Soil Health

Grade: 6th Grade	**Timeframe:** 5 weeks

Unit Overview
Middle level (6th grade) students will participate in several lessons – spanning approximately five weeks – to learn about soil composition and characteristics, and conduct research on soil conservation practices of the past and present. These experiences will lead students to view soil as a natural resource that is affected by human practices.

Essential Questions	**Major Concept**s
Why should we care about soil health? *Can we change the health of soil?*	Science – human impacts on earth systems, design a method, analyze and interpret data Technology – apply digital tools to locate, organize, and use information; report results Engineering – define a design problem, develop a model, evaluate design solutions Math – ratios, unit rates, percents, use appropriate tools

Suggested Lesson Sequence
Prerequisites: Students should be familiar with pH measurement and have an understanding of percentages, decimals, and exponents.

Optional Pre-teaching Lessons (2 sessions – 45 minutes each):
Teacher may provide worksheets on percentages, decimals, and exponents.
Teacher may provide a pH lab investigation with acids and bases.

Lesson 1 – *Establishing Context* (45-60 minutes)
Students will write initial responses to the essential question, listen to historic quotes and conduct Internet research of the Dust Bowl era, and view an apple slice demonstration representing the portion of Earth's usable soil.

Lesson 2 – *Soil Texture Identification* (45 minutes)
Students will use a dichotomous key and measurement to identify soil textures of three different soil samples.

Lesson 3 – *Soil Moisture Investigation* (45 minutes)
Students will go outside to measure soil moisture at various locations.

Lesson 4 – *Soil Test/Research Stations* (5 sessions – 40-60 minutes each)
Students will rotate to ten different stations to investigate soil pH, levels of N, P, and K in soil, soil movement, soil filtration, soil respiration, and to conduct computer research.

Lesson 5 – *Guest Speaker/Reflections* (2 sessions – 45 minutes each)
Students will listen to a guest speaker from a local natural resources agency. Students will discuss

information gleaned from class presentations and analyze data collected during previous investigations. Reflections will be recorded in science notebooks.

Lessons 5A, 5B, 5C – Optional Extension or Alternative to Lesson 5. Students will engage in 3 different labs that identify living organisms and the role they play in healthy soil.

Lesson 6 – *Soil Engineering Design* (8-10 sessions – 45 minutes each)
Students will create their own engineering design projects. *You are a soil engineer. Your job is to engineer a soil (change its composition or pH) to do something specific (filter water, grow a plant, or support worms)*.

Lesson 7 – *Presentations* (4 sessions – 45 minutes each)
Students will present engineering design projects to class.

Lesson 8 – *Conclusions* (30 minutes)
Students will reflect upon learning and write new responses to essential question.

Materials, Tools, & Technology

- ☐ computer/tablet access with Internet
- ☐ notebooks or paper, pencils
- ☐ calculators
- ☐ soil quote, audio clip (lesson 1)
- ☐ apple and knife (for teacher)
- ☐ Vernier LabQuests and moisture probes (lesson 3)
- ☐ Vernier LabQuests and probes – pH, CO_2, turbidity (lesson 4)
- ☐ soil test kits (lesson 4)
- ☐ pH color charts (pre-teaching activity, lesson 4)
- ☐ distilled water
- ☐ clear vials
- ☐ plastic water bottles
- ☐ plastic cups
- ☐ glass jars – quart size
- ☐ metal screening material (small squares)
- ☐ cheesecloth (small squares)
- ☐ Ziplock bags, trash bags
- ☐ plastic gloves
- ☐ cabbage juice for pH indicator (pre-teaching activity)
- ☐ lab task cards/directions
- ☐ data sheets, templates

Vocabulary

soil vs. dirt
silt
tilth
pH
composite
aggregate
acid, base, neutral
alkali
solution
diluted
exponents
mole
mean, median, mode
central tendency
plot

☐ plastic bowls or buckets for dumping tested materials ☐ soil samples from at least three different locations	

