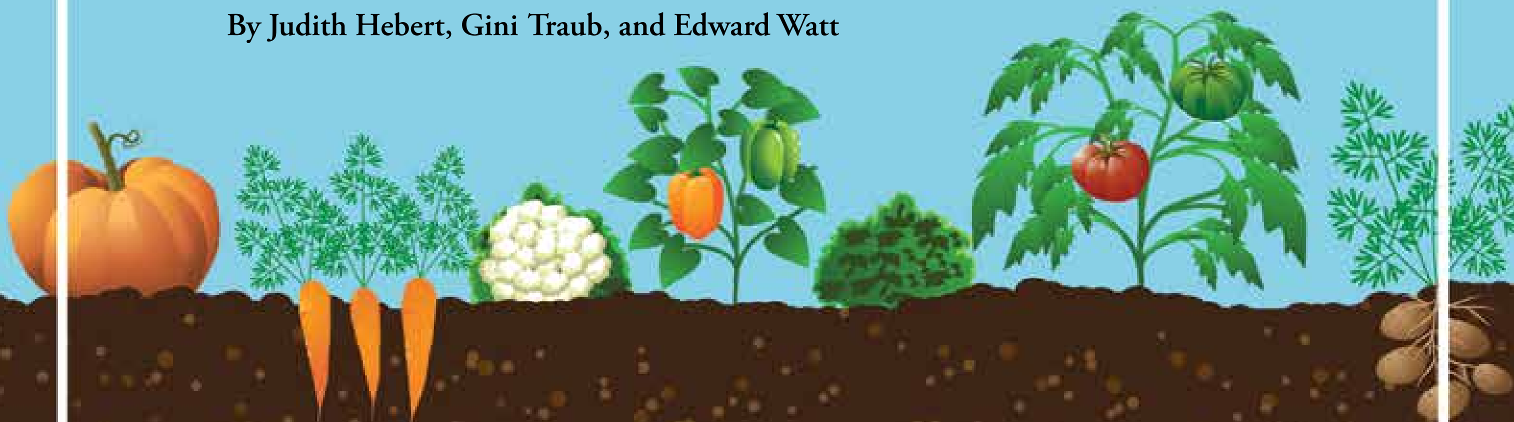
Our Garden Plot Thickens

An interdisciplinary classroom study provides fifth graders with opportunities to explore the properties of soil.

By Judith Hebert, Gini Traub, and Edward Watt



At our school students are accustomed to learning in informal, outdoor settings. We identify food webs, follow animal tracks in the woodland across the street, and harvest pumpkins from our school garden. For the last several years our garden has offered students new perspectives about what they are eating. Discussions in health classes indicated high student interest in food and nutrition with students seeking connections between what they ate and where their food came from. We wanted to involve our fifth-grade students in the full cycle of a garden: soil testing and preparation, garden planning and planting, and through the cycle of growth, development, and harvest. Students were excited about working outdoors and asked, “Do we get to do the planting?”

We, a school science teacher and two supportive, local, environmental educators—decided to use the school garden as a hands-on, real-world opportunity for students to investigate how soils affect plant growth in an outdoor garden setting. Students began in the classroom with hands-on exploration of a variety of soils and sediments, defining and measuring their properties, and recording their observations. These introductory learning experiences about soil properties then formed the basis for students’ choices of soil types that they predicted would achieve maximum crop harvest in the garden. Our lessons, which took place twice a week, provided an opportunity for our students to engage in the engineering design process and later to develop a deeper understanding of scientific processes by investigating a question connected to local food production.

Setting the Stage

The teacher began the project with a class discussion/review. She asked students to generate a list of what plants need to grow. She guided the discussion by having students prioritize the most important variables (example: least important—adequate room for plants to grow). Students concluded that energy from the Sun, soil nutrients, and water availability would be considered most important.

Next, our fifth graders went outside and explored the six raised beds, constructed by our high school carpentry department, located on the grounds of the fire station next door to the school. Students learned that the garden area was fenced to eliminate visits from our outdoor classroom's resident woodchuck. At the site, students worked in pairs, using compasses, to observe and diagram the Sun's path and to record times of greatest sunlight exposure and any shadows over the area. Upon their return to the classroom, students shared their written observations, and then each pair recorded their findings on a whole-class chart. From their observations, the students concluded that the six boxes would all receive the same amount of sunlight at the same times of day as well as equal amounts of rainfall. The teacher then asked students whether this understanding of sunlight and water factors would enable them to predict plant growth. She guided discussion to include soil type as an additional important factor.

