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

Soil Microbiome, Moist Soil, Earth Soil, Mars Soil, Soil Health, Soil Literacy

Title

Towards a "Bright Blue Dot" with Fertile Soils

Authors

Gizem Temiz

Summary

In this learning scenario, students will combine biology-astronomy-information technologies (IT), literature-music and mathematics to explore the importance of soil and the connection between soil-microbiomes-moisture, beneficial minerals and increased soil fertility. Using Astronomy they will make comparisons between Mars-Earth soil, Biology will explain the effect of soil samples with different moisture levels on soil fertility. With math, they will calculate, graph, interpret soil moisture percentages. With AI, they will turn what they have learned into songs, combine outdoor activities with music, puzzle/games with literature. While developing their final products, IT will motivate them to create sustainable solutions to improve soil fertility.

Subject (s)

Biology, Astronomy, Literature, Music, Information Technology.

Real-life questions

- Is soil alive? What are the differences between the soil on our planet Earth and the soil on Mars?
- What is the importance of the diversity of microorganisms in the 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 can be done to ensure that the ecosystem of micro-organisms in our soils, whose moisture content decreases due to climate change, which is a global problem, does not deteriorate, thus increasing the efficiency of the soil?
- How does soil moisture affect soil health?
- How can technology guide us in increasing soil fertility?

Learning objectives

Students will be able to:

- understand that soil is alive, understand the relationship between soil microbiome diversity and health and soil moisture, relate this to climate change and produce sustainable solutions.
- explain how soil moisture supports plant growth and the importance of soil in ecosystems.
- compare the soils of our planet Earth and Mars using NASA data and develop competence in 21st century skills.

Link to curriculum

As global climate change, droughts, floods and fires continue to increase, it is necessary to increase soil education and literacy to turn the vicious cycle we are in into a virtuous cycle. Raising awareness on how to increase soil microbiomes, and therefore soil fertility, by increasing soil moisture, and thus playing a role in creating solutions that restore the natural cycle of soil, will help us connect the 17 UN SDGs, particularly **SDG2.2 (ending micronutrient malnutrition), SDG2.4 (resilient agricultural practices that protect ecosystems) and SDG15.3 (restoring degraded lands)**.
In the curriculum of 'Science (6th, 7th and 8th grades) in our country:

- Living things and life: Recognising micro-organisms living in the soil ecosystem and their interaction with the environment (6.3.1.2),
- Climate change: Explain the effects of climate change on ecosystems (7.4.1.1),
- Biodiversity and ecosystems: The relationships of living things in the ecosystem to each other and to the inanimate environment (8.5.1.2) are linked to biology in our STEM learning scenario.
- The discipline of astronomy in STEM Subject 1 has been integrated with the curriculum sub-heading of Science 6. Comparing the planets in the solar system (6.1.1.1.1.).
- The technology in STEM Subject 4 is integrated with Information Technologies and Software (Years 7-8) Data Literacy: Collecting, analysing and interpreting data is linked.

Age of students

10-13 years old

Time

Preparation time: 1h
Teaching time: 4 lessons, 40 minutes per lesson

- Lesson 1: Biology, Astronomy
- Lesson 2: Biology, Literature

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: Information Technology, Music, Mathematics
- Lesson 4: Information Technology

Teaching resources (materials & online tools)

Material for all lessons

- Computers/tablets.
- Internet connection.

Materials for Lesson 2

Tools Used When Taking Soil Samples:

- Tools such as waist shovel, soil auger or soil probe,
- Auxiliary materials such as plastic bucket, label, data sheet, plastic bag and pencil.

Materials for Lesson 3

- Open space with a safe surface of soil for students to recall what they have learned so far in this lesson.
- Digital balance, containers for weighing soil, paper for notes and calculations, pencil, gloves for soil sampling, trowel or small shovel, water, labels for containers to send samples to the university lab, soil samples (dry and with different moisture content), moisture meter (for air environment).

Materials from Lesson 4

Construction of a fully automatic irrigation system with Arduino soil moisture sensor:

- Arduino board
- Battery support
- Batteries
- Breadboard
- Capacitance-based soil moisture sensor
- 5V relay module
- Small pump
- Glass of water
- Plant
- Wires

Online tools:

NOTE: All online content is translated into the language of the country of implementation.