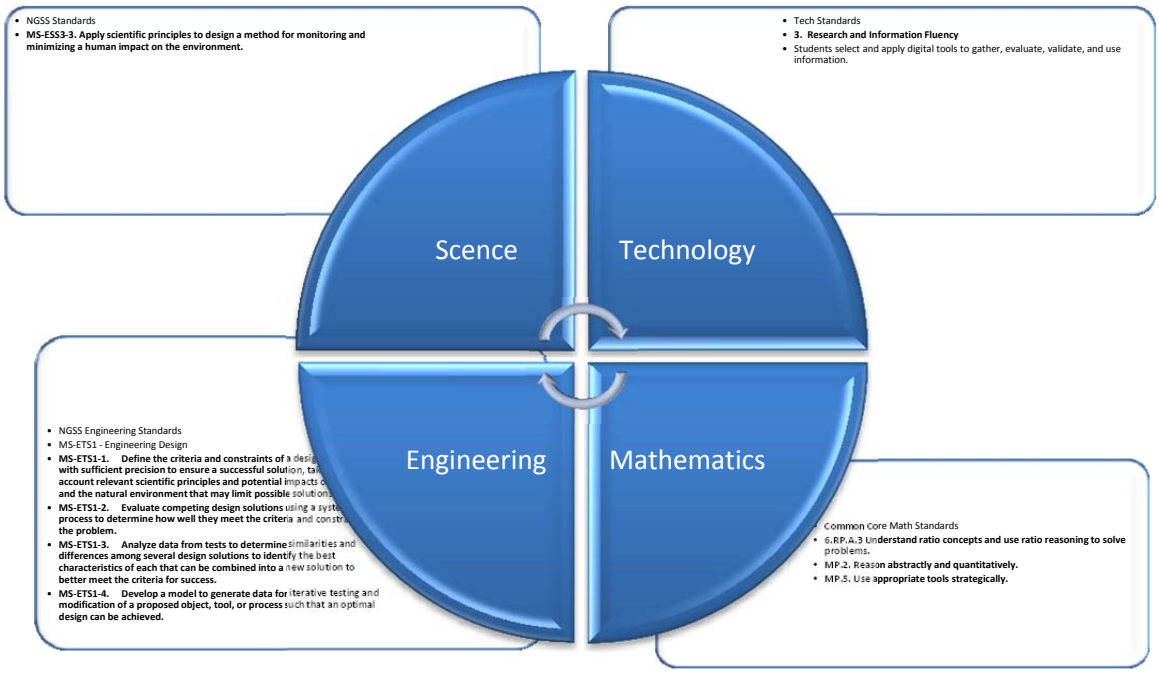
STEM Professional Involvement Ideas

Contact guest speakers from:

- Natural Resources Conservation Service
- County Extension Agent
- Soil and Water Conservation District

Speakers may be asked to conduct demonstrations on soil identification, discuss importance of soil's health in providing local resources, and explain the role of soil engineers.

STEM Connections with Standards



Notes:

This is a fairly comprehensive unit (spanning five weeks) to help students form conclusions about why we should care about soil health. While this unit is designed for a self-contained classroom, it may be adapted for use by the science teacher in a middle school divided by departments. Teachers should not feel obligated to conduct all the listed lessons or rotations in Lesson 4. Use discretion to decide which lessons are crucial to formulate educated responses to the essential question. Teachers may also choose to be more specific with the engineering design project and limit designs to one task (such as "design a water filter").

Appendices List

Establishing Context – Lesson 1		
Grade Level: 6th Grade	**Time Needed:** 45-60 min.	**Subjects:** Science, Technology, Math, ELA-Literacy

Objective/Learning Target: The student will be able to understand that soil is a natural resource affected by human activity.

Standards:
Science:
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
Technology:
3. Research and Information Fluency: Students select and apply digital tools to gather, evaluate, validate, and use information.
Math:
6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP.5. Use appropriate tools strategically.
ELA-Literacy
RH.6-8 Determine the central ideas or information of a primary or secondary source….

Background Information: Only 1/32 of Earth contains land usable for growing crops. Early in the history of the United States, soil was viewed as an inexhaustible resource. Poor farming practices contributed to the loss of valuable topsoil during the Dust Bowl of the 1930s.

Materials:
- ☐ science notebooks (or paper)
- ☐ pencils
- ☐ computers/tablets with Internet access
- ☐ Bureau of Soils quote
- ☐ passage or audio clip from "The Worst Hard Time" by Timothy Egan
- ☐ apple and knife (for teacher)

Vocabulary:

soil (vs. dirt)
topsoil
Dust Bowl
natural resource

Resources:

See Appendix A for Teacher Resources:
Internet Resources for Establishing Context
See Appendix C for Literacy Connections:
Literacy Connections for Establishing Context

Procedures:

1. Post Essential Question – ***Why should we care about soil health?***
    a. Ask students to answer this question in any way they think makes sense at this time. Prompt them to define what is meant by healthy soil. They should copy

the question and write their answers in their science notebooks.

2. Setting the Scene
    a. Share quote from 1909 Bureau of Soils: "The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that cannot be exhausted; that cannot be used up." Ask students if they agree with this statement. Have them copy quote into science notebooks and write a sentence saying they *agree* or *disagree*.
    b. Read passage or play audio clip from *The Worst Hard Time* by Timothy Egan (book about the Dust Bowl), or find Dust Bowl survivor quotes online from sources such as Library of Congress.
    c. Share iconic/historic photographs of Dust Bowl (e.g. Dorothea Lange's photographs, including *Migrant Mother*, taken for the Farm Securities Administration during the 1930s).
3. Research
    a. Have students use computers/tablets and Internet to research Dust Bowl effects caused by changes to soil. Take notes in science notebooks.
4. Reflection
    a. Revisit 1909 quote and argue its accuracy based on research – cite textual evidence. Students should record whether or not they want to change their initial agree/disagree statements based on their research.
5. *Apple as Earth* Demonstration
    a. Cut an apple into four equal parts. Three parts represent the oceans of the world. The fourth part represents the land area.
    b. Cut the land section in half lengthwise. Now you have two $1/8^{th}$ pieces. One section represents land such as deserts, swamps, Antarctic, arctic, and mountain regions. The other $1/8^{th}$ section represents land where humans can live but may not grow food.
    c. Slice this $1/8^{th}$ section crosswise into four equal parts. Three of these $1/32^{nd}$ sections represent the areas of the world which are too rocky, too wet, too hot or where soils are too poor for production, as well as areas developed by people.
    d. Carefully peel the last $1/32^{nd}$ section. This small bit of peeling represents the soil of our earth on which humans depend for food production!

Differentiation Supports:	**Differentiation Extensions:**
• Provide sentence frames for students. • Provide templates to complete for research. • Have students work with partners to research Dust Bowl. • Direct students to view given websites.	• Invite students to find and share other soil quotes. • Ask students to compare and contrast soil quotes – may use Venn diagrams to sort and classify quotes. • Invite students to research soil history of other nations.

