LOESS INTEGRATED LEARNING SCENARIO TEMPLATE

Introduction

In LOESS, the acquisition of soil health knowledge is facilitated using integrated STEM teaching and learning, which is carried out via the Biology Science Curriculum Study (BSCS) 5E Instructional Model by Bybee and colleagues (Bybee et al. 2006) as well as the application of innovative pedagogical approaches (PBL, IBL, etc).

Keywords

Paleostratigraphy, Cultural heritage, Soil solutions, Soilless methods, Soil preservation.

Title

New SOILution: The clues beneath our feet

Authors

Valentina Cesari & Irene Somà

Summary

This learning scenario explores soil as a vital yet non-renewable resource, essential for life, food production and cultural heritage. Students will examine "soil solutions", focusing on the role of soil in nutrient cycling and environmental interactions. Through paleostratigraphy, they will analyse soil layers to uncover past civilizations and its role in preserving cultural heritage. The scenario contrasts traditional farming with innovative soilless methods like hydroponics, emphasizing the importance of soil restoration. By combining ancient practices with modern technology, students will gain insight into sustainable food production, soil conservation and urban farming's impact on biodiversity and mitigating soil consumption effects.

Licenses

Attribution ShareAlike 4.0 International (CC BY-SA 4.0). This license lets others copy and redistribute the material in any medium or format for any purpose, even commercially; it also allows to remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as the license terms are followed.

Subjects

Biology, Chemistry, Geology, Geography, Humanities

Real-life questions

- What types of artifacts or remains can be preserved in soil, and what do they tell us about past civilizations?
- How does urbanization impact soil health and food production?
- How do soil pH and nutrient levels affect the success of crops?
- What strategies can cities implement to support urban farming in areas with sealed 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.

- What are the main advantages and limitations of growing crops without soil?

Learning objectives

- Students will be able to identify and describe the different types and layers of soil in chronological order.
- Students will gain basic knowledge of archaeological stratigraphy.
- Students will reflect on how soil properties can contribute to the preservation of artefacts and human remains.
- Students will be able to describe the causes and effects of soil sealing and identify possible solutions.
- Students will be able to explain how soil supports plant growth and why its physical and chemical parameters are essential.
- Students will be able to describe innovative soilless farming solutions based on the knowledge and control of physical and chemical parameters.
- Students will recognize the importance of preserving soil and analysing its parameters to develop innovative solutions for proximity farming in sealed soil areas.
- Students will be able to apply hands-on methods for soil physical and chemical parameters testing.
- Students will develop scientific observation and data recording skills.
- Students will explore how concepts from Humanities, Earth Sciences, Chemistry, and Biology interconnect to reveal the central role of soil in environmental, economic, and social sustainability.

Link to curriculum

This learning scenario integrates Biology, Chemistry, Geology, Geography and Humanities encouraging an interdisciplinary approach in order to understand the importance of soil. The activities help students develop key STEM skills as outlined by UNESCO, including critical thinking, collaboration, problem solving and creativity. Students will be engaged in hands-on experiments, applying scientific methods to explore soil composition, nutrient cycles, innovative agricultural techniques and uncover past civilization. Students will become aware of the importance of promoting solutions for soil sustainability, contributing to a greener future. The scenario supports several UN Sustainable Development Goals (SDGs): SDG 11 (Sustainable Cities and Communities) by examining urban farming's role in creating sustainable urban environments, SDG 12 (Responsible Consumption and Production) by exploring sustainable soil management, SDG 13 (Climate Action) by promoting soil conservation and carbon sequestration, SDG 15 (Life on Land) by fostering soil biodiversity and restoration.

Age of students

Between 15 to 18 years old.

Time

Preparation time: 2 hours.
Teaching time: approximately 10 hours are needed to complete the learning scenario, but each lesson can be separately implemented.
Before starting the module, teachers involved should:

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.

- Review the curriculum to ensure alignment and prerequisite knowledge.
- Coordinate with colleagues for interdisciplinary consistency.
- Test equipment and ensure the availability of necessary materials.
- Ensure that all required handouts are printed and ready for distribution.
- Provide clear, step-by-step inclusive instructions with visual aids to facilitate understanding.
- Assign videos to watch at home before the lesson for in-class discussion.
- Organize student groups strategically, ensuring they are heterogeneous and inclusive, balancing skills, learning styles, and backgrounds.
- Set clear behaviour and safety rules.
- Define assessment methods and adapt them to students' individual needs (e.g., reports, presentations, etc.).

Teaching time:

- **Introductive lesson:** 1,5 hours (lesson 1)
- **Humanities & Geology**: 2,5 hours (lesson 2)
- **Geology & Geography:** 2 hours (lesson 3)
- **Chemistry & Biology:** 2,5 hours (lesson 4)
- **Humanities, Geology, Geography, Chemistry, Biology:** 1,5 hours (lesson 5)

Teaching resources (materials & online tools)

Materials for all lessons

- Computers/tablet
- Notebooks
- Internet connection
- Coloured papers, markers and a jar

Materials for Lesson 1

- Soil texture in a jar experiment: sample of soils, jars, water
- Image of soil texture triangle (Annex 1)

Materials for Lesson 2

- Practical Activity - Soil texture experiment: various soil samples, water spray bottles, magnifying lenses (optional), laboratory instruction sheet (Annex 2).
- Paleostratigraphy simulation: transparent plastic cups, coloured soil/sand, small artefact-like objects (e.g. beads, buttons, toy bone, etc.).
- Matrix exercises (Annex 3)

Materials for Lesson 3

- Practical Activity 1 - Soil erosion experiment: clear bottles, grass, bare soil, water
- Practical Activity 2 - Permeability test: clear bottles, different types of soil components (clay, sand, gravel), water, containers

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.

Materials for Lesson 4

- Practical activity – Compare physical and chemical parameters of soil and hydroponic solutions: soil samples, distilled water, hydroponic solutions, pH meter, EC meter, multiparameter, test strips.
- Additional practical activity - Qualitative assessment of carbonates: soil samples, vinegar (or diluted HCl).

Materials for Lesson 5

- Paper/poster materials or digital tools for infographics

Online tools:

Lesson 1. Warmup: brainstorming. The worLd in a jar.

