CONSERVATION, ECOSYSTEMS, AND SOIL HEALTH

"How Does Your Garden Grow? (MS)"

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SUMMARY

This lesson is a middle school adaptation of the high school "How Does Your Garden Grow?" lesson. Students will explore soil health principles, soil chemistry, nutrient cycles, and environmental impacts of soil quality. Separate Extend and Evaluate activities are included for each standard.

ESSENTIAL QUESTION

Why should we care about soil health?

DURATION	TIME FRAME	SUBJECT(S)	GRADE LEVEL(S)
300 Minutes	4 - 5 Class Period(s)	Science	6th, 7th, 8th

LESSON SNAPSHOT

1. ENGAGE:

Students will view pictures of healthy and unhealthy soils and crops and speculate on what has caused the difference in the images.

2. EXPLORE:

Students will test soil samples from a variety of locations to evaluate their nutrient levels and pH. Additionally, students will explore several sources to determine properties of healthy soil and practices that support it, followed by a whole-class discussion.

3. EXPLAIN:

Students participate in a digital breakout to gather information about soil chemistry and nutrient cycles. The class will collaborate to make connections among their understanding of soil health, management practices, and nutrient cycling.

4. EXTEND:

Students will construct models that demonstrate the flow of matter and energy in their local ecosystem (6th), grow plants in a variety of healthy and unhealthy soils (7th), or research the consequences of human population growth on soil health (8th).

5. EVALUATE:

Students further develop their ecosystem models to show where specific nutrients move between living and non-living parts of the system (6th), present the plant growth results of their soil health investigation (7th), or create a PSA detailing a specific impact of human population growth on soil health and practices to mitigate it (8th).

LESSON PROCEDURES

1. ENGAGE

Show the students the series of pictures of soil and plants in different soil health conditions (healthy harvested field, bare field, plants growing in healthy and unhealthy soil). Have students do a photo deconstruction, reflecting on what they observed in each photo, the potential causes for differences they notice, and what the healthy plants might have that the unhealthy plants do not.

All four fields are located in different places on the same property. Individual photos included in attachments. Photo credit: Heather Shaffery

TEACHER'S NOTE: GUIDANCE

If students do not get there themselves, guide part of the conversation toward what the plants are growing in (i.e., soil). While plants do not require soil to grow, in these cases soil is where the plants are taking in many necessary nutrients.

After the discussion, ask students to summarize what they think they know about the images in one sentence. Effective sentences will essentially summarize the big takeaway each student got out from the conversation.

2. EXPLORE

ASSESSING SOIL CHEMISTRY

Have students analyze each soil sample, making sure to record the data for the most common soil chemistry tests: soil pH, Nitrogen level, Phosphorus level, and Potassium level.

Have students collect soil samples from possible garden sites around campus. You may have students collect soil from multiple sites to use as a comparison. Students may even bring soil sample from home to test.

Preparing the Soil Samples:

1. All of the tests require a soil solution which is best to prepare at least a day before to get better results due to the nutrients leaching into the water.
2. Have the students create a soil solution by adding 100 mg of soil and 200 mL of water to a beaker or other container.
3. Now have the students use the stirring rod or sticks to blend the mixture.
4. Ensure that students clean the stirring rod thoroughly or use a different stirring utensil for each soil sample.

Testing the Soil Samples: Now that the students have a sense that soil may be important to plant health, have them test the soil types to determine the level of the nutrients present.

1. Hand out the Soil Investigation handout.
2. Provide each group with a soil test data sheet OR have each group create their own data table (See Sample Soil Test Table below).
3. Based on the specific directions for the soil test kit you have purchased, review the procedure for soil testing with your students.
4. Have students document their process and results using tablets or their phone's camera if it is a "Bring Your Own Device" (BYOD) approved environment. These pictures can be incorporated into their final presentation.