Assessment Opportunities:

- Check science notebooks for completion.
- Direct students to build a pie chart showing the portion of Earth's usable soil (may use computers to build graphic).

Citations:

- *American Experience: Surviving the Dust Bowl*. (2013). Retrieved from WGBH Educational Foundation website: http://www.pbs.org/wgbh/americanexperience/features/biography/dustbowl-bennett/
- Egan, T. (2006). *The Worst Hard Time: The Untold Story of Those Who Survived the Great American Dust Bowl*. Houghton Mifflin.
- *Library of Congress: The Dust Bowl*. (n.d.). Retrieved from Library of Congress website: http://www.loc.gov/teachers/classroommaterials/primarysourcesets/dust-bowl-migration/
- Walker, K. (n.d.). *Geography in Our Backyard*. Retrieved from Natural Resources Conservation Service United States Department of Agriculture website: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/al/about/?cid=stelprdb1256999
- *The Apple as Planet Earth* [Video file]. (2010). Retrieved from https://www.youtube.com/watch?v=mA78nPn41F4

Soil Texture Identification – Lesson 2

Grade Level: 6th Grade	**Time Needed:** 45 minutes	**Subjects:** Science, Math, ELA

Objective/Learning Target: The student will be able to use a dichotomous key and measurement techniques to identify soil texture.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

Math

6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.

ELA

6.RST.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
6.RST.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Background Information:

A soil's texture refers to the size of its particles. The largest particle, sand, feels gritty; the medium particle, silt, feels smooth; the smallest particle, clay, feels sticky. The proportions and combinations of its particles identify soil texture. The particles are important building blocks of soil – they affect drainage and erosion rates and they combine to form the structure of soil. Good soil structure supports healthy plant growth.

Materials:

- ☐ soil samples from three locations
- ☐ copies of Appendices B (Lesson 2)
- ☐ pencils
- ☐ calculators
- ☐ permanent markers
- ☐ rulers – metric
- ☐ masking tape
- ☐ water droppers
- ☐ quart size jars with lids (3 jars per small group of students)
- ☐ non-foaming dishwasher detergent, such as Cascade (1 tsp. per jar)
- ☐ newspapers or plastic to cover tables
- ☐ access to sink or rinse buckets
- ☐ paper towels

Vocabulary:

texture
dichotomous
silt
loam
gritty

Notes: Note the time requirement needed for the soil test done in jars.

Resources:

See Appendix A for Teacher Resources:
- Internet Resources for Soil Texture Identification

See Appendix B for Student Resources:
- Dichotomous Key for Soil Texture Identification by Feel
- Triangle for Soil Texture Identification by Measurement
- Student Lab Sheet – Soil Texture Identification by Feel
- Student Lab Sheet – Soil Texture Identification by Measurement

See Appendix C for Literacy Connections

Procedures:

Soil Texture Identification by Feel – Ribbon Test

1. Take a handful of soil from one of the samples.
2. Add water, one drop at a time, kneading the soil in between drops, until the soil feels like moist putty.
3. Place a small amount of moistened clay between thumb and forefinger; gently squeeze soil upward until ribbon of soil forms.
4. See dichotomous key (Appendix B) for texture identification.
5. Use basic descriptors to aid identification:
    a. Sand feels gritty
    b. Silt feels smooth
    c. Clay feels sticky
6. Record observations and identification decisions.
7. Repeat process for other soil samples.

Soil Texture Identification by Measurement Test
Note: Start this test early in the day – you'll need about two hours to observe the settling of silt particles.

1. Spread a few cups of soil on newspaper or plastic – remove debris such as trash, rocks, and sticks; crush large clods of soil.
2. Fill a wide-mouthed quart size jar 1/4 full of soil.
3. Add water to jar until jar is 3/4 full.
4. Add 1 tsp. non-foaming dishwasher detergent (such as Cascade).
5. Screw lid tightly onto jar and shake for 10-15 minutes.
6. Set jar down and do not disturb – allow soil particles to settle out.
7. After 1 minute, use a permanent marker to mark on the jar the level of the sand – remember to label.
8. After 2 hours, mark on the jar the level of the silt.
9. When the water clears, mark the level of the clay – the water usually clears in 1-3 days, but it may take weeks.
10. Measure the thickness of each layer and measure the total soil deposit (all layers added together).
11. Divide the measurement of each layer by the total to figure the percentage of each particle type.
12. Use the Soil Texture Triangle (Appendix B) to find the soil texture identification.

13. Record observations and identification decisions.
14. Repeat process for other soil samples.

Differentiation Supports:	**Differentiation Extensions:**
See resource list (Appendix A) for simplified tests. Provide modified lab sheets for students to complete.	Invite students to research other methods for identifying soil texture – have them complete various tests and compare results.

Assessment Opportunities:

Provide a picture or diagram of a jar of soil with particles settled out – have students label the layers of sand, silt, and clay.
Provide measurements for sand, silt, and clay layers – have students figure percentages of total and find correct identification on Soil Texture Triangle.
Completion of lab sheets.