Lesson 1. Brainstorming and discussion

- A short video about the view of Earth from Mars
  160 milyon km uzaklıktaki Mars'tan Dünya'nın görünüşü - YouTube
- A short video showing NASA taking soil samples from Mars
  MARS : Soil Sample Testing | Soil Sample Testing On MARS | NASA | Real NASA - YouTube
- Why soil is one of the most amazing things on Earth (BBC video)
  https://www.youtube.com/watch?v=OiLITHMVcRw
- Short video about the importance of soil moisture
  https://youtu.be/JMJqRxbBMlE?feature=shared

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.

- A short video on chemical elements found in healthy and unhealthy soils and the relationship between soil moisture and microbiome
  Science of Dr. Earth - Part 2 - YouTube
- A short video on the importance of the soil microbiome for food and human health
  Soil Microbes - Human Health Starts in the Soil. - YouTube
- NASA JPL link with information on Martian soil properties
  Martian Soil | NASA Jet Propulsion Laboratory (JPL)
- A link with information about the content of fertile soil
  ELEKTRONİK TOPRAK ANALİZ CİHAZI (PH / NEM / IŞIK ŞİDDETİ / VERİMLİLİK (EC-TUZLULUK ÖLÇER) TL-1880

Lesson 2. Preparation for next lesson

- Links to soil alphabet and puzzle activities that can be added to the learning about soil section
  Earth and Child - Knowledge Base
  Earth and Child - Let's Learn with Fun
- Soil Science for Children : https://www.soils4kids.org/games (English option)
- PowerPoint Sunusu Soil Analysis And Interpretation

Materials for Lesson 3

- Link with information such as that soil organic carbon is mainly the corpuscles of dead microbes, and that not increasing the microbiome means you are not building soil health or sequestering carbon.
  Soil Test - microBIOMETER
- JoVe video of weighing dry and moist soil and calculating moisture percentage for math integration activity
  Video: Determination of Moisture Content in Soil
- Link to translate what you have learned so far in this learning scenario about soil through Artificial Intelligence into poetry with ChatGP
  https://suno.com/home
- Link to convert soil moisture percentage data into a graph:
  https://mycurvefit.com/

Materials for Lesson 4

- Construction of a fully automatic irrigation system with Arduino soil moisture sensor:
  Soil Moisture Sensor - Comple Guide | Arduino Project Hub
  GitHub - lucasfernandoprojects/arduino-soil-moisture-monitoring: Use Arduino to determine the soil moisture of your sample.

Other useful online resources for research

- A video covering different soil textures and how they affect water retention and plant growth.
  Option 1 https://www.youtube.com/watch?v=knrmCbctGEA
  Option 2 https://www.youtube.com/watch?v=3NK6ZosNxZo

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 Importance of Soil: A video highlighting why soil is vital for sustaining life and ecosystems https://www.youtube.com/watch?v=XfqaJqm5nCk
- Living soil: https://www.youtube.com/watch?v=ntJouJhLM48
- Earth song: https://www.youtube.com/watch?v=tM7VND_o5F8