EXTRA STEP FOR TEST STRIPS

If you are using test strips that require a color comparison, it might be necessary to filter the water sample before collecting data. This is particularly true for nitrogen test strips. Depending on how murky the soil makes the water, it is usually clean enough after 2-3 rounds of filtering through a double or triple layer of coffee filters.

Soil Sample	Texture	pH	Nitrate (NO_3)	Nitrite (NO_2)	Phosphorous (P)	What are some possible issues you notice?

Soil Sample Data Table

INVESTIGATING SOIL AND SOIL HEALTH

Students explore several sources to develop a basic understanding of soil properties and components of soil health.

Have students work in groups to gather information about general soil science, soil health, and soil functions. Each student should record important details in a Window Notes graphic organizer. They will leave the *Nutrient Cycle* box empty for now. If students have regular access to technology, they could also use Google Apps (e.g., Docs, Slides) to collaboratively fill out the notes. A variety of sources that students can use to gather information are provided in the Explore Sources attachment.

EXPLORE DEBRIEF

As a class, summarize the key points to create an anchor chart for each Window Notes box. The soil chemistry information can be incorporated into Soil Properties or Soil Health. Diagrams or drawings of soil horizons and details would also be helpful on an anchor chart.

Some questions to guide the summary discussion include:

- What is soil? How do we describe it?
- What criteria factor into soil health?
- What are the benefits of having healthy soil?
- What soil management practices or strategies would improve soil health?

3. EXPLAIN

Now that students have a general understanding of soil health, transition them into developing concepts about soil nutrients specifically. Students should work together to complete the *How Does Your Garden Grow? Breakout*. They should summarize the information they learn during the breakout in the *Nutrient Cycles* Window Note box, and make additional notes in the other "windows" as necessary.

Ask students to use the 3-Post It Notes strategy in their small groups or individually. At this point only have them complete the Word = ___, and Phrase = ____ notes. Repeat the process you used for the previous anchor charts to to develop one for *Nutrient Cycles*. Ask students to share out their Words and Phrases as part of the summary conversation. If necessary add any new information students discovered to the other three charts as well.

MISCONCEPTIONS, VOCABULARY, NOTES

If the entire class is struggling with content details or missed important information during their Explore activities, this is an appropriate place for direct instruction. To fill gaps or misconceptions, this could include providing a brief lecture, having students take notes over specific concepts, or developing content-specific vocabulary.

Help students synthesize the conceptual pieces for themselves. As part of this process, they should complete the *Sentence* part of the 3-Post It Notes activity. Their sentence should emphasize the connections among the information they've gathered during the Explore and Explain activities and discussions. There are other ways to direct students' knowledge construction, but they should at least work out the following connections:

- the relationship between nutrient cycles and soil health (e.g., how cycles support healthy soil, how unhealthy soil might disrupt cycles)
- how soil management practices support or supplement natural nutrient cycles
- the impact of soil management practices on soil health

Several alternatives to class discussion or a written assignment for this portion of the Explain are suggested below.

CONCEPT (CARD) MAPPING

This strategy can be done physically or digitally. Students can create hand-drawn or digital (e.g., MindMeister, Cmaps) concept maps. They can also use physical cards, either pre-made or class-generated, that they glue/tape down and draw lines to connect ideas. As a whole class you might consider using string to physically connect concepts found on the four anchor charts.

METAPHORICAL THINKING

Students create metaphors based on their personal experience to help explain the connections they are making.

COGNITIVE COMICS

Using either a predetermined structure (e.g., three panels) or letting students choose their own, students draw their conceptual understanding as a comic. These could be shared using gallery walks or brief class presentations.

4. EXTEND

The following activities are aligned to a specific grade level and standard. Each one could be used at any of the three grade levels, depending on your school's specific standards progression. Please select the one that is appropriate for your class.

6TH GRADE - MS-LS2-3

Students will construct a model of matter and energy transfers in their local ecosystem or the ecosystem from which their soils were sampled.