Citations:

Guide to Texture by Feel. (n.d.). Retrieved from Natural Resources Conservation Service, United States Department of Agriculture website: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/kthru6/?cid=nrcs142p2_054311
Whiting, D., Wilson, C., & Reeder, J. (2014, October). *CMG Garden Notes*. Retrieved from Colorado State University Extension website: http://www.ext.colostate.edu/mg/gardennotes/214.html

Soil Moisture Investigation – Lesson 3

Grade Level: 6th Grade	**Time Needed:** 45 minutes	**Subjects:** Science, Technology, Math

Objective/Learning Target: The student will be able to utilize tools and technology to measure soil moisture.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Technology

6. Technology Operations and Concepts: Students utilize technology concepts and tools to learn.

Math

6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP.5. Use appropriate tools strategically.

Background Information:

Soil moisture generally refers to the water that is held in the spaces between soil particles. Soil moisture information is useful to private individuals and public agencies, including gardeners, farmers, weather forecasters, and reservoir managers. Soil moisture can affect weather patterns, the production of precipitation, and the amount of precipitation that runs off into nearby streams and rivers. Knowledge of soil moisture is necessary for making informed decisions about planting crops, scheduling irrigation, controlling floods, and predicting droughts. The current lack of global, continuous soil moisture measurement is considered a problem.

Materials:

- ☐ access to school grounds or park
- ☐ science notebooks, paper, or lab sheets (Appendix B)
- ☐ pencils
- ☐ clipboards (optional)
- ☐ measuring tape or meter sticks
- ☐ moisture meter (simple garden type and/or Vernier probe)

Vocabulary:

circumference
interval
proportion
canopy
gravimetric

Notes: This lesson is one of those that can be done easily and quickly with low tech equipment or one that gives students an opportunity to collect more precise data with high tech equipment. Data presentation and analysis can also be informal or in-depth.

Resources:

See Appendix A for Teacher Resources:
- Internet Resources for Soil Moisture Measurement
- Soil Moisture Data Table Example

See Appendix B for Student Resources:
Soil Moisture Data Table Student Lab Sheet
See Appendix C for Literacy Connections

Procedures:

1. Take students outside to measure soil moisture in several different locations with varying amounts of sun and shade. Suggestions:
    a. Next to building and several intervals away, under eaves and beyond
    b. Next to blacktop and several intervals away
    c. Next to tree trunk and several intervals away, under canopy and beyond
    d. Natural grassy area vs. irrigated lawn
    e. Measure same area again after weather event
2. Divide class into pairs or small groups.
3. Assign one or more soil moisture measurement activities to each pair/group.
4. Use garden type moisture meters and/or Vernier probes to measure soil.
5. Direct students to record data in tables.
6. Build appropriate graphs.
7. Compare results.

Differentiation Supports:

- Strategically assign the simpler soil moisture investigations.
- Provide lab sheets for students to complete.
- Illustrate directions for easier understanding.
- Provide partially completed tables for students.
- Allow students to work with partners.

Differentiation Extensions:

- Encourage students to research other methods for measuring soil moisture – have them complete various tests and compare results.
- Have students collect data over a period of time – compare results.
- Send moisture meters home with volunteers and invite students to measure soil in various locations.
- Encourage students to conduct a scientific inquiry based on questions prompted by this investigation.

Assessment Opportunities:

Completion of lab sheets and data presentations (tables and graphs).
Exit tickets – ask students to name at least five jobs that rely on knowledge of soil moisture.

Citations:

Bowen, M., & Bartley, A. (2014). *Basics of Data Literacy: Helping Your Students (And You!) Make Sense of Data*. NSTA Press.
Arnold, J. E. (1999, December). *Soil Moisture*. Retrieved from NASA website: http://wwwghcc.msfc.nasa.gov/landprocess/lp_home.html

Soil Test Stations – Lesson 4

Grade Level: 6th Grade	**Time Needed:** 5 sessions 40-60 minutes each	**Subjects:** Science, Technology, Math

Objective/Learning Target: The student will be able to utilize tools and technology to test and record data on characteristics of soil pH, salinity, respiration, macronutrient content, and infiltration or water holding capacity. Students will identify practices that impact presence and/or absence of nutrients and characteristics of healthy soil.

Standards:

Science

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Technology

6. Technology Operations and Concepts: Students utilize technology concepts and tools to learn.

Math

6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP.5. Use appropriate tools strategically.

Background Information:

Soil pH is a measurement of the alkalinity or acidity of soil. Soil pH is measured on a scale of 1-14, with 7 as the neutral mark, anything below 7 considered acidic soil and anything above 7 considered alkaline soil.

Different plants have different pH requirements. Certain nutrients can only be accessed by plants when the soil pH falls into an acceptable range.

Salinity is a measure of the salt content in soil.

Soil respiration is the amount of carbon dioxide given off by living organisms and roots in the soil.

Soils supply relatively large amounts of nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur; these are often called the macronutrients. In relatively small amounts, the soil supplies iron, manganese, boron, molybdenum, copper, zinc, chlorine, and cobalt, the so-called micronutrients.

Infiltration is the rate at which water enters the soil.

Soil water holding capacity is the amount of water that a given soil can hold for crop use.

Materials:

- □ N,P,K Soil Test Kits such as Rapidtest
- □ spreadsheet software (Appendix B)
- □ Data Loggers or software
- □ conductivity and CO_2 sensors

Vocabulary:

acidity
macro/micro nutrient
absorption

- □ 2 liter plastic bottles
- □ paper coffee filters
- □ soil samples from different locations
- □ water
- □ stopwatch
- □ graduated cylinders or measuring cups
- □ pencils
- □ clipboards (optional)

Notes: This lesson gives students an opportunity to collect more precise data with high tech equipment. Data can be shared through resources such as Google sheets or recorded via paper-pencil. Data presentation and analysis can also be informal or in-depth. Teachers can adjust the number of test stations to meet time or equipment constraints.