- Tests to determine soil texture (teachers) https://www.fao.org/fishery/static/FAO_Training/FAO_Training/General/x6706e/x6706e06.htm
- What words come to mind when you think about soil? https://www.menti.com/aleu7t19apz9
- Initial assessment interactive quiz: How much do you know about soil? https://visitors-centre.jrc.ec.europa.eu/en/media/tools/quiz-how-much-do-you-know-about-soil
- Soil texture puzzle (online game) https://planeta42.com/geography/soilpuzzle/game.html
- Soil texture simulation using soil texture triangle (inclusive tool) https://www.biologysimulations.com/soil-type
- How to use the soil texture triangle (teachers) https://www.biologysimulations.com/post/how-to-use-the-soil-texture-triangle
- Soil texture calculator (inclusive tool) https://agritechcenter.com.np/soil-calculator.html
- 3 simple soil tests (students) https://www.youtube.com/watch?v=VYsoDulgrNg

Lesson 2. Soil as a time capsule.

- An Introduction to Cultural Soil Heritage (video) https://www.youtube.com/watch?v=REYdnZcRFG4
- What Is soil texture? (video) https://www.youtube.com/watch?v=HcWxoMLRVNI
- What is The Matrix? How do archaeologists use stratigraphy? (video) https://www.youtube.com/watch?v=xv-Yqoktyjg&t=1s
- Why didn't this 2,000 year old body decompose? (video) https://www.ted.com/talks/carolyn_marshall_why_didn_t_this_2_000_year_old_body_decompose
- Roman leather shoes and letters on wooden tables at Vindolanda (UK) (video) https://www.youtube.com/watch?v=-Q-nu-lEWqY
- The soil as a keeper of objective direct sources? Archaeological findings and their interpretation. (video for in-depth activity) https://www.youtube.com/watch?v=TNk5MOPYRCk

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.

Lesson 3. Sealing soil, unsealing disaster.

- Floods wreak havoc in Italy's Emilia-Romagna region (video) https://www.youtube.com/watch?v=M4FEv17PNmY
- Soil sealing: destroying earth's living skin (video) https://www.youtube.com/watch?v=ArRloxzv_2w
- Map of soil consumption in Italy https://www.consumosuolo.it/mappe
- LOESS Soil Map App (citizen science) https://www.loess-soil-map.eu/map

Lesson 4. Rooted in sustainability: innovation in schoolyard for a greener future.

- Initial assessment interactive quiz: How much naturally fertile soil is there on our planet? https://visitors-centre.jrc.ec.europa.eu/en/media/tools/quiz-how-much-naturally-fertile-soil-there-our-planet
- Are indoor vertical farms the future of agriculture? (video) https://www.ted.com/talks/stuart_oda_are_indoor_vertical_farms_the_future_of_agriculture
- Sustainable systems of soilless farming at school in Bologna (Italy) https://cspace.spaggiari.eu/pub/BOLG0001/sitoweb_annamaria_marconi/Sist%20sostenib%20ingl.pdf?_t=1725697763
- Understanding Our Soil: The Nitrogen Cycle, Fixers, and Fertilizer (video) https://www.youtube.com/watch?v=A8qTRBc8Bws
- How to prepare a soil slurry (video) https://www.youtube.com/watch?v=GB5HLqmJzVs&t=14s
- Measuring Soil pH & EC (video) https://www.youtube.com/watch?v=MuTgKqKMJ6I&ab_channel=AptusPlantTech

Lesson 5. The SOILution: puzzling the clues and take action!

- Soil Solutions to Climate Problems (video) https://vimeo.com/146177360
- The Soil: A non-renewable resource (Arpa Piemonte) - IT https://webgis.arpa.piemonte.it/portal/apps/storymaps/stories/6f1121a73acd47fe8395bd4ae40e3196
- European Green Deal https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
- FAO and ITPS. 2021. Recarbonizing global soils – A technical manual of recommended management practices.
  - Volume 3: Cropland, grassland, integrated systems and farming approaches - Practices overview. https://doi.org/10.4060/cb6595en
  - Volume 6: Forestry, wetlands, and urban soils – Case studies. Rome. (p. 239-254)

  "Urban agriculture on rooftops in Paris, France - the T4P research project (Pilot Project of Parisian Productive Rooftops)" https://doi.org/10.4060/cb6605en

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.

- LOESS Project: case studies
  https://loess-project.eu/case-studies/
- State of Soil Posters (EU Commission - Joint Research Centre, 2024)
  https://esdac.jrc.ec.europa.eu/public_path//images/A0-JRC-poster_STATE-of-SOIL.pdf

STEM Strategy Criteria

Developing the LOESS learning scenario will help you and your school comply with the STEM School Label criteria. Please indicate which STEM School Label criteria your learning scenario fulfils: fill in the table, adding information for the criteria your learning scenario tackles; you can delete rows for the criteria that are not included: https://www.stemschoollabel.eu/criteria
Example: see table.

Elements and criteria	How is this criterion addressed in the learning scenario?
Instruction	
Personalisation of learning	The variety of strategies, including brainstorming, collaborative laboratory approach, and case studies, allow for accommodating different learning preferences and abilities. Visual and auditory learners benefit from multimedia resources, such as videos, which enhance understanding through visual and auditory cues. The complexity of tasks can be adjusted using a range of online tools, ensuring that each student's learning experience is personalized. Furthermore, the experiments are versatile, designed to be accessible to students with varying backgrounds and ages, as they include both qualitative and quantitative approaches, promoting a personalized and inclusive learning process.
Problem and project-based learning (PBL)	The learning scenario is based on Project-Based Learning (PBL), where students engage with real-world, complex problems concerning the role of soil in environmental, economic, and social sustainability. They will collaborate in teams to explore open-ended questions, research case studies, and create interactive or multimedia products aimed at increasing soil literacy among their peers. Throughout this learner-centred process, students will actively build and apply their knowledge and skills to address real-world challenges. The scenario fosters critical thinking, problem-solving, and reflection, while promoting collaboration and communication, helping students develop valuable life skills.
Inquiry-Based Science Education (IBSE)	The learning scenario follows a Inquiry-Based Science Education (IBSE) approach, where students engage in exploring the topic of endangered soils through structured inquiry. The teacher facilitates the process by helping students identify key questions and formulate hypotheses. They collect and analyse data, drawing conclusions based on evidence. Throughout the process, students engage in discussions with peers to share and reflect on findings.
Curriculum implementation	The learning scenario's activities are aligned with educational standards and objectives commonly set in schools across Europe. It incorporates various student-centred pedagogical approaches, such as the BSCs 5E Instructional Model, collaborative group work, and project-based learning (PBL), to ensure active participation and effective, engaging learning experiences.
Emphasis on STEM topics and competencies	
Interdisciplinary instruction	In this learning scenario, a variety of activities are implemented by integrating Biology, Chemistry, Geography and Geology providing a holistic perspective and broad interdisciplinarity that also includes the Humanities.
Contextualisation of STEM teaching	Contextualization of STEM teaching is achieved by linking soil composition to real-life challenges explored through hands-on activities and case studies.