STEM Strategy Criteria

Elements and criteria	How is this criterion addressed in the learning scenario?
Instruction	
Personalisation of learning	The learning scenario consists of different activities such as brainstorming, experimental applications according to the individual needs, learning pace and interests of the students. In this way, teaching becomes more meaningful and effective as learning is adapted to the individual needs of the students. In addition, as each student takes responsibility for his/her own learning process, individual differentiation in teaching is provided.
Problem and project-based learning (PBL)	In the learning scenario, students investigate soil health and soil microbiome from real-world problems. Hands-on experiments reflect PBL by enabling critical thinking while developing solutions collaboratively.
Inquiry-Based Science Education (IBSE)	It is integrated into the IBSE learning scenario as students brainstorm, question their curiosity about soil, form hypotheses, test these hypotheses with hands-on experiments and share their conclusions with their peers.
Curriculum implementation	Based on an interdisciplinary approach, it meets the objectives of both the national curriculum and international educational standards. The planned activities aim to improve students' scientific literacy and to increase their awareness of sustainability. The learning scenario contributes to the implementation of the learning outcomes in the science curriculum and equips students with 21st century skills. The scenario is flexible enough to be easily implemented in schools in different countries. Moreover, the learning process is structured, meaningful and student-centred through the integration of the pedagogical approaches of the BSC's 5E Instructional Model.
Emphasis on STEM topics and competencies	
Interdisciplinary instruction	Integrated Learning: The learning scenario will combine biology, astronomy, music, children's literature and mathematics, enabling students to see the connections between these subjects.
Contextualisation of STEM teaching	Soil samples are analysed and findings on the soil microbiome and soil health are linked to real-world problems. By working together across disciplines, teachers build team spirit and inspire students to develop 21st century skills. For example, students who can identify a global problem can create sustainable solutions by integrating science, technology, literature and music. Teachers can also develop mass awareness of global issues by starting a school-wide movement with team spirit motivation, using STEM education approaches to soil health and fertility, and even enriching it with art.
Assessment	
Continuous assessment	As our learning scenario incorporates the stages of BSC's 5E Instructional Model, there will be continuous assessment such as formative assessment. Formative assessment involves monitoring student learning and making necessary adjustments during the learning process.
Personalized assessment	Rubrics appropriate for formative assessment will be used. Each student is assessed at his or her own pace and according to his or her learning needs.

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?
Professionalization of staff	
Highly qualified professionals	Interdisciplinary cooperation among employees, using the steps of the STEM education approach during the implementation of the learning scenario, creates a team spirit and also ensures that they have higher skills in their subjects. In this way, the quality of education and training in the organization is improved.
Existence of supporting (pedagogical) staff	Teaching Assistants and Support Staff will be available to assist students in need with the implementation of learning activities.
School leadership and culture	
School leadership	The school management provides the necessary support for the successful implementation of teaching activities in the learning scenario according to the needs of the students.
High level of cooperation among staff	Teachers of science, mathematics, computer science, music and literature work together and provide all the support for the positive realization and development of the planned activities.
Inclusive culture	Instruction is made inclusive by involving all learners in the implementation of the learning scenario and by conducting personalized assessments according to individual differences.
Connections	
With parents/guardians	Students are connected to their parents throughout the instructional activities to support more meaningful and sustainable learning.
With universities and/or research centers	Allowing students to collect soil samples and prepare samples at different humidity levels ensures that they are collaborating with and receiving support from university laboratories in the same city. University-K12 integration will improve scientific process skills by enabling staff and students to think multi-dimensionally when solving problems.
School infrastructure	
Access to technology and equipment	A computer lab is needed for activities such as the singing activity, which will be done with artificial intelligence applications in collaboration with the computer science teacher. It's necessary to calculate the percentage of moisture in the soil and draw graphs based on this.
High quality instruction classroom materials	Currently, education at our school in the earthquake zone continues in a container and the new school building is being constructed in time for the next academic year. The school will provide all the materials (lab materials and all equipment and devices) needed to implement the learning scenario in the new building.

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.

Description of activities

Name of activity	Procedure	Time
1st Lesson		
5E Phase	**Engage, Explore**	
Subject	**Biology, Astronomy**	
Brainstorming and discussion	The students are shown small blue dot photographs of our Earth taken from Mars and a short video about them. Then a short video of the Martian soil, taken by NASA when they took soil samples from Mars, is also shown and a small brainstorming session is carried out, comparing the living conditions on Mars with our Earth. The inquiry-based discussion (participation phase) will then focus on what students are interested in learning about soil. Some of the brainstorming questions that the teacher can suggest are: • Is soil alive? • What are the differences between the soil on our planet Earth and the soil on Mars? • How does vegetation respond to changes in soil moisture, which drives the exchange of water, energy and carbon between the soil and the atmosphere? • What is the importance of soil microbial diversity? • What can be done to ensure that the ecosystem of micro-organisms in our soils, whose moisture content is decreasing due to the global problem of climate change, does not deteriorate, thus increasing the efficiency of the soil? • How does soil moisture affect soil health? • How can technology help us increase soil fertility?	15′
Discussion and preparation for the next lesson	• Before using the learning scenario, the teacher is asked to make a mind map on the A4 paper provided, to measure the pupils' level of readiness for the subject. • The importance of soil for our world, its vitality, moisture and microbiomes in soil, and the connection between chemical compounds that increase soil fertility are shown to the students to prepare them for the next lesson. • They are told to research at home using the links provided in the online materials section about the relationship between fertile and infertile soils and the chemical compounds they contain, and to use other sources, and they are given a homework assignment to write a short essay on what they have learned. They will also be given a link to a presentation on soil sampling methods in the online resources section and be given the task of preparing the soil sample they will take in the next lesson.	25′
2nd Lesson		
5E Phase	**Explore, Explain, Elaborate**	
Subject:	**Biology, Literature**	
Learning about Soil	Soil alphabet, puzzle and game activities, which can be added to the soil knowledge part, are renewed and reminded by using the links given in the online materials section. During the activity, the pupils are divided into groups,	10′