The next day students examined the garden soil and observed through visual inspection that it looked like sand. We wanted to develop their understanding of particle sizes and the different components of soil. We read portions of *Gary's Sand Journal* by Gary Griggs, Catherine Halverson, and Craig Strang (2007) which provides a fun look at soil properties. We then provided students with prepared samples of sand, clay, topsoil, and decomposed organic matter for them to observe and compare. For safety reasons, we were careful to require supervised hand washing after each time the students handled soil samples, both outdoors and indoors. The hands-on aspects of the soil observations assisted English language learners with participation in the investigations. The teacher demonstrated how to investigate the soil samples, and student assessment drawings precluded the need for extensive vocabulary. Students made individual drawings in their science journals and completed an individual *quick write* defining soil and its properties. These provided us with formative assessment of how well our students understood the property of soil particle size. One group commented that particles in our garden soil were on the large end of the spectrum for sand. Students also recorded an absence of organic materials in the garden soil samples. These findings generated an *I Wonder* segment for discussion. One student suggested that the topsoil might have been blown away by wind. Another said perhaps there was too much farming in the area.

CAUTION

Unit Activities (45-Minute Periods)

Day 1: Review plant needs, visit garden, and make observations

Day 2: Record written observations and reflections of Day 1 activities

Day 3: Examine and compare different soil samples

Day 4: Model local geology using stream table

Day 5: Explore suitability of sand for growing vegetables

Day 6: Engineering design: water retention devices

Day 7: Engineering challenge: test water devices

Day 8: Design soil treatments for garden beds

Day 9: Garden investigation: plant vegetables and record planting plan

Day 10: Fifth grade–fourth grade discussion and collaboration

Next Fall:

Days 1 and 2: Harvest vegetables and record data

Day 3: Share harvest and plan next year's garden

Understanding Local Geology

To help answer the question about why our garden soil was so sandy, we invited an outreach educator from our state's Department of Conservation and Recreation to our class. The educator shared content knowledge about the early geology of our area and provided hands-on activities to simulate Pleistocene glacial sediment deposition. Richard D. Little's *Dinosaurs, Dunes, and Drifting Continents* (2003) is a very informative book for teachers about how a landscape can be shaped by glaciers and other geologic events. Students simulated glacial formations

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Students line up to harvest tomatos.

through the use of a stream table. They observed "sheets" of ice (which the classroom teacher created by freezing water on cookie sheets) pushing through sediments from a higher elevation to a lower one as they illustrated the formation of an ancient glacial lake. Students observed that as the ice moved it picked up and moved sediments, simulating the scouring effects of the glacial ice. Next students simulated and observed over 30 minutes the effect of melting ice. As the meltwater flowed from higher elevations to lower, it deposited those sediments, sorted by size, into a glacial lake. Students created illustrations of changes they observed over a 30-minute period. They created captions that explained why the changes occurred, paying special attention to landforms created by water flow. One student commented that the glacier acted like a wedge, pulling material from the Earth's surface. Students concluded that prior assumptions about the sandy nature of our soil were incorrect. They agreed that the sand could have been deposited by glacial meltwaters. They liked the idea that the glacier acted like a simple machine, scouring sediments from the area.

Garden Harvest Data

Plot	Number of tomatoes
Topsoil/compost	104
Topsoil/compost	124
Topsoil/compost	111
Topsoil/compost	105
Sand/compost	90
Sand only	36
Total	570

Developing Student Ideas

Understanding the sandy nature of our soil allowed our students to return to the question of what type of soil would maximize vegetable production in our garden. In response to teacher questions, students *paired and shared* about what they thought about sand as a growing environment for vegetables. Student pairs recorded on sticky notes their opinions of the advantages and disadvantages of sand as good garden soil, with supporting reasons. Student opinions were shared with the full class, using their sticky notes, and this led to a lively discussion about soils and plant growth. As a formative assessment, students who appropriately used vocabulary terms from the previous lesson received extra bonus points, which are compiled toward student science grades. The activity demonstrated student understanding of vocabulary and soil properties and rewarded student participation. Students remarked again that they observed an absence of decomposed organic materials in the sand. They wondered if our garden soil would have sufficient nutrients to support plant growth. The teacher asked students to think of ways to provide sufficient nutrients for the garden. One student pair excitedly reminded the class, "We have compost right in our own backyard." The class decided they would add compost from our schoolwide composting program to the sand to help plants grow. Some *pair and share* results indicated that students were wondering if the sand would retain enough water because it was so loose and crumbly.