In small groups or as a class, develop a list of functions performed by different types of organisms in an ecosystem based on prior knowledge and any information collected during the previous parts of the lesson (e.g., decomposers break down organic material to release carbon and nitrogen, producers take in carbon and give off oxygen during photosynthesis, etc.). These trophic groups should at least include decomposers, producers, and consumers. Using this information, students should construct model food webs of their school or neighborhood ecosystem. In addition to arrows between organisms to show the direction that matter and energy flow, students should also indicate what process causes matter and energy to flow (e.g., consumers eating producers and bacteria fixing nitrogen in the soil would both be causes of matter and energy flow). If soil samples were not taken from the school, then use the sample location's ecosystem instead. For another resource on soil food webs, click here.

7TH GRADE - MS-LS1-5

Students grow plants in several types of soil to determine (1) optimal soil conditions for a specific type, and/or (2) the effectiveness of a specific soil health strategy for plant growth. Look for plants with short growing times and try to find plants that could be grown in local conditions. The initial setup is one class but analysis may be extended over weeks during growth cycle of plants.

Have students generate a question about what soil conditions (e.g., pH, N) will provide optimal resources for a particular plant to grow. Alternatively or in addition, students might ask a question related to how a soil management strategy impacts plant growth. Student investigations can be informal comparisons or controlled experimental design depending on teacher preference, as long as there are at least two different conditions to compare.

SOIL MANAGEMENT

There are a variety of easy strategies for students to change soil conditions. Examples include adding hydrogen peroxide (0), fertilizer with different nutrient ratios (NPK), and vinegar or baking soda (pH) to soil. Either give students a little time to research methods based on what health factor they choose to target, or provide them with the relevant practice. Three relevant sources are linked here (1, 2, 3), but many gardening websites have suggestions for specific deficiencies.

Setup: Have students...

1. punch holes in the bottom of plastic cups for drainage, fill each one with a specific soil type, and plant a few seeds in each cup.
2. develop a watering and sunlight schedule based on the recommendations that come on the seed packet.
3. come up with a plan for data collection and evaluation. *(What will they measure? How will they decide which soil is the best?)*
4. determine a method for taking pictures the same way multiple times (e.g., height of camera, distance from plant, orientation).

8TH GRADE - MS-ESS3-4

Students compare the change in human population size to changes in land use to draw conclusions about the impacts of human population growth on soil health. They then identify a threat to soil health and research its cause(s), impact(s), and potential solution(s).

LAND COVER CHANGE

The land cover change video linked below shows the amount of land in a certain area that is still covered by natural vegetation. The less green an area, the more that humans have changed the landscape. The video uses BP ("years Before Present time") as its time scale. 0 BP = 1950, so the video simulation ends at the year 2000 (-50 BP). For more information see this article.

Show students the World Population video (population simulation begins at 0:44) followed by the Global Land Cover Change video. Ask them to explain how the two videos relate to one another (e.g., "*As population increases, we use up more natural land.*"). Have students brainstorm some ways increased population size and land use might impact soil health. Students should choose a potential threat to soil health from either their list, a list you provide to them, or through their own independent research. Several useful sources include: 1, 2, 3, 4, 5.

Give students time to research their threat of choice in order to determine:

1. the ways in which the threat damages soil health,
2. what causes the threat to occur,

3. and ways the threat can be avoided, mitigated, or eliminated.

5. EVALUATE

6TH GRADE - MS-LS2-3

Students add to their web models to include the environment in the flow of matter and energy within an ecosystem.

Once students have created food web models, they should add environmental elements to them to construct "ecosystem webs." Students should select one key nutrient from their soil tests as a focus. Using a new color, students should add arrows showing the flow of their nutrient into and out of both the living and non-living parts of the system and indicate what causes the nutrient to flow from one place to another. For example, carbon is taken from the air into plants during photosynthesis and it enters the air and soil during decomposition.