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
	and an environment is created where they learn through fun and competition.	
Which Soil is Healthier?	Students will investigate how soil moisture affects soil health by comparing dry and wet soil types. To do this, soil samples are collected and prepared by following the steps in the link provided in the online materials section. The soil samples, labelled and marked according to their moisture content, are then sent to university laboratories. With the help of the university laboratories, the nitrogen, phosphorus and potassium levels, which are produced by microbes and increase the fertility of the soil, are determined in the samples made with dry soil and two types of soil with different moisture contents. Based on the reports received from the university laboratories, the amounts of these elements in the dry and wet soils will be compared and they will be asked to make comparisons and comments on the increase in the soil microbiome and thus soil fertility. The aim is to experimentally observe the contribution of soil microbiomes to soil nutrient cycling and the effect of moisture content on soil health.	30′
Learning products	Students are asked to write an experimental report in which they record and compare the calculated data between soils with different moisture contents. In the conclusion of the experimental report, students are asked to summarise their findings and comparisons about the effect of moisture content on the soil microbiome and thus on soil fertility by comparing the amounts of elements in dry and wet soils.	
3rd Lesson		
5E Phase	**Explain, Elaborate**	
Subject	**Music, Mathematics**	
I remember what I learned with fun	Pupils are taken to an area in their school or neighbourhood where there is safe soil and greenery. They are seated in a circle and asked what they remember about what they have learnt so far, and together they sing a song they have learnt about soil health (the most appropriate song will be created using artificial intelligence in collaboration with the Information Technology teacher) and they are reminded of what they have learnt during the process. The song created will be taught in collaboration with the music teacher) and they will be reminded of what they have learnt by having a good time.	15′
Calculating Soil Moisture	For the mathematics integration activity, students are divided into groups by following the JoVe video on weighing dry and wet soil and calculating the percentage of moisture in the links given in the Online Resources section and the instructions in the link. The following steps are used: • Weigh both aluminum containers. • Add about 50 g of moist soil to each aluminum container and weigh the containers again. Therefore, the moist weight of the soil sample is now known. • Dry the soil in the oven at 105 °C for one hour. • Remove the soils from the oven and allow them to cool. • Weigh the empty containers and the oven-dried soil again. The weight of the dry soil is now known. • They are asked to write the data obtained by following the steps above on A4 paper. The students then calculate the moisture content of the soil using the formula below: **% moisture content = (weight of moist soil-weight of dry soil)/(weight of dry soil)**	25′

