This arrangement enabled the design and implementation of genuinely interdisciplinary learning experiences.

Three teams were based in secondary schools (in Sweden, Italy, and Spain), and one team came from a primary school in Croatia[1]. To ensure pedagogical quality and cross-national relevance, the teams peer-reviewed and validated each other's scenarios, particularly when working with similar subject combinations.

To align the development process with the LOESS project's research findings (Task 2.2) and the outcomes of the cross-national co-design workshops (Subtask 3.1.2), the teachers participated in three online onboarding sessions. These were facilitated by project partners: EUN, UoV, WILA, and AMU. The sessions introduced the project's goals, core principles of soil education, and key thematic areas, such as the link between soil and the Sustainable Development Goals (SDGs), common soil-related challenges, and strategies for contextualizing soil health in classroom settings.

Once finalised by the 4 teams of teachers, the learning scenarios were also featured in the MOOC "Soil Education: An Integrated STEM Approach", where they served as models for participants developing their own scenarios. Furthermore, the scenarios will be included in the European Atlas of Soil Education and Training (Task 3.6), supporting their broader dissemination and use across Europe.

2.2 Piloting Strategy for the 4 Learning Scenarios

The four LOESS learning scenarios will be piloted in at least one school in each of the 15 countries where a LOESS Community of Practice (CoP) has been established. The piloting phase is scheduled to take place between March and October 2025 (project months M22–M29).

The primary objective of the pilot is to assess the quality, usability, and educational impact of the learning scenarios in real classroom environments. Specifically, the piloting exercise aims to:

- Evaluate the relevance and adaptability of the scenarios to various national curricula and school contexts.
- Examine the effectiveness of the scenarios in fostering student engagement in integrated STEM learning.
- Identify practical challenges encountered by teachers during implementation.

[1] In Croatia, primary education extends up to age 14, overlapping with the lower secondary age range in countries like Spain, Italy, and Sweden, where students typically transition to secondary school around age 11 to 12.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

- Gather educator feedback to refine content, structure, and instructional guidance.
- Build a foundation of evidence to support broader adoption and dissemination of the scenarios across Europe.

Selection of participants

In each practicing country, piloting will be coordinated by one consortium partner and benefit from the established local Communities of Practice as well as the partners' local networks. This ensures a wide reach and helps engage motivated educators from a range of educational contexts.

Each country will involve at least one school in the pilot, aiming for a globally balanced representation through the following selection criteria:

- Teachers at the upper primary and secondary levels with a background or strong interest in STEM education.
- Schools from diverse profiles, including variations in geography (urban/rural), type (public/private), and digital infrastructure.
- Educators with experience in or openness to innovative and interdisciplinary pedagogical approaches.

Teacher participation will be voluntary. Participants will receive pedagogical guidance, access to training resources, and continuous support from their national LOESS partner, where applicable.

Pilot implementation process

Teachers will be invited to choose and implement one or more of the four STEM learning scenarios during the piloting period (March–October 2025). The implementation duration will vary depending on the scenario and local context, typically ranging from 4 to 6 weeks.

The implementation model is flexible, allowing teachers to adapt the content and timing according to their curriculum requirements and classroom schedules. To support effective delivery, teachers will have access to translated materials in their national languages. In addition, optional online training or briefing sessions will be offered, and (where applicable) teachers will have a designated contact person for support throughout the pilot.

Data collection methods

Evaluation of the pilot will rely primarily on data gathered through an online post-implementation teacher survey. Before completing the questionnaire, respondents are required to provide their consent for the use of their data. A full privacy policy, compliant with

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

EU General Data Protection Regulation (GDPR) requirements, is made available to ensure transparency and protect participants' rights.

The survey primarily consists of open-ended questions and is intended to be completed by educators who pilot the learning scenarios, with one questionnaire submitted for each class implementation of a single scenario. While the questionnaires are to be completed in English, educators are welcome to use machine translation tools to help understand the questions and formulate their responses. The online questionnaire focuses on:

- Usability and clarity of the scenarios,
- Students' engagement and participation,
- Learning outcomes,
- Flexibility and adaptability of the activities,
- Potential for replication in other contexts.

All data gathered will be anonymized and used (if needed) to inform the revision and finalization of the learning scenarios. Additionally, where possible qualitative insights will be collected through informal exchanges between piloting teachers and local project partners to capture context-specific feedback, students' feedback and implementation experiences.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

3. A MOOC for Science Teachers

As part of the LOESS project's capacity-building actions under Task 3.2 "Co-design of Experimental Educational Modules for Schools", the Massive Open Online Course (MOOC) titled "Soil Education: An Integrated STEM Approach[2]" was developed and implemented.

This course is designed to strengthen educators' understanding of soil health and support the integration of soil-related topics into STEM teaching practices. It targets a broad audience, including primary and secondary schoolteachers, trainee educators, and both formal and non-formal STEM practitioners interested in adopting interdisciplinary and innovative pedagogies.

3.1 Description of the MOOC "Soil education: an integrated STEM approach"

The course explores the vital role of soil health in addressing urgent sustainability challenges and presents soil as a powerful thematic lens for designing meaningful, real-world, and student-centred learning experiences. It promotes systems thinking, contextualized teaching, and interdisciplinary learning across science, technology, engineering, and mathematics (STEM) subjects.

The MOOC is supported by Scientix®, the leading European community for science education. Scientix® fosters collaboration among STEM teachers, education researchers, policymakers, and other stakeholders, to encourage young people to pursue STEM-related careers and improve science teaching across Europe.

Purpose and intended use

The purpose of the course is to equip educators with the knowledge, tools, and pedagogical approaches, so that they could effectively teach soil-related content in a cross-disciplinary STEM framework. Hosted on the European Schoolnet Academy platform, the course is freely accessible upon registration and is designed for self-paced learning.

The live moderated version of the course was delivered from 3 March to 9 April 2025, during which participants could interact with facilitators and peers through discussions and collaborative activities. This format was intended to foster an active learning community, encourage peer support, and ensure high-quality engagement with course content.

[2] To access all content of the MOOC free registration to the European Schoolnet platform is required. To register, users must provide the following information: full name, email, public username, password and country.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

To successfully complete the course and receive a certificate of completion, participants were required to:

- Browse content, participate in activities and respond to quizzes;
- Design and submit an original learning scenario on soil education aligned with the pedagogical principles and content shared throughout the modules;
- Peer-review the submissions of three other participants, providing structured and constructive feedback using a dedicated rubric.