7TH GRADE - MS-LS1-5

Students present the results of their investigations and explain the relationship between soil health and the growth of their plants.

Students' presentations of their results should provide an explanation for how soil health, nutrient cycles, and plant needs interact to impact growth. Explanations should emphasize how the best soil ended up with/developed the right resources to meet the plant's needs (e.g., healthy soil has lots of bacteria which decompose plants and animals to add nitrogen to the soil for plants to use). If students tried to improve soil health, their explanation should instead emphasize how their management method fits into/fixes/supports nutrient cycles to make the soil healthier (e.g., adding peroxide puts more oxygen into the soil which helps make it compact so it drains water better).

PRESENTATIONS

The actual format of student presentations is up to teachers' discretion, but should include explanations of how the data showed which soil was better and visuals showing differences in plant growth. If technology is available, a stop-motion or time-lapse video showing plant at different points in their growth is an excellent source of evidence to support students' explanations. Examples of ways to create these videos are can be found here (Stop Motion Studio: Google Play, Stop Motion Studio: Apple Store, Stop Motion Animator: Chrome, How to Animate with Google Slides) and are provided in the resources list below

8TH GRADE - MS-ESS3-4

Students produce a PSA about specific practices that support soil health. If students are working in small groups for this portion, be sure to give each student an opportunity to explain their understanding individually for assessment purposes.

As a final presentation, ask students to create a Public Service Announcement about the dangers posed to soil health. They may choose to create their PSA from a stance advocating for the benefits of improved soil health or highlighting the threat of not protecting the soil from their particular threat. A Two-Minute Documentary or similar format would be appropriate for this activity.

The PSAs should synthesize what students have learned throughout the lesson about soil. As part of reporting on their three research components from the Extend, students should address what characterizes healthy soil and the specific cause-effect details about their chosen threat as it relates to the specific content they've recorded in their Window Notes throughout the lesson.

STANDARDS

- Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

MATERIALS LIST

- Soil samples
- Gloves
- Paper towels and/or disinfectant wipes
- Mineral-free water (e.g., DI water)
- Soil test kit or chemical test strips
- Devices with internet access
- Sticky notes
- Containers for growing plants (7th)
- Fast-growing plant seeds (7th)
- Posters, markers, etc. for creating presentations and for Anchor Charts

ATTACHMENTS

- Explore Resources.docx
- Soil Investigation Handout.docx
- Window Notes Handout.docx
- Soil Hand Texture.docx
- Conventional Till Winter Wheat.jpg
- No Till Winter Wheat.jpg
- Tall Grass Prairie_June.jpg
- Old World Blue Stem_July.jpg
- H-Chart.docx
- Soil Conditions Experiment - 7th.docx
- Ecosystem Model - 6th.docx
- Threat Research - 8th.docx

RESOURCES

- How Does Your Garden Grow Breakout: https://sites.google.com/ou.edu/gardengrowbreakout/home
- World population video: https://www.youtube.com/watch?v=khFjdmp9sZk&t
- Global Land Cover Change video: https://www.youtube.com/watch?v=gBTIlaf12-4
- What do Archaeologists Mean by BP: https://www.thoughtco.com/bp-how-do-archaeologists-count-backward-170250 SSSA
- International Year of Soils video playlist: https://www.youtube.com/watch?v=vDL6F6GkAzI&list=PLZVYohulygMqtilTezSHbzveYUj3WLjdm
- Stop Motion Studio: (Google Play) https://play.google.com/store/apps/details?id=com.cateater.stopmotionstudio
- Stop Motion Studio: (Apple Store) https://apps.apple.com/us/app/stop-motion-studio/id441651297
- Stop Motion Animator (Chrome): https://chrome.google.com/webstore/detail/stop-motion-animator/dhgmfcabdnkbdhelnooodefedbilcpho
- How to Animate with Google Slides: http://ditchthattextbook.com/2018/03/29/11-tips-for-creating-stop-motion-in-google-slides/