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
	The teacher will guide the calculation of the percentage of moist soil. Although the measurement is simple, it is important to determine the soil moisture content to better understand soil properties. Thus, soil moisture is analysed using a simulated rainfall study to determine the retention of minerals in moist soil.	
Learning products	The groups are asked to work together to produce an experimental report on the moisture content of dry and wet soils. They are guided to graph the relationship between the amount of water added to the soil and the percentage of moisture in the soil, using the application in the link provided in the online materials. The effect of soil moisture on soil health is discussed by interpreting the correlation.	
4th Lesson		
5E Phase	**Elaborate**	
Subject:	**Information Technology**	
I am making a fully automatic irrigation system with Arduino soil sensor	By this stage, having learned that soil moisture increases the amount of soil microbiome, which increases the amount of beneficial minerals in the soil and makes the soil healthier, by brainstorming with Biology-Astronomy, remembering what they have learned with Biology-Literature and Music, and reinforcing it with Mathematics with Biology-Mathematics activities, the students are now ready for the Technology and Engineering Integration step of the STEM education approach. In this activity, to be carried out with Arduino software and hardware, a fully automatic irrigation system will be built using the Arduino soil moisture sensor and the materials given in Lesson 4. In this way, they will implement this application of a sustainable solution proposed to moisten the soil in a controlled way using technology. In addition, they will gain motivation, awareness and soil literacy by developing different solutions in the future. From the link provided in the Online Materials section, the circuit connections shown in the image on the Arduino page are made on the breadboard using cables, capacitive humidity sensor and other hardware elements, and the Arduino code provided is downloaded to the Arduino program installed on the computer and run. Capacitive sensors measure the dielectric permittivity of the soil. The presence of water in the soil changes the dielectric permittivity. This changes the capacitance of the sensor. This change is then measured to determine soil moisture. The relay module is connected to the Arduino and powered by batteries. The water pump is connected to the relay. The soil moisture sensor is connected to the Arduino. The sensor is placed in the soil and the pump in the water. The 'irrigation-system.ino' file is uploaded by clicking on the GitHub link provided on the website. In this way, the students obtain the final product of the automatic irrigation system by carrying out the steps of prototyping - testing - debugging and obtaining the model, which are part of the engineering steps. GitHub - lucasfernandoprojects/arduino-soil-moisture-monitoring: Use Arduino to determine the soil moisture of your sample.	40’
Learning products	The rubric prepared by the teacher and given in Annex 1 is used for assessment.	

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.

Initial assessment

- In the initial assessment of my LOESS learning scenario, to assess students' prior knowledge, skills and understanding of the topic: - Students are shown a short video of Martian soil taken by NASA when they took soil samples from Mars, and a small brainstorming exercise is carried out comparing living conditions on Mars with our Earth.
    - Is soil alive? What are the differences between the soil on Earth and the soil on Mars?
    - How does the plant cover respond to changes in soil moisture, which controls the exchange of water, energy and carbon between the soil and the atmosphere?
    - What is the importance of soil microbial diversity?
    - What can be done to ensure that the ecosystem of microorganisms in our soils, whose moisture content is decreasing due to the global problem of climate change, does not deteriorate, thus increasing the efficiency of the soil?
    - How does soil moisture affect soil health?
    - How can technology help us to increase soil fertility?
- Before using the learning scenario, a mind map is used to find out the teacher's level of readiness on the topic.

Formative evaluation

For formative assessment in my LOESS learning scenario:

- Students are asked to write a short essay based on what they have learned from their calculations about the minerals contained in soils of different moisture content.
- Students can be asked to give feedback by reading each other's short essays. The aim is to develop critical thinking skills by enabling them to make judgements according to certain criteria. To do this, use the peer assessment rubric in Annex 2.
- Students can produce a graph by recording their observations and hypotheses during the experiment on calculating the percentage of soil moisture. This will help them to develop their scientific process skills.

Final assessment

- The final product, the Arduino model, will be evaluated with the rubric in Annex 1.
- The final assessment will be in the form of an exam (See Annex 3)

Student feedback

Students' opinions and responses will be collected through the Google Form questionnaire using the following questions:

- What did you learn that you didn't know before?
- What conclusions did you draw about the differences between Mars and Earth soils?
- Did you come up with any solutions to improve soil health and fertility?
- What did you like best about these activities? What could be improved?

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.

Teacher feedback

Teachers will be given a “self-assessment rubric" for evaluation. Rubric in Annex 4.

Reflection on the development process

In creating my LS learning scenario, my inspiration was to increase my students' interest and attitudes towards science and to encourage them to think critically and produce solutions that they will find themselves when faced with real life problems.

The idea of comparing the living conditions on Mars and Earth was inspired by the growing interest in space exploration and the importance of STEM-based learning approaches. The question *'Is soil alive?'* aimed to engage students in active learning by giving them the opportunity to experience the process of scientific discovery.