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An Engineering Design Challenge

Following the compost discussion, we asked our students to think about how water retention of soils might affect plant growth. The teacher asked the students: How can we measure how well sand retains water when compared to other soil types? David Lindbo's book, *Soil: Get the Inside Scoop* (2008), provides a nice discussion of how soils retain water. Another resource to share with your students is the online slide show of soil properties found in Internet Resources.

We reviewed the engineering design process with our students, emphasizing the need for considering a variety of approaches and solutions. The Boston Museum of Science's Engineering is Elementary curriculum (*www.eie.org*) provides an excellent structure for guiding the design process (see Internet Resources). Students gathered in their science groups to brainstorm devices that would measure how much water was retained by our garden soil samples and other known samples. We presented our students with a variety of materials, including cut-in-half soda bottles, different-size funnels, paper towels, measuring cups, graduated cylinders, and precut squares of window screening. After viewing the available materials, student groups sketched and labeled diagrams. They wrote down the steps of what they would do to create their device to measure the volume of water retained. Students' journal diagrams and sketches were used as additional formative assessments by the teacher. Student groups presented their measuring device designs to their fellow students for comments. Following presentations and discussion, groups dove in and created their devices according to their designs … mostly. After the devices were constructed, we came back together and identified student roles for the groups: soil measurer, water measurer, water pourer, timer, and recorder. We agreed on roles for individuals in each group, matching specific tasks with student learning styles or strengths.

Students eagerly participated in planting, weeding, and harvesting.

Once students' roles were clearly understood, student groups set to work to test their soil samples. They poured water into their invented devices, timing how quickly it moved through each sample and noting how much water flowed through their sample. Groups recorded time and water volume. Following these informal investigations, student groups recorded their data, including both time and volume measurements, on a full classroom chart organized by soil type. A rich class discussion arose from observing the data chart. Which soil retained more water? Which one retained the least? Which one let the water flow through the quickest? Following our full-class discussion, students worked individually to write up their own analysis and interpretation of the class's data. Students' written analyses and discussion formed the basis for teacher formative assessment. Modified assessments for ELL students were assigned for completion with bilingual teacher. These assessments included students graphing the class data and discussing these results orally with our ELL teacher.

Students' data clearly led to the conclusion that water traveled most quickly through sand and least quickly through clay. Students were asked whether the clay would be the best choice for garden soil since it retained water for the longest amount of time. During discussion many students wanted to say yes because they knew plants needed water, but they were not accustomed to thinking about plants having too much water. Through whole-class discussion we helped students think about water in clay soils. What if it rained for a long period of time? Is too much water as much of a problem as too little? Students were guided to realize that plant roots might rot and therefore would not benefit from the use of a clay-only soil.

The Garden Investigation

Next, students returned to the question of maximizing yield in the garden. Discussion led quickly to their decision to manipulate the soil types in the different garden beds. Through whole-class discussion, students decided that a certain number of their six raised beds would best be filled with a combination of topsoil and compost. One group of students reminded the class that the sand they observed earlier did not contain decomposed matter. Another group noted that topsoil "clumped," and they thought this would allow it to hold more water. Students chose to fill four boxes with topsoil provided by our city's Department of Public Works mixed with cafeteria compost. They filled the fifth box with sand and compost, and left the sixth box with just sand. Teachers without school gardens could choose to plant tomato plants in individual containers filled with the different types of soil.

Working with a local master gardener, acting as mentor, we chose tomatoes, potatoes, and pumpkins for planting since these crops all provide a fall harvest for returning students. The National Agriculture in the Classroom website is a good resource for teachers interested in school gardens (*http://agclassroom.org*). Students demonstrated clear understanding during whole-class discussion that the crop harvest from each box would determine the fertility of that soil type and its effect on plant growth. Our garden mentor provided plants and seed potatoes. When the big day came, after all possibilities of frost were over for our area, our garden mentor assisted the students in planting, maintaining proper planting depth and row widths in the boxes. After planting, students laid out strings in the six boxes, creating a map of each bed and dividing the space into 5×10 ft. areas. They carefully recorded what crops were planted where and mapped the garden plots using graph paper. Each plot contained one pumpkin plant, two tomato plants, and approximately 10–15 seed potatoes. For the remainder of the school year, students took turns watering crops. Straw mulch was used to minimize weeds.