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.

Elements and criteria	How is this criterion addressed in the learning scenario?
Assessment	
Continuous assessment	The learning scenario integrates continuous assessment by using formative evaluation strategies such as peer feedback and teacher observations to monitor student progress, develop self-assessment skills, and adapt instruction for enhanced learning outcomes. Self-assessment tools , e.g. a feedback questionnaire (see Annex 4) , help students develop metacognitive skills.
Personalized assessment	An inclusive and effective learning experience is ensured through personalized assessment, using diverse evaluation methods tailored to students' individual needs, learning styles, and progress.
Professionalization of staff	
Highly qualified professionals	The scenario requires the involvement of highly qualified professionals with strong subject-specific expertise, the ability to approach topics from an interdisciplinary perspective, and solid pedagogical skills to effectively facilitate the proposed learning activities. It could be useful to invite external experts from the local area coming from the industry and academic research.
Existence of supporting (pedagogical) staff	Involving support staff in learning activities is suggested to ensure adequate assistance for students according to their individual needs. This involves using scaffolding tools like guiding questions, which encourage students exploring various perspectives and applying concepts to practical scenarios.
Professional development	The sharing and implementation of this learning scenario within an interdisciplinary team of teachers, including those from the humanities, can promote professional development and mutual enrichment, encouraging a broader implementation of learning pathways focused on the development of soil literacy.
School leadership and culture	
School leadership	School leadership is essential for providing direction towards achieving a laboratorial teaching approach, with a primary focus on student-centred pedagogy. It is also vital for building a vision where soil literacy and sustainability are central. Furthermore, school leadership can promote a collaborative environment for both teachers and students, facilitating continuous improvement in the teaching and learning process.
High level of cooperation among staff	The scenario requires a high level of cooperation among staff to ensure the learning efficacy of planned activities by clearly defining interdisciplinary boundaries and conducting laboratory activities in small, coordinated groups, all of which should be provided with clear instructions. In this scenario, all teachers and lab technicians involved should continuously coordinate and, when possible, conduct lessons collaboratively.
Inclusive culture	To foster an inclusive culture, it is important to organize small, heterogeneous groups where each student can receive support and feedback from peers. It is not advisable to encourage competition by setting excessively rigid deadlines for task completion. Students should be able to engage in discovery learning at a self-paced rate as much as possible. Tasks should be tailored to each student's abilities, and peer collaboration should be encouraged.
Connections	
With industry	Connection with industries can be achieved by inviting local experts in the fields of agroecology, permaculture, and hydroponics, who can illustrate professional opportunities for students in the area of green jobs.
With parents/guardians	The learning products can be showcased during an open meeting for families to promote soil literacy within the local community.

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.

Elements and criteria	How is this criterion addressed in the learning scenario?
With other schools and/or educational platforms	Students should collaborate to create a learning product that explores and promotes sustainable cultivation systems and local food or highlighting the importance of soil for cultural heritage using educational platforms such as eTwinning.
With universities and/or research centers	Connection with universities can be achieved by inviting experts in the fields of geology, archaeology, and agroecology, who can describe the skills and pathways necessary to pursue a specialized research career in each of the mentioned fields.
With local communities	Students will work in groups to develop a product that highlights the connection between their local community and the objectives of the European Green Deal, including identifying local organizations involved in environmental, social, and economic sustainability.
School infrastructure	
Access to technology and equipment	The request to collect and analyse data for completing activities necessitates access to a computer lab or a BYOD (Bring Your Own Device) approach. Hands-on activities in Biology and Chemistry require a well-equipped science laboratory. In particular, those related to aquaponic and hydroponic systems necessitate the presence of equipment such as an outdoor classroom with aquaponic, bioponic, or hydroponic systems (see online tools – lesson 4), as well as a purchased or student-made movable hydroponic system constructed from reclaimed materials. Archaeology, geography and geology activities also require reclaimed materials and different soil components.
High quality instruction classroom materials	The annexes included in this learning scenario are essential materials for delivering instruction and should be implemented according to students' learning needs.

Description of activities

The LOESS learning scenario must include a ***minimum of three lessons*** *as well as* ***indoor and outdoor activities.*** *In the below table add or delete lessons as required. Please, make sure to incorporate* ***all 5E phases*** *in the learning scenario following the* [*Biology Science Curriculum Study (BSCS) 5E Instructional Model*]() *by Bybee and colleagues (Bybee et al. 2006)*

Name of activity	Procedure	Time
	1st Lesson - The worLd in a jar.	
5E Phase	Engage, Explore, Explain, Elaborate and Evaluate	
Brainstorming warmup	The lesson begins with a brainstorming session to assess students' prior knowledge about soil. Students will use Mentimeter to collaboratively create a word cloud based on their associations with soil.	About 15' minutes
The worLd in a jar - Vocabulary and soil jars activities	Students will explore the concept of soil texture through interactive activities, collaborative learning, and hands-on experiments. The lesson aims to assess prior knowledge, introduce key vocabulary, and engage students in soil texture analysis using both physical and digital tools.	About 15' minutes

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.