Following the conclusion of the live period, the course materials remain freely available for at least five years after the project's end, ensuring continued access and long-term impact. However, outside of the live phase, the platform does not offer moderation or opportunities for submission and peer review.

 It is intended to serve as both a professional development resource and a practical toolkit to support the uptake of sustainability-focused, STEM-integrated teaching practices across Europe.

Structure and modules

The MOOC is structured as a 5.5-week course that guides educators through the interdisciplinary potential of soil education within a STEM framework and beyond. Divided into four modules, released weekly on Mondays, the course supports participants in progressively deepening their understanding of soil-related topics while building practical, classroom-ready skills.

Although the live, moderated phase has concluded, all course materials remain accessible for self-paced learning. Educators are encouraged to follow the original weekly rhythm to maintain the intended learning flow and fully engage with the content and activities. The total estimated workload during the live period was 4 to 6 hours per week, amounting to approximately 22 hours of professional development, including the final assignment.

The first module of the online course introduces the fundamentals of soil health and its vital role in environmental sustainability and everyday life. Participants explore the links between soil education, the UN Sustainable Development Goals, and EU green policies while discovering how innovative pedagogies can enrich STEM teaching through soil-focused content. This module also presents the LOESS learning scenario template, which serves as a central tool throughout the course.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

In the second module, the focus shifts to the integration of soil education with the BSCS 5E Instructional Model and the principles of Education for Sustainable Development (ESD). Participants examine how ESD and the SDGs can be meaningfully embedded into curricula to address real-world soil challenges and promote sustainability. They explore various STEM pedagogies and how to apply them effectively to soil education, gaining hands-on experience with the 5E model and its classroom applications. A live webinar on the BSCS 5E Instructional Model for soil education took place on 11 March 2025, and the recording is now available within the course for those who were unable to attend or wish to revisit the session.

The third module broadens the perspective beyond STEM to include the economic, social, and ethical dimensions of soil education. Participants learn to design and implement indoor and outdoor soil-related activities and to incorporate broader societal considerations — such as ethics and sustainability — into their teaching practices while continuing to refine their use of the LOESS template.

The final module focuses on assessment strategies, guiding participants to distinguish between formative and summative approaches and to critically evaluate their learning scenario. This stage also marks the introduction of the final assignment: designing a complete learning scenario and submitting it for peer review. During the last 1.5 weeks of the live course period, participants had the opportunity to finalise their scenarios and review at least three submissions from peers using a shared evaluation rubric. Both submission of the final assignment and participation in the peer-review process were only available during the live phase of the MOOC.

To support this collaborative process and strengthen the learning community, a live TeachMeet event was held on 27 March 2025, as part of module 4. This informal, interactive session gave participants a chance to share ideas, good practices, and lesson plans, while connecting with fellow educators. A recording of the TeachMeet is now available in the course platform, offering continued inspiration and peer-driven insights even after the live phase of the MOOC has ended.

Target audience and intended learning outcomes

The online course is tailored for primary and secondary school teachers, practice-teachers, and both formal and non-formal STEM educators who are eager to enrich their teaching practice with innovative, interdisciplinary approaches to soil education. It supports participants in deepening their understanding of soil health and its relevance to society, sustainability, and STEM education, while equipping them with practical strategies and pedagogical tools for classroom implementation.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

By the end of the course, participants will be able to investigate and explain what soil is and why its health is vital for human and environmental well-being. They will explore how soil-related knowledge can be taught through interdisciplinary methods and will gain familiarity with the BSCS 5E Instructional Model as a framework to support active, inquiry-based learning. The course also enables participants to integrate biological, chemical, economic, social, and ethical aspects of soil health into their teaching. Ultimately, learners will apply this knowledge by designing a learning scenario that is ready to be used or adapted within their educational setting.

As the course is designed entirely in English, participants are required to have a sufficient command of the language to understand the content, engage in course activities, design and submit their own learning scenario[3], and provide peer reviews[4] on the work of fellow participants.

Pedagogical approach employed

The MOOC was designed using a blended pedagogical model that draws from both cMOOCs and xMOOCs; it is grounded in instructional design principles and a constructivist approach to learning. The course combines the structured delivery of content and defined learning objectives characteristic of xMOOCs with the participatory, learner-driven aspects of cMOOCs to create a rich and dynamic learning experience.

Collaboration is central to the course design: participants are encouraged to engage with one another throughout, not only to exchange ideas but also to co-construct knowledge through peer interaction. Peer training is a key component, based on the belief that every participant brings valuable experience and perspective — making each learner a potential teacher. This is exemplified in the peer-review process, collaborative forums, and live events like the TeachMeet.

While the course includes a top-down flow of information through core instructional materials and guidance from course designers, it also leaves space for learner agency. Resources and learning objectives are shaped both by course designers and by participants themselves. Educators are invited to contribute their insights and materials — especially through the creation of their own learning scenarios — reinforcing the idea that meaningful learning happens when learners take an active role in shaping their educational journey.

Although the MOOC is hosted on a centralized platform to ensure accessibility and coherence, it fosters a learning community that extends beyond the platform itself. The result is a pedagogical approach that values both structure and openness, offering a flexible yet

[3] Only relevant to participation that took place during the live period.
[4] Ibidem.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

purposeful path for educators to explore interdisciplinary soil education and its integration into STEM teaching.

Accessibility

The MOOC is hosted on the European Schoolnet Academy platform, which is built using open edX technology. The platform aims to align with AA-level accessibility standards as outlined in the Web Content Accessibility Guidelines (WCAG), supporting inclusive access for a wide range of participants, including those with visual, hearing, motor, or cognitive disabilities.

In keeping with these standards, the course strives to provide a learning experience that is both perceivable and operable for all users. Course content is typically structured with clear headings and follows a logical order, with attention given to readable text and sufficient contrast between foreground and background elements. Language used in the course is intended to be accessible and jargon is explained where appropriate, though the complexity of some topics may naturally vary.

Alternative formats are made available for much of the core content. Many images are accompanied by alternative text to support screen reader use, and most video materials include captions and/or transcripts to accommodate different learning preferences and needs. Audio content is generally supported by text-based alternatives. While implementation of these features may differ slightly across modules, the intention is to support multiple modes of access whenever possible.

The platform allows for keyboard-only navigation, ensuring that learners who cannot use a mouse can still engage with course elements. Quizzes, discussions, and other interactive components are designed to be broadly accessible without requiring fine motor control, although functionality may vary slightly depending on the specific tool or browser used.