During the planning process, I researched formative assessment methods in STEM education. NASA's studies on Mars habitats, scientific articles and educational materials contributed greatly to my process. I reviewed resources related to soil education and looked for applications to create learning environments for my students with STEM concepts. In particular, I found that methods such as brainstorming, experiment report writing and peer assessment enabled students to become more actively involved in the learning process. In this process I learnt that designing a learning scenario is not just about planning the content, but also about designing activities that capture students' attention, motivate them and relate to real-world problems. I also realised that feedback mechanisms play an important role in increasing the effectiveness of the lesson and ensuring that learning is sustained. I discovered that it is important to balance scientific accuracy with simplicity to ensure that activities are engaging and age appropriate.

My other source of inspiration and the Scientix ambassador who introduced me to Scientix was my teacher Umut GÜZEL.

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 – A model development rubric

Models prepared by groups will be evaluated with model development rubric.

	1- Underachievement	2- Successful	3-Very Successful
PLANNING	Planning is low understandable rate. Timing and applicability limited.	Planning is clear and straightforward in many ways. Timing and applicability are largely accurate.	Planning is very understandable, clear and applicable. Timing is very successful.
INFORMATION GATHERING - RESEARCH	Few information, which is not very clear, reached from very few sources.	Although it was not systematic, some sources have been accessed accurately	The most accurate information has been systematically obtained from many sources and it is clear
THE PARTS TO BE USED IN THE MODEL AND SELECTION OF MATERIALS	Selected parts only work and it just saves the situation.	Selected parts enough	All selected materials are the best materials available.
TESTING AND DEVELOPING THE MODEL	He was able to test the model with little care and solved the problem in a limited way.	He/She tested the model with a certain amount of care and some problem was identified. Solved problems in a functional way to a certain extent	He/She tested the model best and identified its problems and made the best improvements he needed.
PROPER OPERATION OF THE MODEL	The Model works at a certain rate, but does not last at all in a difficult situation.	The model works well enough unless it's an extremely difficult situation.	Model in all conditions too works effectively

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– Student Peer Review Rubric

Fertile and Infertile Soil - Relationship with Chemical Compounds

Evaluation Criteria	3 (Very Good)	2 (Good)	1 (Should be improved)
Relevance to the topic (Does the composition address the topic?)	☐	☐	☐
Accuracy of Scientific Information (Is the information on fertile/infertile soil and chemical compounds accurate?)	☐	☐	☐
Use of Research Sources (Is it based on online materials and other sources?)	☐	☐	☐
Paragraph Structure and Expression (Are the parts of the text organized and clear?)	☐	☐	☐
Use of Scientific Terms (Are terms used in the right places?)	☐	☐	☐
Originality (Did he write in his own words, is there any copied content?)	☐	☐	☐
Spelling and Punctuation	☐	☐	☐

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 3– Final assessment exam questions

1- Compare the soil of Mars and the soil of Earth.
2- Is Earth soil alive?
3- Briefly explain how microbiomes living in the soil make the soil fertile.
4- Why is soil moisture important?
5- How did you prepare soil samples with different moisture content in this learning scenario? Which soil sample was more fertile in the university analysis? Briefly explain why.
6- Briefly describe the steps you followed in the activity of fully automatic irrigation system with soil moisture sensor activity.
7- Can you suggest other solutions to increase soil fertility?
(Questions 1-5 are 12 points each, questions 6 and 7 are 20 points each)

Annex 4- self-assessment rubric for teachers

Lesson	Student engagement (1-5)	Student understanding (1-5)	Teaching method effectiveness (1-5)	Group work/ collaboration (1-5)	Teacher comments	Improvements
Lesson 1						
Lesson 2						
Lesson 3						
Lesson 4						

Matrix explanation:
• Student engagement (1-5) - Rate how engaged students were in the activity, with 1 being not engaged and 5 being very engaged.
• Student understanding (1-5) - Rate the level of understanding demonstrated by students, with 1 being minimal and 5 being deep understanding.
• Teaching method effectiveness (1-5) - Rate the effectiveness of the teaching methods used for each lesson.
• Group work/collaboration (1-5) - Rate how well students worked together in their groups.
• Teacher comments/observations - Space for teachers to provide qualitative feedback on what worked, what didn't, and any notable observations.
• Suggested improvements - Teachers can suggest any changes or improvements for future iterations of the lesson.

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.