Name of activity	Procedure	Time
	Step 1: Prepare a soil jar Each small group of students will prepare a soil jar by filling it with a soil sample and adding water. They will mix the water and soil, then set it aside to settle for at least one hour. **Step 2: Prepare a word jar** While waiting, students will work on vocabulary activities. Using small coloured papers, students will write down words from the Mentimeter word cloud and place them in a jar. The colour of the paper will indicate the lesson in which the word was introduced. In future lessons, new words will be added using different colours. The teacher will facilitate a discussion about key terms that emerge.	
Group glossary creation	Students will work in small groups to research the meanings of the words collected in the vocabulary jar. Each group will compile a glossary with simple definitions. The glossary will be updated throughout the unit.	About 30' minutes
Soil Texture Puzzle Activity	Students will attempt to solve the soil texture puzzle to reinforce their understanding of soil composition. New vocabulary terms from the jar and glossary will be integrated into the activity.	About 10' minutes
Soil Texture Determination	If the soil in the jars has settled, students will analyse its layers to determine texture. If sedimentation is incomplete or for students with special educational needs, an online soil texture simulation will be used (see provided online tools). The Soil Texture Triangle (Annex 1) will be distributed and explained by the teacher. Students will use the triangle to identify the soil texture type based on their observations. For students needing additional support, the Soil Texture Calculator tool will be provided. It is useful to also perform the ribbon test. The video "3 Simple Soil Tests'" can be provided to students at the end of the lesson as material for home study, as it reviews the tests conducted and their importance for understanding soil characteristics and its fertility.	About 20' minutes
Learning product	Soil glossary.	
2nd Lesson - Soil as a time capsule		
5E Phase	Engage, Explore, Explain, Elaborate and Evaluate	
Subject 1	Humanities, Geology	
Engage: "Soil as a time capsule"	This lesson introduces the fundamental concepts of archaeology through the observation of soil and the analysis of stratigraphy, with a focus on cultural soil heritage. Practical activities and reflective discussions are included, supported by video resources, simulations and empirical soil testing. The lesson begins with the viewing of a short documentary "An Introduction to Cultural Soil Heritage" by the British Society of Soil Science Following the video, a guided discussion is proposed to explore the idea that soil is not only a natural element but also a cultural one. Reflective questions may include: • How can soil be considered part of cultural heritage? • Why might the ground be as important as the monuments built upon it?	About 15' minutes

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.

Name of activity	Procedure	Time
Soil texture test for archeologists	This activity introduces another simple method for identifying soil texture, used in both scientific and archaeological fieldwork. A small quantity of soil is rubbed between the thumb and index finger with and without adding a drop of water (see Annex 2). Observations are recorded in a table, including sample ID, tactile sensation, and tentative classification. This activity helps understand how soil texture affects preservation and archaeological context. The video 'What is soil texture?' (see online tools) can help students grasp the main concepts by accommodating different learning styles and special educational needs. Reflective questions may include: • Which soil type dominates your test sample? • How does the texture affect excavation conditions? • Which soils preserve organics best? • How can you infer environmental or human activity from the soil?	About 30' minutes
Paleostratigraphy simulation	This simulation aims to provide a practical introduction to archaeological stratigraphy through the creation and analysis of layered "dig sites". 1. Teachers will guide students in preparing artificial stratigraphic columns in plastic cups by layering coloured soil and embedding small objects at different levels. 2. The dig sites will be exchanged among groups. 3. Each team analyses the stratigraphy, sketches a profile of the layers, and writes an interpretation of the sequence of events represented. This activity introduces the concept of the archaeological matrix.	About 30' minutes
The matrix : connecting time and space	The lesson continues with the explanation of archaeological stratigraphy through multimedia and guided instruction (see online tools). Key concepts are introduced, including: • stratigraphy as a tool for interpreting the chronological order of human activity. • the Harris matrix as a diagram to record the stratigraphic relationships between single units of stratigraphy - referred to as single 'contexts' • the importance of keeping artefacts in context to preserve their meaning. It is highlighted that disrupting the order of layers can result in the loss of historical information. The purpose of the activity is to understand the different types of relationships that exist between the layers of the soil and to create a diagram that represents them (Harris matrix). Exercises of increasing difficulty will be provided, and students can complete some of them in pairs at school while others will be assigned as individual homework (see Annex 3).	About 30' minutes
Exploring a case study	A case study is introduced through the TED Talk "*Why didn't this 2,000 year old body decompose?*" (see online tools). This video presents the extraordinary preservation of Lindow man, a man who died over 2,000 years ago. The conditions of the environment allowed for the near-complete conservation of his body. Teachers can also use other stunning examples such as excavations at Vindolanda that revealed everyday life in Roman Empire (see online tools). After viewing, a reflective task is proposed: If something needed to be preserved for 2,000 years, what kind of soil would be most suitable, and why?	About 30' minutes

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.

Name of activity	Procedure	Time
	This task encourages the integration of knowledge acquired during the soil texture test and stratigraphy simulation, prompting consideration of parameters such as oxygen availability, water retention, acidity, and clay content. As a further in-depth activity aimed at fostering critical thinking, students could watch the video *"The soil as a keeper of objective direct sources? Archaeological findings and their interpretation."* and engage in a guided discussion, trying to identify, together with the teacher, sources that lend themselves to different interpretations.	
Learning products	• Students add new words in the jar using different coloured papers and update the glossary. • Students will produce a diagram of the stratigraphic relationships related to the exercises they have completed (homework). • Soil experiment report (homework): students will document their observations and conclusions from the soil texture tests.	About 15' minutes at school
3rd Lesson – *Sealing soil, unsealing disaster*		
5E Phase	Engage, Explore, Explain, Elaborate and Evaluate	
Subject 2	Geology, Geography	
Practical activity 1 - Soil erosion experiment	To begin, students will explore how vegetation influences soil erosion. They will take two clear bottles and fill one with grass-covered soil and the other with bare soil. By carefully pouring water into both, they will observe how the presence of vegetation affects runoff and erosion. Through this simple yet effective demonstration, students will discuss how plant cover helps stabilize the soil, reducing erosion and minimizing the risk of environmental degradation.	About 30' minutes
Practical sctivity 2 - Permeability test	Next, students will investigate how different soil compositions impact water infiltration. They will prepare clear bottles filled with different types of soil components: clay, sand, and gravel. By pouring a fixed amount of water into each bottle, they will observe how quickly or slowly the water permeates through the soil. This hands-on experiment will prompt discussions on how soil permeability influences flood risks and water retention, highlighting the critical role of soil composition in environmental sustainability.	About 15' minutes
Understanding the consequences of unhealthy soil	To deepen their understanding, students will watch at home a series of videos illustrating the real-world impact of soil sealing and erosion. The first video provides a recent account of the devastating floods in Emilia-Romagna, emphasizing the role of impermeable surfaces in exacerbating the disaster. The second video offers a broader perspective on how soil sealing is progressively destroying the earth's living skin, making landscapes more vulnerable to extreme weather events. After watching, students will engage in a guided discussion at school to analyse the main causes and effects of floods and soil sealing, considering factors like urbanization, deforestation, and land mismanagement. The guiding question for the discussion will be: • How does human activity influence the soil's ability to absorb water? • What are the consequences of altering this balance? They will also brainstorm possible solutions to mitigate these issues.	About 30' minutes at school

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.