Soil tests for pH and salinity are modeled using Vernier LabQuest2, sensor, and Earth Science with Vernier Labs. However, other methods and/or sensors may be easily substituted to test soil pH and salinity.

Soil Test Class Data Table includes cells for soil tests in other lessons in this unit.

Resources:

See Appendix B for Student Resources
- Soil Test Data Table—Blank
- Soil Test Data Table—Example
- Soil Water Holding Capacity
- Soil Salinity with Vernier
- Soil pH with Vernier

See Appendix C for Literacy Connections

Procedures:

1. Set up testing stations with testing equipment and lab/task sheets.
2. Divide class into pairs or small groups. Assign one soil sample to each group.
3. Assign beginning station to each pair/group.
4. Direct students to record data for their sample in Soil Test Class Data Table
5. Compare results.

Differentiation Supports:

- Illustrate directions for easier understanding.
- Provide partially completed tables for students.
- Allow students to work with partners.

Differentiation Extensions:

- Have students research logarithms and how they are used to measure large and small numbers related to pH.
- Have students collect data over a period of time – compare results.
- Send test kits or sensors home with volunteers and invite students to

	measure soil in various locations. ● Use Google Sheets or other shared tools for students to share data from different sites or classrooms.
Assessment Opportunities: ● Completion of lab sheets and data presentations (tables and graphs) ● Exit tickets –	
Citations: ● Vernier Lab Manuals ● Water Holding Capacity Lab - *http://www.ccge.org/resources/learning_centre/classroom_activities/infiltration.asp*http://www.ccge.org/resources/learning_centre/classroom_activities/infiltration.asp	

Guest Speaker/Reflections – Lesson 5

Grade Level: 6th Grade	**Time Needed:** 2 sessions – 45 minutes each	**Subjects:** Science, Math, ELA

Objective/Learning Target: The student will be able to interpret soil health information presented by a STEM professional and reflect upon discoveries made during soil investigations.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Math

MP.2. Reason abstractly and quantitatively.

ELA

6.SL.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

Background Information:

Soil bureaus have roots going back to the 1890s in the United States. In 1994, the USDA renamed the Soil Conservation Service as the Natural Resources Conservation Service to better reflect their objectives. Several other natural resource agencies and organizations, such as the Soil and Water Conservation Society and Soil Science Society of America, exist to promote the understanding and conservation of soil. Most of these organizations share a mission to educate the public about soil science and soil conservation.

Materials:

- ☐ pencils
- ☐ science notebooks or paper

Vocabulary:

conservation
natural resources
pedology

Notes: STEM professionals from local natural resource agencies are usually eager to share soil science information with young citizens. Presenters often have materials and prepared demonstrations/activities as part of their education outreach programs.

Resources:

See Appendix A for Teacher Resources:
Internet Resources for Soil Conservation Agencies
See Appendix C for Literacy Connections

Procedures:

1. Contact a local soil conservation agency and invite a STEM professional to make a classroom presentation.
2. Work with the STEM professional prior to their visit:
    a. Outline important concepts to be covered.
    b. Request specific demonstrations, if desired.
    c. Determine space and material needs, such as access to sink, table, computer/projector.
3. Prepare students for STEM professional's visit:
    a. Review audience skills.
    b. Outline note-taking requirements.
4. Invite local media and/or take pictures to share on school website, etc.
5. After the presentation, lead class discussion and direct students to complete reflections – help students integrate knowledge gained from STEM professional with knowledge they have obtained through soil lessons done in class.

Differentiation Supports:

- Provide templates for note-taking
- Provide sentence frames for post-visit reflections

Differentiation Extensions:

- Invite students to research the origins of natural resource agencies – When was the agency founded and for what purpose? How has it evolved over the years?

Assessment Opportunities:

Check notes taken during presentation or reflections recorded after presentation.
Quiz students over main concepts presented by STEM professional.

Citations:

Soil Glue – Lesson 5A

Grade Level: 6th Grade	**Time Needed:** 45 minutes	**Subjects:** Science, Technology, Math

Objective/Learning Target: The student will be able to identify the presence and importance of organic substances in soil as well as the impact that disturbing the soil has on soil health.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Technology

6. Technology Operations and Concepts: Students utilize technology concepts and tools to learn.

Math

6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP.5. Use appropriate tools strategically.

Background Information:

Soil organisms increase in abundance and in species variety when soil is not disturbed. Fungi make proteins, such as glomalin, that ooze into the soil and help glue soil particles together.

When soil is heavily cultivated (tilled) or disturbed during construction, the surface layer (topsoil) is often drastically changed, buried, or removed. This reduces the amount of organic matter in the soil and the amount of glue that is available to hold soil together as aggregates. Soil habitat is destroyed and live soil creatures are reduced in number and/or variety, or they are eliminated.

When the soil is not disturbed, more animals, plants, fungi, and microorganisms thrive in the soil. The amount of soil glue, such as glomalin, increases and the soil holds together better.

Slaking is the breakdown of large, air-dry soil aggregates into smaller sized microaggregates when they are suddenly immersed in water. Slaking occurs when aggregates are not strong enough to withstand internal stresses caused by rapid water uptake.