Navigation throughout the course is intended to be predictable and consistent, with menus, buttons, and page layouts largely uniform across modules. Sudden content shifts and pop-ups are generally avoided to minimize confusion and cognitive load.

Where feasible, the course aims to minimize potential barriers for users with different types of disabilities. Content avoids rapid flashing, and form elements provide clear instructions and user feedback. In most cases, learners can increase text size up to 200% without losing functionality or access to essential content.

Finally, the course promotes inclusive communication practices, including the use of gender-neutral language, balanced representation, and efforts to avoid stereotypes. The design and delivery of the MOOC are guided by a strong commitment to creating a flexible, inclusive learning environment that welcomes a diverse audience of educators.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Development process

The development of the online course was a collaborative and iterative process, co-created by the LOESS consortium partners and coordinated by the EUN LOESS team. The course design was informed by the research outcomes from WP2 and the cross-national co-creation workshops conducted under WP3, ensuring it addressed both educational and project needs. The European Schoolnet Academy pedagogical team worked closely with the EUN LOESS team to guarantee that the course's structure and content aligned with the EUN Academy's pedagogical and quality standards as well as learner-centred approach.

The development process began in September 2024, gradually intensifying through October and November, and reaching its peak during December 2024 and January 2025, as partners finalized materials and prepared the course for launch. A detailed calendar guided the workflow, allowing all contributors to coordinate effectively across tasks and deadlines.

All LOESS partners played a role in shaping the course, contributing according to their areas of expertise. Notable contributions include:

- AMU, which developed key content, sources, and activities on soil science.
- UoV, which focused on soil education in connection with the UN Sustainable Development Goals (SDGs), Education for Sustainable Development (ESD), and the social, ethical, and economic dimensions of soil education.
- ControV, which provided engaging video content featuring real-life field-based activities.
- UIBK, which contributed extensively to content and activities on the BSCS 5E instructional model and served as the topic expert during the webinar dedicated to this teaching approach.

EUN, in addition to overseeing coordination and pedagogy, developed the learning scenario and rubric templates, and supervised the creation of the four case studies, including the production of the related video interviews.

Course promotion began in early December 2024, coinciding with the opening of registrations, and continued throughout the lead-up to the launch. All consortium partners actively contributed to the promotion efforts, helping to maximise outreach and participation across their national and professional networks. Meanwhile, most of the course content was finalized by January 2025, ensuring a smooth and timely start to the official course rollout.

Impact on professional development

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

With almost 800 participants enrolled and 400 educators completing the course, the MOOC demonstrated strong engagement and relevance among educators during the live period: at this stage, it is estimated that the MOOC impacted indirectly about 9600 students.

To ensure long-term impact, the course content will remain accessible for at least five years past the end of the project, allowing educators to revisit the materials at their own pace, refresh their knowledge, and integrate new insights into their practice. This ongoing availability supports sustained professional learning and allows the course to continue benefiting both current and future cohorts of educators committed to advancing environmental and STEM education.

During the live period, the course offered a certificate of completion from the European Schoolnet Academy, with additional accreditation opportunities available in specific regions. Teachers from Castilla y León and Galicia (Spain), Emilia-Romagna (Italy), and Ireland could obtain official recognition from their regional or national education authorities, provided they registered through the appropriate local platforms. These options allowed participants to align the course with their professional development requirements.

3.2 Piloting Strategy for the MOOC "Soil education: an integrated STEM approach"

The online course was piloted and evaluated during its live run, which served as a real-time testing phase. This live period provided an ideal setting to observe how participants engaged with the content and activities while benefiting from platform moderation and live events. These interactive elements prompted meaningful participation and allowed for the collection of both quantitative and qualitative feedback.

The evaluation strategy combined platform analytics — including registration and participation data automatically captured by the European Schoolnet Academy — with ad-hoc data collection through two voluntary surveys: one administered before the course (pre-survey) and one after completion (post-survey). Participation in both surveys was entirely voluntary, and all data were collected only with participants' informed consent and in full compliance with the EU General Data Protection Regulation (GDPR).

This mixed-methods approach provided valuable insights into:

- The profile of course participants,
- Their impressions and overall satisfaction with the course,
- Their self-assessed knowledge and confidence related to the course topics.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

This piloting strategy helped validate the course's design, relevance, and pedagogical effectiveness, while also identifying areas for potential improvement in future iterations.

3.3 Results of The Piloting Exercise

The MOOC attracted strong international interest, with 1 358 educators from 75 countries registering for the course. Of those, 775 participants actively engaged with the content by completing at least one unit, resulting in an engagement rate of 57%. A total of 400 participants completed the course in full, meaning they explored all sections and completed all required activities, leading to a completion rate of 52% — a notably high figure for an open online course. According to these figures, it is estimated that the course indirectly impacted about 9 600 students at this stage.

The course reached educators worldwide, with the top participating countries including Turkey (332 participants), Spain (83), Greece (54), Romania (50), Italy (49), and Portugal (32). The highest number of course completions also came from Turkey (186), followed by Spain (44), Greece (34), Romania (32), and Italy (20).

Insights from the pre-course survey show that most participants were secondary school teachers, predominantly female, and aged 36 or older. The feedback collected through the post-course survey was overwhelmingly positive:

- 97% agreed that they would apply the ideas and examples from the course in their teaching practice.
- 97% of respondents rated the overall course value as "Good" or "Very Good".
- 95% agreed that the course made them more confident and able to design a learning scenario about soil health.
- 95% of respondents stated that the quality of the course met their expectations.
- 94% expressed interest in participating in a similar course by European Schoolnet Academy.

Analysis of data from both the pre- and post-course surveys reveals a significant increase in participants' confidence and perceived expertise in addressing soil and soil health in their professional practice after completing the MOOC. Before the course, only 13% of respondents reported feeling confident in implementing soil-related content in their work. This figure rose to 44% in the post-course survey, indicating a substantial boost in participants' self-assurance and preparedness to apply what they had learned.

Moreover, the proportion of participants who identified themselves as having expertise in soil education and the ability to guide others increased from 6% before the course to 26%

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

afterward. This progression demonstrates the MOOC's effectiveness not only in building individual capacity but also in fostering a sense of leadership and professional growth among educators.