Name of activity	Procedure	Time
Mapping soil sealing and citizen science	Students will analyse the Map of Soil Consumption in Italy to investigate soil conditions near their school or home. A guiding question for the discussion will be: How does urbanization contribute to soil sealing? What regions are most affected? Using the LOESS Soil Map App, students document and report soil-related issues in their local environment. A guiding question for a reflection will be: How can citizen science help improve soil conservation?	About 30' minutes
Learning products	• Soil experiment report (homework): students will document their observations and conclusions from the erosion and permeability tests. • Citizen science report (homework): students submit their findings from the soil sealing mapping activity. • Students add new words in the jar using different coloured papers and update the glossary.	About 15' minutes at school
4th Lesson – *Rooted in sustainability: innovation in schoolyard for a greener future*		
5E Phase	*Engage, Explore, Explain, Elaborate and Evaluate*	
Subject 3	Biology, Chemistry	
Engage: "How much naturally fertile soil is there on our planet?"	This lesson explores the theme of sustainability in agriculture, with a focus on innovative and environmentally friendly solutions that can be implemented even in school environments. The lesson includes interactive activities, authentic resources, and hands-on experiments to deepen students' understanding of soil, nutrients, and soilless farming systems. To begin the lesson, students are invited to take part in an online quiz that prompts them to reflect on the importance of fertile soil and its limited availability on our planet. Once students have completed the quiz (see online tools), a short class discussion follows: • What surprised you in the quiz results? • Why is fertile soil essential for food and ecosystems? • Do you think we're using soil in a sustainable way? This activity helps students activate prior knowledge and begin thinking critically about the problem of soil degradation.	About 15' minutes
Exploring a case study	Students will watch at home the TED Talk "Are indoor vertical farms the future of agriculture?" After watching, they reflect at school on the following: • What agricultural problems does the speaker identify? • What are the benefits of vertical farming? • Could this system work in your city or school? Why or why not? Students are then introduced to a real example of sustainable farming systems implemented at a school in Bologna, Italy. This document (see online tools), in English, outlines three systems: hydroponics, aquaponics, and bioponics. Working in pairs or small groups, students choose one system and create an infographic or short visual presentation (digital or on paper) that: • Explains how the system works • Highlights its environmental benefits • Shows why it could be effective in a school setting	About 60' minutes at school

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.

Name of activity	Procedure	Time
Deepen understanding	The class focuses on the science behind soil fertility and plant nutrition. Students will watch at home an animated video about nitrogen cycle and fertilizers (see online tools). After watching, they will reflect at school on the following: • Why is nitrogen important for plants? • What are nitrogen fixers and what do they do? • How do fertilizers affect the nitrogen cycle?	About 15' minutes at school
Outdoor activities: comparative analysis of soil and soilless systems	Students apply what they learned in a hands-on activity focused on analysing soil and nutrient solutions for hydroponic systems. **Soil analysis** **Step 1: Prepare a soil slurry** Students collect soil samples from different locations (schoolyard, garden, or even potting soil) and watch a short tutorial on how to prepare a soil slurry (see online tools) **Step 2: Measure pH, EC and other chemical parameters** Students then measure the pH, electrical conductivity (EC) nitrogen content and other parameters of the soil slurry and nutrient solutions for hydroponic systems using meters or test kits (see online tools). In the absence of test strips for other chemical parameters, students can perform a qualitative assessment of carbonates using soil samples and vinegar (or diluted HCl). Students place a small amount of soil in a container and add a few drops of vinegar or diluted hydrochloric acid. If carbonates are present, they will observe bubbling or fizzing, caused by the release of carbon dioxide gas. This simple reaction helps identify carbonate-rich soils. Students record their results and compare values across different samples or with a nutrient solution used in hydroponic/bioponic/aquaponic systems. A class data table in experiment report helps visualize the variation. Discussion questions: • What does the pH tell us about the soil? • What does EC indicate? • How do measurements of different physical and chemical parameters affect plant health? • How could this analysis guide us in creating a sustainable school garden or indoor system?	About 45' minutes
Learning products	• Students can create a mind map to connect key concepts: Soil – Nitrogen – Fertility – Sustainability (homework). • Experiment report: comparison of physical and chemical parameters across different soil samples or with a nutrient solution used in hydroponic/bioponic/aquaponic system (homework). • Students will add new words in the jar using different coloured papers and update the glossary.	About 15' minutes at school
5th Lesson - *The SOILution: puzzling the clues and take action!*		
5E Phase	Engage, Explore, Explain, Elaborate and Evaluate	
Subject 4	Biology, Chemistry, Geology, Geography, Humanities	
Engage: "Soil solutions to	This lesson invites students to explore soil as a key player in the fight against climate change and its role in all the faces of sustainability. Learners are guided through a journey of discovery and collaboration, culminating in	About 10' minutes

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.