Slaking indicates the stability of soil aggregates, resistance to erosion and suggests how well soil can maintain its structure to provide water and air for plants when it is rapidly wetted. Limited slaking suggests that organic matter is present in

	soil to help bind soil particles and microaggregates into larger, stable aggregates.
Materials: □ samples of tilled and untilled soil for each group □ pencils □ clipboards (optional) □ 2 wide-mouth glass jars per group □ 2 pieces ¼ inch wire mesh 1.5 x 6 inches for each group	**Vocabulary:** organic glomalin aggregates slake till
Notes: This lesson may be used as an extension to Lesson 5 or may be substituted if the teacher is unable to locate a guest speaker. This lesson may be done as a demonstration to the entire class or students may work in small groups to complete. Data presentation and analysis can also be informal or in-depth.	

Resources:

See Appendix A for Teacher Resources
Soil Quality Fact Sheet - Soil Glue
See Appendix B for Student Resources
Soil Quality Fact Sheet - Soil Glue - Student Exercises
See Appendix C for Literacy Connections

Procedures:

1. Divide class into pairs, small groups or set up class demonstration.
2. Follow procedures in Appendix A for set up
3. Provide student lab sheets provided in Appendix B

Differentiation Supports:	**Differentiation Extensions:**
● Have students watch the first 2:40 of the YouTube video on this webpage that models a slake test with two soil types http://www.soilquality.org/indicators/slaking.html ● Students can complete slake test using different procedures located at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051290.pdf (#9 Slake Test pp 20-21)	● ● Have students collect data over a period of time – compare results ● Send moisture meters home with volunteers and invite students to measure soil in various locations ● Encourage students to conduct a scientific inquiry based on questions prompted by this investigation

Assessment Opportunities:

- Completion of lab sheets and student exercises.
- Exit Ticket.

Citations:

- *Soil Quality Fact Sheet: Soil Glue.* USDA. Natural Resource Conservation Service. 2010, May.
- Soil Quality Test Kit Guide. USDA. Natural Resource Conservation Service. 2001, July
- Soil Health. USDA. Natural Resource Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/ Accessed January 2016.

What Bugs Are in Soil? – Lesson 5B

Grade Level: 6th Grade	**Time Needed:** 2-3 45 minute sessions	**Subjects:** Science, Technology, Math

Objective/Learning Target: The student will be recognize the role that arthropods play in soil health and will use a Berlese Funnel to count and identify small arthropods present in soil.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience.

Technology

6. Technology Operations and Concepts: Students utilize technology concepts and tools to learn.

Math

6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP. 3. Construct viable arguments and critique the reasoning of others.
MP.5. Use appropriate tools strategically.

Background Information:

Soil organisms increase in abundance and in the species variety when soil is not disturbed.

Arthropods are joint-legged animals with segmented bodies and an exoskeleton. This diverse group is composed of the insects, arachnids (spiders, mites and scorpions), crustaceans (shrimp, lobster, crabs, etc.), millipedes and centipedes.

A Berlese Funnel is a device that is used to extract insects from soil samples. It uses a heat source to dry the sample, forcing the insects through a screen and into a container.

Materials:

- □ samples of tilled and untilled soil for each group
- □ pencils
- □ clipboards (optional)
- □ 1 funnel per group
- □ 1 piece ¼ inch wire mesh (approximately 3 x 3 inches) per group
- □ 1 jar, 2 liter or gallon plastic container per group
- □ lamp or light source
- □ jeweler's loupe or microscope

Vocabulary:

arthropod

Notes: This lesson may be used as an extension to Lesson 5 or may be substituted if the teacher is unable to locate a guest speaker. Data presentation and analysis can also be informal or in-depth.

Resources:

See Appendix A for Teacher Resources
- Soil Quality Fact Sheet - Soil Glue

See Appendix B for Student Resources
- Berlese Funnel Lab Sheet
- Data Table/Student Reflection

See Appendix C for Literacy Connections

Procedures:

1. Divide class into pairs, small groups or set up class demonstration.
2. Follow procedures in Appendix A for set up
3. Provide student lab sheets provided in Appendix B

Differentiation Supports:

- Create sentence frames for students to complete writing requirement.

Differentiation Extensions:

- Have students count and sketch each type of arthropod observed then create a data table, bar chart and pie graph showing the relative distribution.
- Have students research or provide them with a guide for arthropod identification and then have them identify each type in their sample, listing the characteristics. Use a resource like BugGuide.net http://bugguide.net/node/view/3/bgpage

Assessment Opportunities:

- Completion of data table and student exercises.
- Exit Ticket - Tell what you know about organisms in soil.

Citations:

What Else is Living in Soil? – Lesson 5C

Grade Level: 6th Grade	**Time Needed:** 1-2 45 minute sessions	**Subjects:** Science, Technology, Math

Objective/Learning Target: The student will learn how to measure microbial activity, and through guided inquiry will demonstrate an understanding of microbial activity as an indicator of soil health.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience.

Technology

6. Technology Operations and Concepts: Students utilize technology concepts and tools to learn.

Math

6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP. 3. Construct viable arguments and critique the reasoning of others.
MP.5. Use appropriate tools strategically.