Qualitative feedback from course participants highlights the course's strong impact on both professional learning and classroom practice. Many found the MOOC enjoyable, engaging, and highly educational, with several commenting on the value of its structure, interactivity, and collaborative environment.

One participant remarked that the course was "pivotal in helping me plan a tangible and effective unit about soil," noting how the rich content made it difficult to choose a focus due to the abundance of interesting topics. Another shared: "The creative and inspiring environment kept my engagement and interest alive throughout the process."

Educators appreciated the STEM-integrated approach, citing features such as the 5E instructional model, peer assessment, the Padlet format for collaboration, and the inclusion of sustainable development goals, inquiry-based science education (IBSE), and project-based learning (PBL). As one participant noted, "It was the first Scientix course I attended with such massive active participation, as evidenced by the Padlets."

Although some participants questioned the full alignment of certain content with STEM, the overall response was positive. A STEM practitioner reflected, "I do eco-friendly projects all the time — it was good to combine them in a learning scenario."

Several participants also commented on how the peer-to-peer interactions, despite the online format, created a sense of community and support. One noted: "I was hesitant at first because it wasn't face-to-face, but I thought the peer interactions were OK, and I enjoyed all the shared resources."

Others expressed appreciation for the dedication and expertise of the course team, recognizing the care and thoughtfulness behind the learning experience: "The expertise and perspectives you shared enriched this journey and made it more meaningful. I deeply appreciate the time, energy, and care you dedicated to the process."

Participants also offered thoughtful suggestions to enhance interactivity, deepen feedback, and expand practical application. Several participants highlighted the value of the video content, noting that it supported visual and auditory learning and helped to simplify complex topics. To build on this strength, many recommended the inclusion of more interactive elements within videos, such as in-video quizzes, reflective pauses, or interactive exercises, to allow learners to apply knowledge in real-time and stay more actively engaged.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Another recurring suggestion was the addition of more real-life classroom examples and case studies. Participants expressed interest in seeing how teachers implement LOESS-inspired scenarios in actual educational settings, preferably through short video case studies or testimonials. These examples could serve as concrete models to help educators visualise how theoretical concepts — particularly the 5E model — can be translated into practice.

To further inspire participants and showcase the diversity of possible implementations, educators suggested sharing a wider variety of completed learning scenarios, ideally from different countries, subject areas, and educational levels. This could expand participants' perspectives and offer richer cross-cultural and interdisciplinary insights.

Finally, several participants expressed interest in more immersive learning tools, such as virtual labs, simulations, and interactive quizzes, which could help reinforce key scientific and pedagogical concepts and make the learning experience more hands-on and applicable to real-world teaching challenges.

In addition, while peer feedback was appreciated for its supportive tone, some participants would have welcomed more critical input to help them further improve their work and develop more robust educational materials.

These suggestions will be considered in the planning of possible future editions of the course to enhance interactivity, practical relevance, and pedagogical impact for an even more meaningful learning experience.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

4. A blueprint for exemplary sustainable practices

The LOESS Blueprint is intended for educators at various levels who are interested in integrating soil health topics into their teaching. In addition to outlining the importance of incorporating soil-related content into education, the Blueprint introduces the 5E instructional model (Bybee et al, 2006), which serves as a guiding framework for designing educational programs that have the potential to lead to deep learning and exemplary sustainable practices.

It offers a structured, research-based approach to fostering soil literacy through engaging and effective teaching strategies. Grounded in constructivist pedagogy and aligned with European policy objectives, the Blueprint functions both as a practical guide and a source of inspiration for developing impactful, sustainability-oriented educational experiences. The document concludes with case studies from selected LOESS partners, illustrating exemplary practices in diverse educational settings.

4.1 Description of the Blueprint

The educational objectives of establishing soil literacy and introducing the concept of soil health in Europe are central to the European Green Deal. They are also critical to realizing the EU's long-term vision for sustainable rural development and meeting the targets set out in the EU Soil Strategy for 2030. Achieving these ambitions requires a strong educational foundation: integrating soil-related topics into primary, secondary, and tertiary curricula is essential. Such integration offers students at all levels immersive learning experiences that spark curiosity and nurture a deeper sense of environmental responsibility.

However, realizing this vision is not without challenges. As Hartemink et al. (2014) highlighted, a growing gap exists between advances in soil science research and what is taught in schools — particularly at the undergraduate level. This blueprint directly addresses that gap by promoting student engagement and strengthening conceptual understanding through the 5E instructional model developed by Bybee et al. (2006). Drawing on a range of 20th-century educational theories, the 5E model provides a structured framework that fosters inquiry, motivation, and meaningful learning, making complex scientific concepts more accessible and relevant in educational settings.

Target audience

This blueprint is intended primarily for those who educate pre-and in-service teachers, as well as educators working in institutions that support learning outside the classroom. However, it can also serve as a practical framework for teachers at the pre-primary, primary, and secondary levels. It is designed to support anyone interested in developing and implementing

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

research-based teaching units — both in general and specifically focused on soil and soil health — within their existing educational practice.

The blueprint includes a variety of exemplary sustainable practices[5] aligned with clearly defined learning goals, organized into five complementary phases. Each practice is easily adaptable to different age groups, allowing for flexible integration across educational contexts.

Purpose and intended use

The content of soil education programs varies across European countries due to differences in educational systems and national priorities. Nevertheless, there is a growing trend toward integrating soil-related topics into school curricula. As van der Putten et al. (2018: 28) note, there is a pressing "need for educational programmes that create awareness of the role of soil in the life of individuals, communities and European society as a whole." The desk research (sub task 2.2.2), conducted at the beginning of the project, revealed that teaching materials on soil health education were often linked to other, seemingly overarching topics. For example, in Austria, soil was typically addressed either in the context of forest soils or closely associated with agricultural productivity.

Despite progress in some countries, the implementation of comprehensive soil health education across Europe remains uneven. A key challenge lies in the lack of consistent approaches to teaching soil science across regions and educational frameworks. Additionally, the degree of emphasis placed on soil education varies significantly, with some regions prioritizing it more than others. This inconsistency highlights the need for increased collaboration and coordination at the European level to promote soil literacy and raise awareness among both students and educators.

LOESS addresses these challenges by proposing this blueprint for sustainable and exemplary practices in soil education and follows the goal to raise awareness on soil health topics as well as improving soil literacy in society. The blueprint builds on insights gained from earlier project stages, such as the desk research and interviews (sub task 2.2.2) conducted in Work Package 2. Its current structure and content were shaped through a co-design workshop (T3.2) involving stakeholders with expertise in diverse educational and scientific fields who agreed on making use of the 5E model.