Name of activity	Procedure	Time
climate problems"	concrete proposals for improving soil health in their own environment. This learning experience blends science, sustainability, humanities, citizenship, and creativity, showing students that the solution to some of our biggest challenges might just be under our feet. We start with a powerful video, "Soil Solutions to Climate Problems" (see online tools) , to spark curiosity and set the stage. Students reflect on the idea that soil could be part of the climate solution and of fulfilling sustainability goals using also what they've learned in previous lessons.	
Piece together the SOILutions	Students will work in groups to "piece together" the SOILution by investigating a series of resources to get information and inspiration: an interactive storymap from Arpa Piemonte, case studies from the LOESS project and FAO's technical manuals on sustainable soil practices, containing also urban farming examples like rooftop gardens in Paris, and powerful visual tools like the "State of Soil" poster from the JRC. They also will explore how these connect with the goals of the European Green Deal. The lesson concludes with reflection activities and peer feedback, encouraging students to think critically about their role as changemakers. A digital feedback questionnaire (e.g., via Google Forms) helps the teacher evaluate the impact of the hands-on learning and teamwork, and to improve future lesson planning.	About 80' minutes
Learning products	Students will work in groups to create a product that connects their local community to the goals of the European Green Deal, identifying local organizations involved in environmental, social, or economic sustainability. They will apply their knowledge by proposing a practical solution for their school or community—such as a composting system, rooftop garden, awareness campaign, or soil protection initiative. As part of this, each group can also implement a short presentation or poster about the most sustainable farming system they explored, explaining why it suits their school and how it contributes to a greener future (see lesson 4). Each group's output will represent a "piece" of a collective puzzle, which the class assembles together to visualize how local and global strategies are interconnected. The learning products could be showcased during an open meeting for families to promote soil literacy within the local community.	

Initial assessment

Interactive pre-lesson quizzes on soil and fertile lands (lesson 1 and 4).

Formative evaluation

- Interactive quizzes.
- Glossary (lesson 1,2,3,4).
- Completion of the soil texture puzzle and correct identification of soil type using the texture triangle (lesson 1)
- Diagram of the stratigraphic relationships related to the exercises they completed (lesson 2)

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.

- Citizen science report: students submit their findings from the soil sealing mapping activity (lesson 3).
- Teachers will observe students' participation in group work during hands-on activities, discussions, word cloud and glossary activities and will provide feedbacks (lesson 1,2,3,4,5).

Final assessment

- A collaborative presentation, mind map or infographic summarizing key points from findings from their soil investigations and/or key points from the video discussions.
- Soil Experiment Reports: students document their observations and conclusions from:
    - soil texture experiments;
    - erosion and permeability tests;
    - comparison of physical and chemical parameters across different soil samples or with a nutrient solution used in hydroponic/bioponic/aquaponic systems.

Student feedback

Students will be able to give feedback and discuss the lessons through:

- oral comments during guided discussions;
- experiment reports (discussion section where students can reflect on problems encountered and suggest improvements);
- self-assessment questionnaire.

Teacher feedback

For the feedback on how the lessons were received and implemented, teachers can write some comments using for the assessment a combination of methods to ensure a comprehensive understanding of how the lesson was received and implemented.

1. ***Analyse self-assessment questionnaire***:
   Students will be provided with a simple, structured self-assessment questionnaire (see Annex 4), asking them to rate their understanding of key concepts on a scale of 1 to 5.
2. ***Collect oral and written feedback***:
   During group discussions or at the end of the lesson, teachers can invite students to share their thoughts on the lesson's content, its relevance, and any challenges they faced. This feedback can be gathered both orally during discussions and in writing through their experiment reports. By encouraging informal sharing, students can feel comfortable expressing both positive and constructive feedback. They can also reflect on the improvement of their knowledge.
3. ***Reflection about word jar activity***:
   Teachers can invite students to think about the improvement of their knowledge about soil watching the result of soil jar activity and the connected glossary.

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.