Background Information:

Rather than being an inert material, soil contains a dynamic living ecosystem. The 1-5% **organic matter found in soils includes living organisms**. Although most soil organisms are invisible to the naked eye, they help the soil in multiple ways. One major benefit is their ability to help improve soil tilth. Soil **tilth** is the suitability of a soil to support plant growth. Soil organisms also play a central role in making nutrients available to plants. Soil organisms increase in abundance and in the species variety when soil is not disturbed.

Soil organisms break down organic matter, making nutrients available for uptake by plants and other organisms.

Soil respiration is a measure of the carbon dioxide (CO_2) released from organisms living in the soil and from the decomposition or breaking down of soil organic matter. Soil respiration reflects the ability of the soil to support soil life including plants, soil animals (worms, etc.), and microorganisms. It is possible for soil respiration to be too high but that usually occurs after the soil has been tilled.

For Extension: The basic respiration equation is glucose + oxygen → carbon dioxide + water + ATP

ATP Adenosine triphosphate is an organic

	compound that occurs widely in living tissue and serves as a major source of energy for many cellular processes Glucose is an energy source for most organisms.
Materials: □ soil samples for each group (enough to fill 2/3 of the bio-chambers or plastic bags). □ CO_2 sensor for each group □ bio-chamber or plastic bags □ pencils □ clipboards (optional) □ water □ fertilizer (e.g. miracle grow), compost and/or peat moss □ blender or other tool to disturb soil	**Vocabulary:** respiration microbe slope carbon dioxide organic till tilth
Notes: This lesson may be used as an extension to Lesson 5 or may be substituted if the teacher is unable to locate a guest speaker. Data presentation and analysis can also be informal or in-depth. Soil should come from the same location. If there are a sufficient number of CO_2 sensors, each group should set up their own control (see Step 5 in Procedures). If CO_2 sensors are limited, one control may be set up for the whole class to use.	

Resources:

See Appendix B for Student Resources
Soil Respiration Lab Sheet
See Appendix C for Literacy Connections

Procedures:

1. Define key vocabulary terms
2. Provide direct instruction on concept of respiration.
3. Divide class into pairs or small groups.
4. Each group decides (from a list of suggestions) what change to make to their sample
5. Set up one unchanged soil sample as the control for the entire class. Use this as the model for how to set up lab equipment and data collection.
6. Provide student lab sheets in Appendix B

Differentiation Supports:	**Differentiation Extensions:**
● Create sentence frames for students to complete writing requirement.	● Have students use graphing calculators or online graphing utility such as http://www.meta-calculator.com/online/

	• Create a class data table and graph including all soil samples. Use chart paper or technology like Google sheets to record data. • Students collect soils samples from different locations and create inquiry questions to explore and answer.

Assessment Opportunities:

- Completion of data table and student exercises.
- Exit Ticket - Tell what you know about organisms in soil and why soil needs to have organisms in it.

Citations:

http://www.ext.colostate.edu/mg/gardennotes/212.html

Lab adapted from http://pendleton-apenviro.wikispaces.com/file/detail/Soil+Respiration+lab+sensors.doc

Soil Engineering Design – Lesson 6

Grade Level: 6th Grade	**Time Needed:** 8-10 sessions – 45 minutes each	**Subjects:** Science, Engineering, Math

Objective/Learning Target: The student will be able to follow the engineering design process to engineer soil to do a specific task.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Engineering

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Math

MP.5. Use appropriate tools strategically.

Background Information:

We want to get rid of dirt, but preserve soil. What's the difference? Dirt is what gets on our clothes and under our nails. Soil contains minerals, air, water, and organic matter. We rely on soil to grow food, filter water, and provide materials. According to Natural Resources Conservation Service, "Soil quality is how well soil does what we want it to do." Soil quality/health is affected, for better or worse, by our practices. As world population and food production demands rise, keeping our soil healthy and productive is of paramount importance. Healthy soil could provide solutions to some of our planet's biggest challenges.

Materials:

- ☐ engineering/science notebooks or paper
- ☐ pencils
- ☐ copies of Engineering Design Project Template (digital or print – see Appendix B)
- ☐ various supplies for engineering soil projects

Vocabulary:

criteria
constraints
scientific principles
systematic
iterative
modifications
design solutions

Notes: Many students will not yet have the skills to complete this project independently. It is advisable to provide guidelines, timelines, check-in points, etc., to help keep students on track to complete the project on time. Providing a template will help students understand directions and know what their next steps should be.

Resources:

See Appendix A for Teacher Resources
    Internet Resources for Soil Engineering Design
See Appendix B for Student Resources
    Engineering Design Project Template
See Appendix C for Literacy Connections

Procedures:

1. Present engineering design challenge to students:
   You are a soil engineer. Your job is to engineer a soil (change its composition or pH) to do something specific (filter water, grow a plant, or support worms).
2. Review the engineering design process:
   a. Identify the problem
   b. Brainstorm
   c. Design
   d. Build
   e. Test and evaluate
   f. Redesign
   g. Share solution
3. Explain criteria (task to be completed) and constraints (materials and timeline) to be used in completing project.
4. Share assessment plans – rubric or scoring guide. Remind students that they will be sharing their completed design projects with the rest of class, and any other audience members you wish to include, such as other classes at school, parents, administrators, school board, STEM professionals, and local media.
5. Allow students to choose soil-engineering task (filter water, grow a plant, or support worms).
6. Allow students to decide if they want to work independently or with partners/teams. Help students find partners/teams, if desired.
7. If using this project for a performance task, work sample, and/or grade, remind students that the written report (completion of template) must be done independently even if they worked with a partner/team to complete their designs.
8. Invite students to begin!
9. Monitor students. Offer assistance and clarifications. Use strategic questioning strategies to guide students without imposing your own ideas or telling students what to do.
10. Employ management strategies to help students stay focused, productive, and able to complete their projects on time.