Key components of the blueprint

The objective of the LOESS Blueprint is to intertwine up-to-date soil research knowledge and education research-based strategies, and to enhance soil literacy education in Europe. Thus,

[5] The list of exemplary sustainable practices was compiled with the support of several LOESS partners as well as the EduglobalSTEM group and INS Escola Freixes. Link to the list of practices is included in annex.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

the blueprint presents the LOESS teaching and learning framework that is based on the 5E model by Bybee and colleagues (2006). Following this model will support educators in outlining clear learning objectives regarding soil health education. The blueprint aims to emphasize both conceptual understanding and environmental awareness and is designed to offer examples that are adaptable to different classroom settings and age groups.

The BSCS 5E model is illustrated through selected examples of classroom activities and learning scenarios. These scenarios were co-designed by educators and researchers across Europe and reflect the diversity of approaches needed to address local and regional challenges in soil health education.

To encourage its implementation, the blueprint includes a collection of case studies from LOESS partner institutions. These case studies demonstrate how the instructional model can be successfully applied in real-world contexts, highlighting both opportunities and challenges encountered by educators during this process. They also serve as a source of inspiration and provide concrete examples that other educators can adapt and replicate.

Instructional model: the 5E framework

The 5-phase approach is already well tested and there are several studies proving its effectiveness when following the scheme (Koyunlu Ünlü & Dökme, 2022). The model is based on the idea of constructivist learning and aims to give learners the opportunity to deeply understand the subject matter via different learning activities and first-hand experience. The goal is to engage students in creative thinking and putting their ideas into practice. Planning in advance is crucial for implementing the individual phases.

While the phases do not need to be followed in a particular order it is important to include each one, as they complement and support one another. The time allocated could vary depending on the overall time available. The planning supports educators to understand when it is time to evaluate a specific task or when it is helpful to pose supportive questions or give further scaffolds as this will support students to develop their higher-order thinking skills (Alrawili, 2020).

Research in the recent decade of Inquiry Based Science Education (IBSE) brought us profound knowledge about how to scaffold good science learning. Thus, the blueprint will give examples on how to support learners to learn most effectively.

The 5E instructional model consists of five distinct phases which complement each other and therefore offer different learning goals to achieve. By designing educational programs accordingly, the teacher or educator creates a motivating and learning-intensive program that not only engages students physically but also promotes deep learning. The joint effects of

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

hands-on and minds-on learning enable children with different needs to learn successfully. The LOESS blueprint describes these 5 Phases taking the Soil Health concept into consideration i.e.:

- **Engage** - This phase aims to spark students' interest in a particular soil topic and to assess students' prior knowledge and pre-existing ideas. LOESS activities begin with exciting elements like hands-on experiments, puzzling phenomena, concept cartoons, videos, or soil mysteries.
- **Explore** - In this phase, students explore aspects of a given issue through activities designed by teachers, allowing them to test ideas, solve problems, and acquire background knowledge. The goal is to enhance students' preconceptions and support cognitive processes through precise questioning and student-centred activities.
- **Explain** - In this phase, students explain their new understanding of a soil phenomenon and connect it with prior knowledge using mind maps, presentations, role plays, and posters. Teachers provide feedback to address misconceptions and support students in using scientific language accurately. Additionally, teachers may offer explanations to guide students toward a deeper understanding.
- **Extend** – In this phase, students deepen their understanding of soil-related phenomena and practice newly acquired skills by applying their knowledge to new and related contexts. It encourages them to develop strategies for using these skills independently, make informed decisions, and take meaningful action. This phase fosters creativity and promotes the application of knowledge to real-world challenges.
- **Evaluate** – This phase is a critical component of effective LOESS teaching. While student-centred and hands-on activities are highly engaging, they can result in a high cognitive load and may not always lead to systematic knowledge building. To address this, formative assessment plays a vital role in monitoring learning, providing timely feedback, and guiding instructional support. In parallel, summative assessment at the end of the learning process ensures a comprehensive evaluation of students' knowledge and skill acquisition.

Development process

The LOESS Blueprint was developed through a collaborative and iterative process involving educators, researchers, and stakeholders from multiple European countries. The development began with a review of existing literature and policy documents, followed by the identification of educational needs through curriculum analysis and stakeholder engagement. The participatory approach ensures that the blueprint is grounded in both educational theory and classroom practice, while remaining adaptable to a wide range of contexts.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

4.2 Piloting strategy for the Blueprint

To ensure the usability, relevance, and pedagogical effectiveness of the LOESS Blueprint, a structured piloting strategy has been developed. The primary objectives are to test the instructional model in authentic classroom environments, collect feedback from educators, and refine the materials based on practical implementation experiences.

As part of this strategy, the Blueprint has been embedded into a student teacher course[6], where it supports participants in completing their final project. Accordingly, pilot participants have been selected from future teachers enrolled in this course. In parallel, members of the Austrian Community of Practice (CoP) have been invited to review and provide feedback on the Blueprint's usability and adaptability in various educational contexts.

The piloting phase is scheduled to begin in June 2025 (M25). Data will be collected in the form of written reflections, documenting how the Blueprint was used in lesson planning and to what extent it supported educational outcomes. Participation is voluntary, and all data will be gathered with informed consent, in full compliance with the EU General Data Protection Regulation (GDPR).

This piloting strategy will play a key role in validating the design and instructional value of the LOESS Blueprint while identifying areas for enhancement in future iterations and broader implementation.

5. Educational Course for Biology and Environmental Education Teacher Students

Findings from the research conducted in WP2 clearly show that content knowledge and skills related to soil topics—and the concept of soil health in particular—are significantly underrepresented in most curricula across Europe. These topics are often treated as optional add-ons, addressed only if time permits, rather than being recognized as essential for understanding environmental, societal, and economic systems.

To address this educational gap, the LOESS project developed a dedicated course for biology and environmental education teacher students, as well as non-formal educators in training.

[6] The Educational course for biology and environmental education teacher students mentioned in chapter 5 of this document.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The course is designed to support them in building their professional teaching competencies around the critical topic of soil health.

5.1 Description of the Educational Course for Teacher Students

The course is designed as a stand-alone module but can also be seamlessly integrated into existing teacher education programs with a focus on environmental and sustainability education (ESD). It comprises four core sessions, each approximately 1.5 hours long, and is complemented by guided self-study and reflection tasks. The course can be delivered in blended, in-person, or online formats, with a preference for in-person implementation to maximize engagement and collaboration.