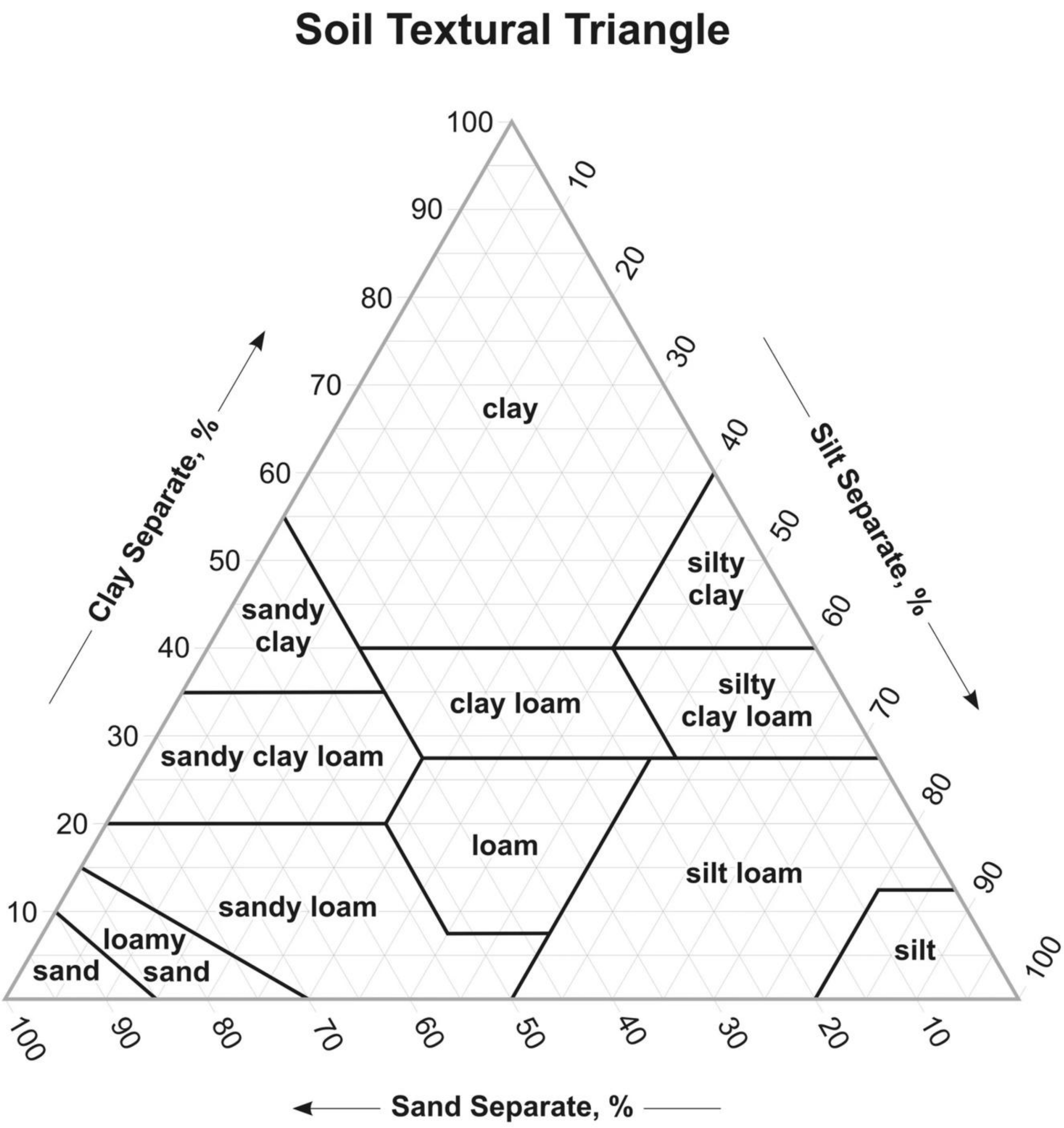
Reflection on the development process

The initial ideas for this learning scenario were inspired by the global emphasis on sustainability and the crucial role of soil in mitigating climate change. As an educator, I aimed to design a lesson that would highlight soil health's scientific importance while connecting it to real-world applications like sustainable farming. The focus on "soil solutions" for climate issues came from research into global initiatives like the European Green Deal and the FAO's recarbonizing soils manual, which stress the importance of soil management for a sustainable future. To inform my plan, I explored videos, articles, and case studies, particularly the LOESS Project and urban agriculture initiatives like rooftop farming in Paris. I also drew inspiration from my school's hydroponic, bioponic, and aquaponic systems, as well as interdisciplinary work in archaeology. This helped me create interdisciplinary lessons that could be taught independently or as part of a broader unit, showing soil's relevance to sustainability in environmental, social, and economic contexts and cultural heritage. Through this process, I learned the value of integrating hands-on activities and real-world applications. I also realized the importance of adaptation to student interests, needs and regional contexts, ensuring deep engagement with the content and its broader implications.

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.

Annex 1 – Soil texture triangle



https://www.biologysimulations.com/post/how-to-use-the-soil-texture-triangle

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.

Annex 2 – Soil texture test for archaeologists

Soil texture test for archaeologists

This activity helps archaeologists and students classify soil texture by touch and observation, a key step in understanding stratigraphy, site formation, and the potential for artifact preservation.

1. Initial observation (dry soil)

- Observe the **colour**, **grain size**, and presence of **inclusions** (pebbles, charcoal, organic fragments).
- Note whether the sample appears **cohesive or loose**.
- Smell the soil—humic layers often have a distinctive organic scent.

2. Tactile test (dry soil)

- Take a small amount of soil and **rub it between thumb and forefinger**.
- Feel whether it is:
  - **Gritty and loose** → Suggests **sand**.
  - **Smooth and floury** → Suggests **silt**.
  - **Fine and sticky** → Suggests **clay**.

3. Moisture test (wet Texture)

- Add a few drops of water to the sample.
- Mix until the soil is damp but not muddy.
- Repeat the tactile test:
  - Does it **form a ball** in your hand?
  - Can you **roll it into a cylinder** or **ribbon** between fingers?

Classification Table (simplified, based on Carandini A.: *"Storie dalla terra". Einaudi, 1996*)

Soil	**Feel (Dry)**	**Feel (Wet)**	**Features and behaviour**	**Archaeological Relevance**
Gravelly	Gritty	Loose and non-cohesive	Mixed with small stones. Loose and fast-draining.	Found in slopes or riverbeds. Poor for preservation, but may reflect natural transport layers.
Sandy	Gritty	Non-cohesive	Large, visible grains. Disaggregates easily. Excellent drainage, but poor moisture and organic retention.	Typical in coastal or riverine areas. May contain eroded or displaced artifacts. Low preservation for organic remains.
Silty	Silky	Slightly sticky	Rich in silt, a particle finer than sand but coarser than clay. Moisture-retentive but less cohesive than clay. Forms weak clumps.	Found in floodplains or lake margins. Often good for preserving archaeological remains. Indicates slow, watery deposition.

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.

Clayey	Smooth, dense and hard	Very sticky and plastic	Very fine particles. High water retention. Forms stable shapes.	Often found in floodplains. Forms sealed layers. Excellent for preserving organics (wood, seeds). Difficult to excavate due to compaction.
Peaty	Soft, spongy	Mucky	Rich in partially decomposed vegetation. Dark, acidic, high in organics.	Good for preserving wood and textiles. Corrosive to metals. Typical of wetlands and bogs.

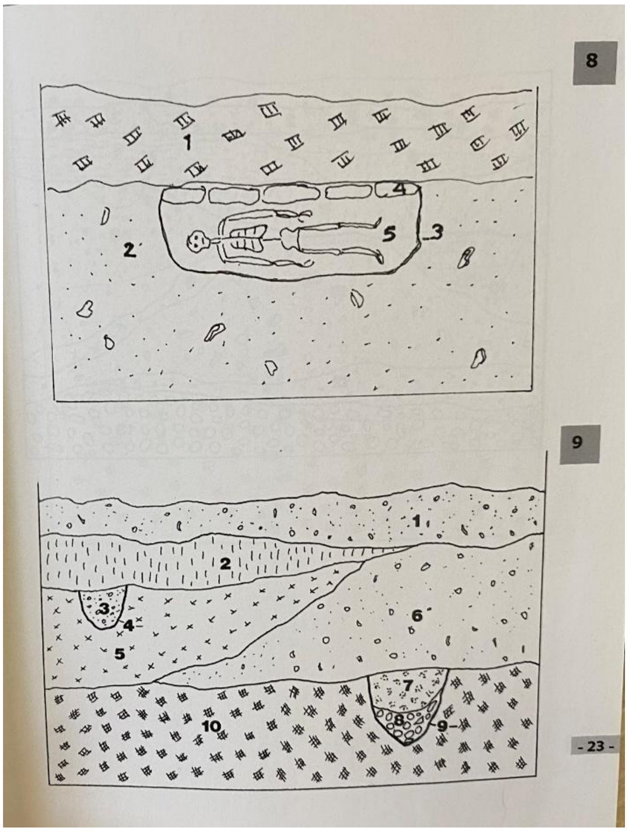
Some soils show **intermediate or mixed characteristics** — for example:

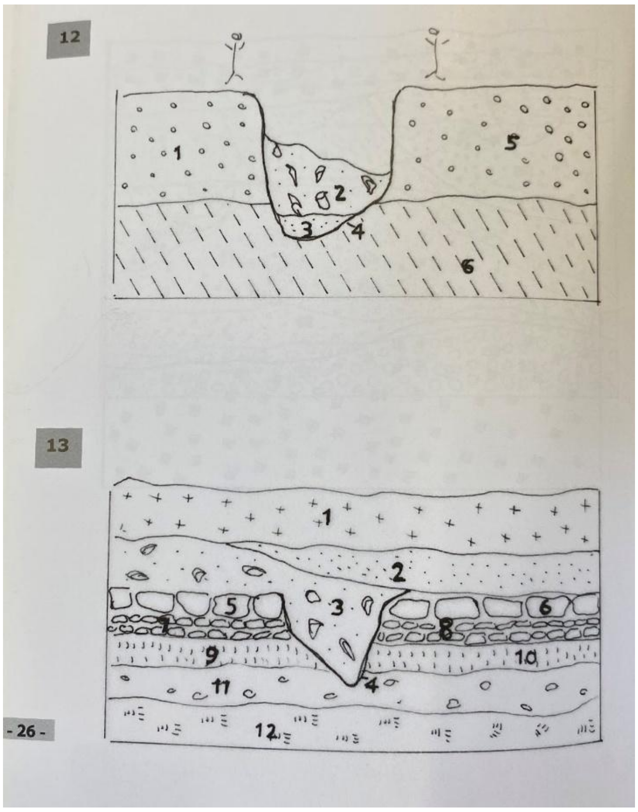
- **Silty clay**: smooth and sticky, not easy to break apart.
- **Sandy clay**: gritty and sticky, breaks easily.
- **Silty sand**: smoother than sand, doesn't forms a ball or stain the fingers.
- **Clayey sand**: forms a ball, stains the fingers.

However, for this introductory test, we will **focus only on the five basic soil types**: **sandy, silty, clayey, gravelly, and peaty**. Mixed textures can be explored in advanced stratigraphic analysis.

Annex 3 – Matrix exercises

Level 1 - basic: n. 8, 12
Level 2 - intermediate: n. 9, 13





Laura Amadori et al: QuantoBasta. Esercizi di Matrix. Edizioni Espera , 2017.

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.

Annex 4 – Feedback questionnaire

This questionnaire can be shared digitally using platforms like Google Forms or any other survey tool, and it will give teacher a clearer understanding of how effective the hands-on activities and teamwork were in the lessons and how teacher can improve the planning of each lesson.

New Soilution – Feedback Questionnaire

Please complete the following questionnaire to help us improve the lessons. Your responses are valuable for enhancing future learning experiences.

1. Rate your understanding of the following concepts:

(1 = Not at all, 5 = Fully understood)

- **Soil health and its importance in climate change mitigation**
  - ☐ 1
  - ☐ 2
  - ☐ 3
  - ☐ 4
  - ☐ 5
- **Carbon sequestration and its connection to soil**
  - ☐ 1
  - ☐ 2
  - ☐ 3
  - ☐ 4
  - ☐ 5
- **Sustainable farming practices and their relation to soil health**
  - ☐ 1
  - ☐ 2
  - ☐ 3
  - ☐ 4
  - ☐ 5
- **Urban agriculture practices and their role in sustainability**
  - ☐ 1
  - ☐ 2
  - ☐ 3
  - ☐ 4
  - ☐ 5
- **The concept of soil as a cultural heritage**
  - ☐ 1
  - ☐ 2
  - ☐ 3
  - ☐ 4
  - ☐ 5

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. Reflect on the lessons:

- **What did you find most interesting or helpful about each lesson?**
  (Open text response)
- **Was there anything in the lessons that you found difficult or unclear?**
  (Open text response)

3. Hands-on Activities and Team Working:

- **How effective did you find the hands-on activities in helping you understand the concepts?**
  ☐ Very ineffective
  ☐ Ineffective
  ☐ Neutral
  ☐ Effective
  ☐ Very effective
- **Do you feel the hands-on activities were engaging and useful in making the lessons more interesting?**
  ☐ Not at all
  ☐ Somewhat
  ☐ Neutral
  ☐ Yes, definitely
- **How well did working in teams help you understand the contents?**
  ☐ Very poorly
  ☐ Poorly
  ☐ Neutral
  ☐ Well
  ☐ Very well
- **Do you feel that teamwork allowed you to learn from your peers and gain new perspectives?**
  ☐ Not at all
  ☐ A little
  ☐ Neutral
  ☐ Yes, to some extent
  ☐ Yes, definitely

4. Real-World Application:

- **Do you feel confident applying what you've learned in real-world situations?**
  ☐ Yes
  ☐ No
  ☐ Not sure

5. Feedback for Improvement:

- **What suggestions do you have for improving future lessons on this topics?**
  (Open text response)

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.

- **How would you rate the overall lesson 1 (*The worLd in a jar*)?**
  - ☐ Very Poor
  - ☐ Poor
  - ☐ Average
  - ☐ Good
  - ☐ Excellent

- **How would you rate the overall lesson 2 *(Soil as a time capsule)?***
  - ☐ Very Poor
  - ☐ Poor
  - ☐ Average
  - ☐ Good
  - ☐ Excellent
- **How would you rate the overall lesson 3 (*Sealing soil, unsealing disaster*)?**
  - ☐ Very Poor
  - ☐ Poor
  - ☐ Average
  - ☐ Good
  - ☐ Excellent
- **How would you rate the overall lesson 4 (*Rooted in sustainability: innovation in schoolyard for a greener future*)?**
  - ☐ Very Poor
  - ☐ Poor
  - ☐ Average
  - ☐ Good
  - ☐ Excellent
- **How would you rate the overall lesson 5 (*The SOILution: puzzling the clues and take action!*)?**
  - ☐ Very Poor
  - ☐ Poor
  - ☐ Average
  - ☐ Good
  - ☐ Excellent

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.