The Summer

Our fifth graders would be at the middle school next September at harvest time. So, we decided to have our students share information about their planting project with students from the current grade 4 class, next year's fifth graders. Fifth graders met one-on-one with fourth graders and described their prior research to prime them for the fall harvest results. Students shared information recorded in their science notebooks. Oral discussions were supervised by the teacher. Fifth graders shared their thoughts about which soils would best support vegetable production in the school garden. The fourth graders individually wrote their predictions about which soil type would provide the best vegetable harvest. We kept the fourth graders' predictions on file over the summer. The fourth graders would have to wait until next September to determine whether their own predictions were correct. Fifth-grade students reflected in their science journals about their paired activity. The teacher designed a rubric and evaluated students based on predictions of soil fertility, information from science journals, and topics shared with fourth-grade students as her summative unit evaluation (see NSTA Connection for the rubric).

Since the garden plot was located on the neighboring fire station grounds, we arranged with the firefighters to water the garden during the summer. Teachers without friendly firefighters next door are faced with perhaps the biggest challenge in school gardening—how to care for the plants over the summer. We have tried volunteer summer workdays, assigned family care weeks, and a lot of garden hope over the years with varying degrees of success.

Harvesting the Data and Drawing Conclusions

The following school year, our new fifth graders visited the garden after reviewing their predictions. Students harvested over 560 plum tomatoes! They created line graphs illustrating the harvest from each plot. They determined that the topsoil/compost combination produced the most tomatoes. Students concluded that sand alone did not provide enough nutrients or water for plant growth, but that the topsoil/compost did. Harvest was happily shared with staff and students, as well as the firefighters.

These experiences provided students with opportunities to observe firsthand the cyclical events involved in managing a school garden. A deeper understanding of how the properties of soils affect plant growth emerged organically from the study. Students eagerly participated in all aspects of the activities whether planting, weeding, or harvesting. And all were very excited about collecting seeds to be used in the garden next year! ■

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Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

5-ESS2 Earth Systems *www.nextgenscience.org/5ess2-earth-systems*	
Performance Expectation *The materials/lessons/activities outlined in this article are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.*	**Connections to Classroom Activities**
5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	Students work with models to observe the interactions of ice, water (hydrosphere), and sediments (geosphere) demonstrating glacial deposition.
Science and Engineering Practices	
Planning and Carrying Out Investigations Developing and Using Models Constructing Explanations and Designing Solutions	Students • use devices to measure water retained by different soil types. • construct explanations regarding the movement and retention of water in the devices. • determine soil amendments to increase water retention of sandy soil in school garden.
Disciplinary Core Ideas	
ESS2.A Earth Materials and Systems • Earth's major systems are the geosphere, the hydrosphere, the atmosphere and the biosphere. • These systems interact in multiple ways to affect Earth's surface materials and processes.	Students constructed explanations for connections between glacial deposition and soil properties on their school site from working with stream tables with ice, water, and sediments to model real-world systems.
Crosscutting Concepts	
Systems and System Models	Students draw and construct models to explain soil properties, and successful harvests in school garden.
Structure and Function	Students explore and develop understanding of correlation between soil properties and plant growth.

References

Engineering is Elementary. 2007. *Landforms and geotechnical engineering for elementary students: A stick in the mud: Evaluating a landscape.* Boston, MA: Museum of Science.

Griggs, G., C. Halverson, and C. Strang. 2007. *Seeds of science/Roots of reading: Gary's sand journal.* Berkeley, CA: Regents of the University of California.

Lindbo, D.L. 2008. *Soil: Get the inside scoop.* Madison, WI: Soil Science Society of America.

Little, R.D. 2003. *Dinosaurs, dunes, and drifting continents: The geology of the Connecticut River Valley.* 3rd ed. Easthampton, MA: Earth View.

NGSS Lead States. 2013 *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press. *www.nextgenscience.rg/next-generation-science-standards.*

Internet Resources

Engineering is Elementary
www.eie.org

National Agriculture in the Classroom program
http://agclassroom.org

Slide show on soil properties
www.slideshare.net/MMoiraWhitehouse/properties-of-soils-teach-9807299

NSTA Connection

Visit *www.nsta.org/SC1503* for the rubric.