The course begins with a general introduction to educational theory and subject-specific pedagogy, providing participants with a strong conceptual foundation. This is followed by a step-by-step exploration of the 5E instructional model and its underlying learning theories, including constructivism, conceptual change, and inquiry-based learning. Each session includes a theoretical input phase, collaborative group activities focused on the creation of teaching materials, opportunities for self-reflection and peer feedback, and structured discussions.

By the end of the course, participants will have developed their own teaching scenarios on soil health and critically reflected on their potential implementation in school settings.

Purpose and intended use

The course aims to empower future teachers of biology and educational science to meaningfully integrate soil health education into their teaching practice. Its primary objectives are to:

- Bridge the gap between academic content and real-world environmental challenges by embedding soil education within STEM and sustainability frameworks.
- Support teacher students in designing, implementing, and evaluating soil-related learning units using the 5E instructional model.
- Promote student-centred, inquiry-based teaching approaches that foster engagement and deeper learning.

The course offers a flexible structure with ready-to-use materials and reflection tools, enabling adaptation to diverse national curricula and learner needs. It also creates opportunities to embed the Sustainable Development Goals (SDGs) and the objectives of the EU Mission a Soil

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Deal for Europe into classroom practice. As a result, participants gain not only content knowledge but also a critical, reflective pedagogical mindset aligned with current environmental education priorities.

Target audience and intended learning outcomes

This course targets students in teacher training and teacher education programmes for biology and environmental education. It is designed to provide them with the necessary knowledge about soil health, pedagogical skills, and educational competencies that are needed to teach soil-health topics in an interdisciplinary way. In addition, the course is meant to support them in developing the skills that are crucial to become competent and reflective teachers who can integrate soil health meaningfully across curricula.

Upon successful completion of the course, participants will be able to:

- Design and implement engaging learning units on soil health using the 5E instructional model.
- Identify and address learners' preconceptions in biology classrooms through tools such as concept cartoons.
- Critically analyse the ecological and societal relevance of soil health in local and global contexts.
- Collaborate with peers to co-create, test, and adapt effective teaching materials.
- Develop inclusive, inquiry-based learning activities that align with current sustainability and educational frameworks (e.g., SDGs).
- Evaluate and reflect on school curricula, identifying opportunities and gaps in soil health education.
- Assess their own learning processes and provide constructive feedback to peers through reflective and collaborative methods.

The course combines a range of active and collaborative learning strategies, including:

- Presentations and input lectures
- Think-Pair-Share activities
- Group and plenary discussions
- Journal paper reading and analysis
- Learning by doing
- Concept Cartoons and Concept Maps
- Socio-Scientific Issues (SSI) discussions
- Inquiry-based learning methods

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The course comprises a total of 12 hours of teaching contact time, which includes interactive sessions and the presentation of lesson plans to peers. In addition to the guided sessions, participants are expected to engage in approximately 15 hours of self-directed learning. This independent study time involves activities such as reading selected journal articles and developing a soil health education unit based on the 5E instructional model.

Pedagogical approach

This course brings together a range of pedagogical approaches, with a strong emphasis on inquiry-based learning (IBL). Students engage directly with real soil samples, carry out small-scale investigations, and draw their ~~own~~ evidence-based conclusions. This hands-on exploration fosters curiosity and scientific thinking, while concept cartoons and group discussions are used to address students' preconceptions. These methods help surface everyday ideas about soil and create moments of cognitive conflict—opportunities where resolving inconsistencies can lead to deeper conceptual understanding.

Central to the course is the use of the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate), which provides a clear and structured learning pathway. Each phase of the model is actively integrated—not only as a theoretical framework for science teaching, but also as a practical tool for planning and reflection. This allows students to internalize the model and apply it meaningfully in their own future classrooms.

The course also incorporates flipped classroom elements, where students prepare selected materials in advance. This approach maximizes in-class time for hands-on work, peer interaction, and meaningful discussion while shifting the role of the instructor toward that of a learning facilitator. It further encourages student autonomy by promoting responsibility for one's own learning process.

A key component of the course is the integration of socio-scientific issues (SSI). By linking soil health to broader political, ethical, and ecological questions, students are encouraged to connect scientific knowledge with real-world concerns and societal debates. In this way, the course fosters not only knowledge acquisition but also a sense of agency and relevance.

Throughout the course, students are also introduced to the principles of science communication and develop skills to present complex information clearly and effectively through visual (posters), oral (presentations), and written formats. The emphasis is on making science accessible without oversimplifying its content.

Collaboration is a core feature of the course design. Students co-develop learning materials, reflect on their ideas, and provide feedback to one another. This peer learning approach strengthens their professional identity as future educators and prepares them to address soil health and other environmental challenges in a confident and informed way.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Modules description

The following section provides a brief description of the course's four modules and complements the information presented in the accompanying slide deck. This combined documentation ensures full replicability of the course. The complete set of slides is available here and linked in the annex.

Module 1: Challenge your ideas *(Related PowerPoint slides: 1–11)*

This opening session sets the tone for the course by encouraging participants to engage with the core ideas of meaningful and effective environmental education. The primary educational goals are to *activate students' prior knowledge*, *raise awareness of gaps in current curricula*, and *highlight the relevance of soil health* as a key topic in sustainability education.

The session begins with an individual reflection activity, prompting students to consider what constitutes meaningful teaching in environmental education. In small groups, they identify and prioritize the elements they find most important, share their perspectives, and present their ideas in a plenary discussion. This collaborative exchange lays the groundwork for uncovering implicit assumptions and encourages early articulation of pedagogical values.

To deepen understanding, the concept of Soil Health is introduced through a short video, which serves as a springboard for discussing critical questions that education research and practice must address to enhance Soil Literacy in society. This is followed by a short theoretical input presenting criteria for good environmental education, drawing on the work of Meyer (2004). Rather than prescribing fixed standards, the session emphasizes the importance of flexibility and responsiveness to diverse teaching contexts. Students are encouraged to critically examine these criteria and relate them to their own educational experiences.

The session concludes with an analysis of national school curricula to assess the extent to which soil literacy is addressed. This activity fosters critical thinking about existing educational frameworks and highlights opportunities for integrating soil health more meaningfully into formal education.

Requirements and Flipped Classroom aspects:

- Task 1.2: The task is to read Meyer's criteria for 'good teaching' Meyer (2004) beforehand, to make some notes and bring them to the next lesson
- Task 1.3: Inform yourself on the topic of soil health by watching the following video: https://www.youtube.com/watch?v=53bbzE2IpKc
- Task 1.4: Students should look up documents on national curricula beforehand.

Lesson Plan - Module 1: Challenge your ideas

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Phase and Time	Content and Tasks
Introduction (10 minutes)	Warm-up-task: "What does good environmental education mean to you?" Individual reflection and group discussion
Reflection (20 minutes)	Educational Principle, criteria for good environmental education
Knowledge Input: Soil Heath (10 Minutes)	Video on Soil Health Education (+Task), Chart
Soil Literacy (50 Minutes)	Individual work: analysis of curricula Reflection and discussion in plenary

Table 2: Course for teacher students, lesson plan - module 1

Module 2: Engage Learners *(Related PowerPoint slides: 12–23)*

This second session is designed to deepen students' understanding of effective science teaching by introducing the 5E instructional model developed by Bybee et al. (2006). The educational aim of this module is threefold: to *familiarize future educators with the structure and pedagogical value of the 5E model*, to *explore how engaging teaching strategies can foster curiosity and participation*, and to *raise awareness of the powerful role that learners' pre-existing ideas play in shaping the learning process*.

The session begins with a concise overview of the five key phases of the 5E model highlighting how each phase contributes to the design of meaningful, inquiry-based learning environments.

To illustrate the Engage phase in practice, students participate in contrasting introductory activities that awaken curiosity and activate prior knowledge. First, they listen to an underground soundscape from Sounding Soil and are invited to speculate about the origin of the sounds. This auditory exploration encourages imaginative association and fosters emotional engagement with the often-invisible world of soil life.

This is followed by a more analytical task: students examine a photograph of a landslide and consider what this image reveals about current environmental challenges related to soil health. By connecting classroom learning to real-world events, this activity emphasizes the relevance and urgency of soil-related issues.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The focus then shifts to a key concept in science education — the impact of student preconceptions on learning. After a brief theoretical input on why addressing prior knowledge is essential for effective teaching, students take part in a creative exercise where they design concept cartoons. These short, illustrated dialogues represent common misconceptions or intuitive ideas that learners may have about soil. The activity encourages participants to think from a learner's perspective and helps them develop a diagnostic lens for uncovering and addressing misunderstandings.

Once the cartoons are drafted, students present them in small groups, share feedback, and reflect on the range of perspectives encountered. The session concludes with a journal article reading, which reinforces the theoretical underpinnings of the 5E model and further connects classroom practice to educational research.

By the end of this module, students not only gain a structured approach to planning inquiry-based lessons but also develop greater sensitivity to how learners' ideas shape the learning experience — key skills in becoming reflective and effective educators.

Lesson plan – Module 2: Engage Learners	
Phases and Time	**Content and Task**
Knowledge input (15 min)	5E Model, EU Mission Soil,
Learning by doing (30 min)	Examples for ENGAGE activities Designing a Concept Cartoon
Knowledge input: students pre-existing ideas about soil (45 min)	Individual work: journal paper reading, discussion in plenary

Table 3: Course for teacher students, lesson plan - module 2

Requirements and flipped classroom aspects

- Task 2.1: Get familiar with Concept Cartoons by reading:
  Naylor, S., & Keogh, B. (2013). Concept cartoons: What have we learnt?. *Journal of Turkish Science Education*, *10*(1), 3-11.
- Task 2.2: Read:
  Ero-Tolliver, I., Lucas, D. & Schauble, L. (2013): Young Children's Thinking About Decomposition: Early Modelling Entrees to Complex Ideas in Science. Research in Science Education, 43, p. 2137-2152/
- Task 2.3: Bring a jar of soil to the next session

Module 3: Explore and Explain Soil Issues *(Related PowerPoint slides: 24–38)*

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The third session builds directly on the previous work around the Engage phase and introduces participants to the next stages of the 5E instructional model: Explore and Explain. Its educational focus is to help future teachers *learn how to effectively guide students through open-ended investigations*, *support the construction of scientific explanations* — particularly in the context of soil health — and *understand how the complexity and information density of visual materials can impact student learning*.

The session opens with a hands-on group activity in which students examine soil samples they have collected from their local environments. They compare texture, smell, colour, and visible contents such as soil organisms. This practical task is designed to promote inquiry-based learning (IBL) by encouraging curiosity, observation, and hypothesis formation. Through this process, students begin to see soil not as inert material, but as a dynamic, living system. The activity also serves as an example of how authentic, place-based learning can be used to enhance engagement in school settings.

A short theoretical input follows, introducing key principles of scientific knowledge construction. Rather than passively absorbing information, learners are encouraged to actively build understanding through observation, dialogue, and connection to prior knowledge. Various methods for promoting active learning are presented, and participants are invited to reflect on how these approaches align with different learning goals and student needs.

Transitioning into the Explain phase, the focus shifts to the articulation of understanding. Participants consider how explanation — whether verbal, written, or visual — deepens learning. As the session emphasizes, "those who explain, learn the most." A curated series of visual representations of soil (e.g., diagrams, infographics, microscopic imagery) is introduced to illustrate the role of visual literacy in science education. Students analyse how such materials can support or hinder learning depending on their complexity and clarity. They also discuss common challenges that learners may face when interpreting information-dense visuals.

By the end of the session, participants will have experienced and critically examined both the Explore and Explain phases of the 5E model. They will gain insight into how guided inquiry and structured opportunities for explanation can transform students' understanding of soil and strengthen their ability to communicate scientific ideas.

Lesson plan – Module 3: Explore and Explain Soil Issues	
Phase and Time	**Content and Task**
Learning by doing (35 min)	Group Work: comparison of soils regarding smell, texture, … Identify soil animals

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Knowledge Input: how scientists gain knowledge (15 min)	EXPLORE-concept
Knowledge Input: deepen learning via explaining (40 min)	EXPLAIN-concept, activity: explain visuals in your own words Discussion about characteristics of good explanations

Table 4: Course for teacher students, lesson plan - module 3

Requirements and flipped classroom aspects:

- Task. 3.1: Students are asked to Bring soil samples and identification keys for soil animals
- Task 3.2: Search for and bring with you soil visuals (posters, pictures, graphics, diagrams)
- Task 3.3: Students should develop information cards about soil animals and how they contribute to the soil system

Module 4: Elaborate Soil Knowledge and Evaluate Students' Learning Progress *(Related PowerPoint slides 39 – 54)*

The fourth and final session focuses on the Elaborate and Evaluate phases of the 5E instructional model, equipping participants with strategies to help students deepen their understanding of soil-related topics and assess their learning progress. The educational goals of this module are threefold: first, to *familiarise participants with how to design and facilitate the Elaborate and Evaluate phases* in their own teaching practice; second, to *introduce concept mapping* as an effective formative and summative assessment tool that supports the evaluation of student learning; and third, to *provide insights into how socio-scientific issues (SSI)* can be used as a pedagogical strategy to encourage students to expand and apply their knowledge in ways that connect science to real-world challenges.

Working in small groups, participants take on a creative challenge: they either prepare a pitch aimed at persuading local politicians to act on soil pollution or design an educational outreach programme to raise public awareness about the health impacts of soil degradation and how it can be prevented. These tasks allow students to practice translating scientific knowledge into accessible, real-world communication and provide a model for how similar SSI-based activities can be implemented in their own classrooms.

The session then turns to the Evaluate phase, with a focus on assessment practices. The difference between formative and summative assessment is discussed, with particular attention to feedback strategies that support learning. Concept mapping is introduced as an effective tool for evaluating student understanding and fostering metacognition.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

In preparation for their final assignment, participants receive the exam task: designing a 5E-based educational unit on soil health. This task serves to integrate all major course elements — the 5E model, inquiry-based learning (IBL), and SSI — into a cohesive teaching design. Students present and discuss their units in follow-up sessions, receive peer and instructor feedback, and revise their work before submitting it for grading.

This module equips participants with practical strategies to help learners apply knowledge, reflect critically, and engage in complex real-world issues, while also providing the tools to assess student learning effectively.

Lesson plan – Module 4: Elaborate Soil Knowledge and Evaluate Students' Learning Process	
Phase and Time	**Content and Task**
Knowledge input and learning by doing (30 min)	ELABORATE concept and learning goals; activity on soil types
Knowledge input and activity on SSIs (30 min)	Input on the concept of SSI teaching, engaging in an SSI activity
Knowledge input and activity on Evaluation (30 minutes)	Formative and summative evaluation, Concept Maps and concept map analysis
Exam Task	Create a 5E Lesson plan addressing a soil topic Present the Lesson plan to get and give feedback, revise the lesson plan before the final submission

Table 5: Course for teacher students, lesson plan - module 4

Requirements and flipped classroom aspects

- Task 4.1: Bring information on soil types/ask students to research on soil types beforehand
- Task 4.2: Bring information on soil pollution/ask students to research on soil pollution beforehand
- Task 4.3: Prepare for students' lesson plan presentations

5.2 Piloting Strategy for the Educational Course for Teacher Students

The piloting phase aimed to test the implementation and effectiveness of the Blueprint for Soil Education within an authentic teacher training context. The pilot group consisted of students enrolled in a teacher training course, with university lecturers acting as facilitators and

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

observers. In addition, members of the Austrian Community of Practice (CoP) participated as external reviewers, providing valuable feedback on the Blueprint's usability and adaptability across diverse educational settings.

The piloting was scheduled for April–May 2025 (M25). Participation was entirely voluntary and conducted in full compliance with the EU General Data Protection Regulation (GDPR).

Throughout the student course, the Blueprint was fully integrated into the teaching and learning process. It served both as a structural guide for each module and as a conceptual framework for applying the 5E instructional model. This integration allowed for a thorough and practice-oriented evaluation of the Blueprint's capacity to support the design and delivery of effective learning scenarios on soil health.

A key focus of the piloting phase was to assess whether the course effectively enabled students to transfer theoretical knowledge into practical teaching competencies. To this end, the final task of the course constituted the central component of the piloting strategy: students were required to develop and implement complete teaching units based on the 5E model. These units covered four full sessions and reflected interdisciplinary and inclusive approaches to soil health education.

The implementation of these units was observed and assessed by an expert in biology and environmental education. Observational and qualitative data collected during this process was used to evaluate the Blueprint's clarity, adaptability, and impact on teacher students' professional development and instructional design skills.

Objectives of the Piloting Exercise

The piloting exercise aimed to evaluate the course's effectiveness in enabling teacher training students to:

- Understand and apply the 5E instructional model in lesson planning,
- Develop interdisciplinary and inclusive teaching units focused on soil health,
- Reflect critically on their own teaching practices and the curricular integration of soil-related topics,
- Demonstrate educational transfer from theory to practice through the co-creation of learning materials.

The overarching objective was to assess whether students could effectively apply the 5E model in their own lesson design and teaching practice. Data collected during the pilot is available upon request (in German).

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

6. References

Alrawili, K. S., Osman, K., & Almuntasheri, S. (2020). Effect of Scaffolding Strategies on Higher-Order Thinking Skills in Science Classroom. Journal of Baltic Science Education, 19(5), 718-729.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). The BSCS 5E instructional model: Origins and effectiveness. Colorado Springs, Co: BSCS, 5 (88-98).

Hartemink, A. E., Balks, M. R., Chen, Z. S., Drohan, P., Field, D. J., Krasilnikov, P., ... & Walter, C. (2014). The joy of teaching soil science. Geoderma, 217, 1-9.

Koyunlu Ünlü, Z., & Dökme, İ. (2022). A systematic review of 5E model in science education: proposing a skill-based STEM instructional model within the 21st century skills. International Journal of Science Education, 44(13), 2110-2130.

van der Putten, et al., (2018). Opportunities for soil sustainability in Europe. (EASAC policy report; No. 36).

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

7. Annex

Links to LOESS educational resources developed under T3.2 and related material i.e.:

- LOESS learning scenario Soil detectives
- LOESS learning scenario The life beneath our feet
- LOESS learning scenario Save our soils
- LOESS learning scenario Exploring soils
- LOESS learning scenarios online post-implementation teacher survey
- LOESS learning scenarios online post-implementation teacher survey privacy policy
- LOESS MOOC Soil Education: An Integrated STEM Approach[7]
- LOESS Educational course for Biology and Environmental teacher students
- LOESS exemplary sustainable practices based on the 5E model

[7] To access all content of the MOOC free registration to the European Schoolnet platform is required. To register, users must provide the following information: full name, email, public username, password and country.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.