Differentiation Supports:	**Differentiation Extensions:**
• Provide engineering design templates. • Allow students to work with partners or teams. • Strategically choose supplies to make available to specific students/teams.	• Have students keep a digital diary (digital pictures/video, word processing) of the steps they took to engineer their soil. • Invite students to create an advertisement (poster, jingle, brochure) for their completed designs. • Ask student volunteers to "sell" their design ideas to prospective buyers (rest of class or appointed panel) in "Shark Tank" TV show style.

Assessment Opportunities:

Score completed design projects with a rubric or scoring guide.
Apply a rating scale to judge effectiveness of engineered soils.
Take online quiz from Natural Resources Conservation Service at http://www.proprofs.com/quiz-school/story.php?title=mte1mduwoaih7n

Citations:

Scientific Inquiry. (2015). Retrieved from Oregon Department of Education website: http://www.ode.state.or.us/search/page/?id=2708

Soil Health. (n.d.). Retrieved from USDA Natural Resources Conservation Service website: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/

Soil Health Quiz 1. (n.d.). Retrieved from ProProfs website: http://www.proprofs.com/quiz-school/story.php?title=mte1mduwoaih7n

Shark Tank. (2015). Retrieved from NBCUniversal website: http://www.cnbcprime.com/shark-tank/

Soil Engineering Design Presentations – Lesson 7

Grade Level: 6th Grade	**Time Needed:** 8-10 sessions – 45 minutes each	**Subjects:** Science, Engineering, Math

Objective/Learning Target: The student will be able summarize and present results/findings from Engineering Design Challenge.

Standards:

Science

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Engineering

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Math

MP.5. Use appropriate tools strategically.

Materials:

- □ engineering/science notebooks or paper
- □ pencils/ markers/crayons
- □ graph paper
- □ rulers
- □ completed engineering design project template (digital or print – see Appendix B, Lesson 6)

Vocabulary:

criteria
constraints
scientific principles
systematic
iterative
modifications

□ computer or tablet □ projector and screen □ poster board	design solutions

Notes: Many students will not yet have the skills to complete this project independently. It is advisable to provide guidelines, timelines, check-in points, etc., to help keep students on track to complete the project on time. Providing a template will help students understand directions and know what their next steps should be.

Resources:

- Teacher Resource - Key Terms for Engineering Design Scoring Guide (includes student exemplars)
  - http://www.ode.state.or.us/teachlearn/subjects/science/assessment/sciinquiryengdesign_key_terms.pdf
- Student Resources - Official State Scoring Guides (Oregon)
  - Engineering Design Scoring Guide http://www.ode.state.or.us/search/page/?id=32
  - Speaking Scoring Guide
  - http://www.ode.state.or.us/search/page/?id=32
- See Appendix C for Literacy Connections

Procedures:

1. Present options and pros/cons for presentation formats
   a. Posterboard
   b. Tri-fold
   c. Digital Slideshow (PowerPoint, Google slides)
   d. Supernote or other tablet application
2. Create content requirements
   a. Explain process and findings
   b. Call out the explicit STEM knowledge required to complete project
   c. Review Speaking Scoring Guide
3. Add embellishments
4. Establish procedure for presenting - be sure to consider:
   a. Time constraints
   b. Order
   c. Audience
   d. Feedback/Questioning protocols
5. Students present their projects

Differentiation Supports:	**Differentiation Extensions:**
● Provide templates for slideshow or poster organization	● Invite soil engineer to attend ● Invite administrators

Assessment Opportunities: ● Score presentations with a rubric or scoring guide.	

Conclusions – Lesson 8

Grade Level: 6th Grade	**Time Needed:** 45-60 min.	**Subjects:** Science, Technology, Math, ELA-Literacy

Objective/Learning Target: The student will be able to understand that soil is a natural resource affected by human activity.

Standards:
Science:
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
Technology:
3. Research and Information Fluency: Students select and apply digital tools to gather, evaluate, validate, and use information.
Math:
6.RP.A.3 Understand ratio concepts and use ratio reasoning to solve problems.
MP.2. Reason abstractly and quantitatively.
MP.5. Use appropriate tools strategically.
ELA-Literacy
RH.6-8 Determine the central ideas or information of a primary or secondary source….

Background Information:

Materials:

- ☐ science notebooks (or paper)
- ☐ pencils
- ☐ computers/tablets

Vocabulary:

soil (vs. dirt)
topsoil
dust bowl
natural resource

Procedures:

1. Briefly review each lesson and main learning in the unit
2. Re-Post Essential Question – ***Why should we care about soil health?***
    a. Ask students to think about their new learning on the topic of soil health. They should copy the question and write their answers in their science notebooks. Remind students to include as much detail as possible, using new understandings from the lessons in the unit.

Differentiation Supports:	**Differentiation Extensions:**
● Provide sentence frames for students.	● Invite students to write an advertisement for a gardening website or publication outlining their processes and their new & improved soil. ● Students write a letter to the editor about the need to be aware of soil health. ● Students write an article for a soil-based publication.

Assessment Opportunities:

- Check science notebooks for completion. Compare to response in Lesson 1.

Citations: