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Integrating STEM and Sustainability through Learning Gardens

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Integrating STEM and Sustainability Education through Learning Gardens:

A Place-Based Approach to the Next Generation Science Standards

by Sybil S. Kelley and Dilafruz R. Williams; Portland State University

Our ecological and social problems are deeply interconnected. Climate change, habitat destruction, loss of biodiversity, food insecurity, air and water pollution, along with innumerable other environmental problems, are increasingly related to issues of equity and social justice. Addressing these problems requires a citizenry that is both scientifically and ecologically literate, ensuring that all people are empowered with the understandings, dispositions, and skills to address the challenges of this modern world.

CLEARING readers are likely familiar with another crisis of our times, the idea of “Nature Deficit Disorder” that Richard Louv (2005) so poignantly described in his landmark book, *Last Child in the Woods: Saving our Children from Nature Deficit Disorder*. Louv and numerous other leaders of the *No Child Left Inside* initiative have done a remarkable job pointing out the parallel phenomena of increasing numbers of children with ADHD and loss of time spent in nature, particularly unstructured time to explore, engage in imaginative play, and utilize

all the senses. Nonetheless, time that children spend in school has become more rigid, siloed by discipline (e.g. 90+ minute literacy blocks), and disconnected from students' daily lives and lived experiences.

As a society, we place unrealistic demands on educators. Classroom teachers are continually expected to do more with less—less money, less support, less time—with increasing mandates and pressures of accountability, whether from *No Child Left Behind* or *Race to the Top.* Informal educators provide a remarkable array of learning experiences, yet many teachers do not have the time or capacity to make use of these opportunities, particularly since in most cases, field trips have to be rigorously defended and justified in context of the school-day curriculum. However, since the early 1990s, the school garden movement has been working to mitigate traditional schooling taking place within the four walls of the classroom by bringing students outdoors on school grounds right where the schools are housed.

The adoption of the *Next Generation Science Standards* (NGSS) by 26 states has the potential to transform teaching and learning in and out of schools. The focus of the NGSS is on 12 "big ideas" in science (the Disciplinary Core and Component Ideas, NRC, 2012), bringing these together into process oriented learning goals (learning performances) that bridge scientific content with the practices of science and engineering, and crosscutting concepts that span all the disciplines of science (e.g. patterns, cause and effect, and systems and system models). The NGSS raises the bar for science in schools, and will require that much more attention be paid to science starting in elementary school. To help in this process, the NGSS are integrated by design. First, science education has been integrated into STEM education (Science, Technology, Engineering, and Math), elevating the practices and content of engineering design to the level of scientific inquiry. Further, the NGSS provide connections and links to the Common Core State Standards (CCSS), making them much more useful for developing integrated, project-based units of instruction. We believe that school gardens provide a rich milieu to put the NGSS into practice, making science relevant to the lives of students as they engage with their own place in meaningful ways across disciplines.

STEM and Sustainability Education: Sense of Place

As an individually and socially constructed phenomenon, relationship to place is complex and so is the creation and development of meaning, attachment, and identity based on this relationship. To know one's place is prerequisite to knowing one's self. According to several scholars, *sense of place* is recognized as a key component of sustainability and sustainability education. Wendell Berry (1990) tells us that if we do not know where we are, we cannot know who we are. David Orr (1992) explains that people with a sense of place become "inhabitants" who dwell deeply, steeped in connections. Similarly, David Sobel (2004) asserts that people tend to protect what they love and know; therefore the actual places where we live, work, and play, become an explicit part of sustainability initiatives.

Sustainability education takes a holistic, systemic view of the world, is place-based, experiential, and transformative. Effective, high-quality STEM teaching, which should include learning experiences that are relevant and meaningful to students' lives, are active and interactive, and make use of observation and evidence to develop meaning and understanding (knowledge claims). STEM and sustainability education are complementary and should be brought together in mainstream education.

Not only do we need to weave STEM and sustainability education together, we need to elevate both more prominently in schools. Recent studies have illuminated statistically significant reductions in science instructional time in elementary classrooms (Blank, 2013). These findings are quite troubling considering the need for scientifically and ecologically literate graduates. If we wait until middle and high school to emphasize science, we have already lost a tremendous number of students, most typically students who are already marginalized in mainstream educational (and other) systems. Making use of learning gardens can provide a solution. Teaching and learning in gardens is a way to increase student engagement in learning, and also to support different learning styles, integrate various disciplines, and revitalize schools and neighborhoods.

Using “living soil” as a metaphor for re-envisioning education, Williams and Brown (2012) state,

> *Gardens present an appropriate life-enriching ecological practice that guides curriculum, teaching, and learning. In an era characterized by educational malaise and apathy and amidst a repetitive discourse of racing to the top, gardens offer an alternative and regenerative model for bringing schools to life that differs significantly from mechanistic techno-scientific reform efforts oriented toward economic globalization.* (p. 22)

In other words, school gardens and the living soil within them can provide a place-based context for teachers and students to learn together, alongside other community members, including the non-human members, developing a sense of interconnectedness and understanding of our place in ecological systems.

Williams and Brown (2012) outline seven pedagogical principles that are foundational to garden-based education, and that shift learning from a dry, disconnected model to one that is active and alive. Learning gardens cultivate a sense of place, awaken the senses, and foster wonder and curiosity; further, through practical experience, learners observe rhythm and scale, develop understandings of interconnectedness, and value biocultural diversity. Much of schooling focuses on visual and auditory learning modalities. Learning gardens on the other hand provide multisensory, kinesthetic learning experiences for children (and adults). They provide accessible places to build connections to nature—allowing learners to see, feel, hear, smell, and taste the wonders of nature. In our own teaching and working with teachers in low-income schools in particular, we have found the desperate need for this connection among adults and children alike.

As districts, schools, and individual classroom teachers work to implement the NGSS, innumerable, place-based opportunities exist to address national, state, and local goals within the context of learning gardens. Nonetheless, it will require leadership at many levels to reach the vision of the NGSS and the school garden movement. Principals need to see the value of garden-based education and embrace this type of teaching and learning by supporting and protecting their teachers. As professionals and leaders working directly with students, teachers will need support in developing relevant, place-based lessons that address the NGSS. Teachers must be integral players, bringing their expertise and experiences to the process.

In our summer professional development course entitled, *Integrating STEM and Sustainability Education through Learning Gardens*, classroom teachers, garden-based educators, and graduate students in the Leadership for Sustainability program work together to implement a place-based curriculum with elementary students in a summer garden program through SUN Schools (Schools Uniting Neighborhoods). In the afternoons, this diverse group of educators has the opportunity to grapple with the content and design of the NGSS, and to work collaboratively to develop integrated, standards-based instructional units that are contextualized in school learning gardens. For the NGSS to become a reality, teachers will need more professional learning experiences that empower them to put their expertise and knowledge of their students (their place) into the design and implementation of well-planned instructional units. NGSS and the *Framework for K-12 Science Education* (NRC, 2012) from which they were developed provide the structure and scaffolding for building curriculum, but efforts led by teachers and partners from higher education and the local community will provide the flesh and details for implementation.

In the following paragraphs, we will highlight some examples of what the NGSS in learning gardens can look like in practice. The first scenario provides an example of an engaging encounter that could open the door to numerous explorations, while the second is an actual lesson we have used in the summer garden program. Both highlight the rich learning opportunities that emerge and are literally just outside the classroom door.

In science, teachers are often encouraged to use the “5E” instructional model (Bybee et al, 2006) that includes “Engage, Explore, Explain, Extend, and Evaluate.” In the garden, all five E’s can be woven together, but “engage” and “explore” are particularly ripe. Last summer, a group of teacher candidates and youth ranging in age from four to twelve years old were thoroughly engaged and excited by this predator-prey discovery. For teachers, such wonders provide an anchor for numerous learning experiences.

Figure 1: An unexpected discovery of a Goldenrod Crab Spider feasting on an unsuspecting honey bee yielded immediate fascination and interest among students and teachers alike.

For example, a Kindergarten teacher could help her students investigate the needs of different plants and animals in the garden. By gathering age-appropriate data (perhaps a simple table with a name and/or drawing of the organism and what the students observe each organism eating), students can develop an explanation of how different animals eat different (and in some cases the same) things. This would directly address the Kindergarten NGSS related to structures and processes in organisms, specifically the component concept about matter and energy flow in organisms (from NGSS (2013), **K-LS1-1.** Use observations to describe patterns of what plants and animals (including humans) need to survive). First grade teachers and students could build on foundations laid in kindergarten by focusing on the structure and function of plants and animals, and how an organism's structures help it survive and grow (**1-LS1-1.** Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs).

As another possible direction, this initial discovery could serve as the platform for introducing the 3rd grade standards related to heredity and biological evolution. By combining hands-on data collection in the garden with internet research, or perhaps inviting a local scientist/arachnologist to visit the class, students could compare the variations among this particular species of spider (e.g. some have red strips, others do not), as well as traits of other spider species. Using their data, they could construct an argument about why some species are more likely to survive in particular habitats over others (**3-LS3-2.** Use evidence to support the explanation that traits can be influenced by the environment; **3-LS4-2.** Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing (NGSS, 2013)).

Figure 2: Students collaborate to gather data about the number and diversity of species they can observe and record in their habitat sampling area.

In each of these possible scenarios, there are also numerous interdisciplinary connections to reading and math expectations in the Common Core State Standards (CCCS) and to real world issues. For example, as third graders learned about the relationships between species and their specific habitats, they could also read a variety of texts describing the flora and fauna, as well as abiotic components, of different ecosystems. They could read and discuss the role of pollinators in ecosystems, and how pollinators are so crucial to our own food sources, particularly those in a specific location—i.e. for *this* place. As a culminating product, students could create a short video or poster that argues why sustainable agriculture practices are vital to food security and the planet as a whole.

The second example is one that we have experienced first-hand in the summer garden program connected with the *Integrating STEM and Sustainability Education through Learning Gardens* course—Is Soil Alive?—the driving question behind two days of soil explorations. The first day was spent collecting samples to test for soil composition. As students waited for the layers of sand, silt, and clay from various locations around the school yard to settle in their jars, they explored decomposers in the compost and worm bins, and those found in the garden. As a culminating activity (that could also serve as an assessment), students were given a worksheet that asked them to draw what they had observed above and below ground in the garden. The overarching question, "Is soil alive? Explain your thinking" guided students.

This cluster of lessons provides several clear connections to the NGSS, particularly related to "Interdependent Relationships in Ecosystems," "Cycles of Matter and Energy Transfer in Ecosystems," and "Biogeology" of Earth's systems. But equally important, an open-ended question such as "Is the Soil Alive?" helps students and teachers grapple with the nature of science. In this particular example of viewing soil as an ecosystem, students were provided with a concrete example of some relatively abstract, complex ideas. It let them think and learn about systems, interconnections, cycles, and flows, laying a strong foundation for further exploration and

Figure 3: Students and teachers search for critters (aka, decomposers) in the raised garden beds at their school.

learning in upper grades. Students had the opportunity to engage in logical reasoning and discourse, using empirical observations to support their claims. Some of the more complicated explanations of why the mineral portions of soil are non-living while the system as a whole can be considered alive, at the most basic level, were understandable to the elementary-age students. If teachers had given "the right answer" as is traditionally related to properties of living and non-living elements of soil, they would have discouraged students from thinking, imagining, inferring, and looking for evidence. Furthermore, a response that declared soil as not being alive because it is made up of sand, silt, and clay could have denied students a deeper exploration into the microbial ecology of soil and compost.

Figure 4: While observing and recording the decomposers found in the compost bin, a student observed this black soldier fly emerge from its pupa. It is hard to imagine doing a better job of explaining life cycles than an experience such as this can provide

Recommendations/call to action:

School and community learning gardens provide rich, easily-accessible contexts for integrating STEM and sustainability education. Learning experiences that are multisensory, place-based, and interconnected come to life in the garden, making teaching and learning relevant and meaningful to students and teachers alike. The recent adoption of the Next Generation Science Standards, which emphasize application of knowledge, higher-order thinking skills, and demonstration of proficiency through performance, present the educational community with a unique opportunity to make better use of such spaces for teaching and learning. To help move our community closer to this vision, we offer a few suggestions to help in this process:

1. Think big, start small—meaningful change takes time. It is important to spend time envisioning and planning in the early stages so that your garden-based aspirations can be turned into reality.
2. Whether you are new to outdoor, garden-based education or an experienced practitioner, it is important to set shared expectations and norms with your students. Too many children have not spent a lot of time outside in nature. Furthermore, when they have been outside during school hours, it is often recess, not learning time. It is important to be clear that even though students are outside the classroom, it is still time for learning.
3. Related to number two, get outside regularly. As students become more familiar with the garden routines, they will be more comfortable and "on-task." Consider learning outdoors to be equally essential as learning with technology. Nature time is as important as screen time.
4. Share your successes (and challenges)—with colleagues, your principal, parents, and your students.
5. Connect with other educators and resources. For instance, the following websites can provide even more links to others interested in learning gardens: Oregon School Garden Summit (http://www.ode.state.or.us/search/page/?id=4202), OSU Extension's gardening program (http://extension.oregonstate.edu/gardening/), Learning Gardens Laboratory (http://www.pdx.edu/elp/learning-gardens-laboratory) and many other local, regional, and statewide organizations.
6. Most of all, have fun! Learning should be a fulfilling lifelong endeavor. That will only happen if it is fun, engaging, and meaningful. Learning gardens are the perfect mileau!

Photo Inspiration:

Figure 5: Learning gardens also provide numerous opportunities for arts integration.

Figure 6: Arts integration and bilingual language development—gardens can provide a cultural entry point for many students from diverse backgrounds.

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Figure 7: Collecting daily measurements of temperature and weather conditions helps students develop understandings of hard-to-grasp, abstract concepts. Additionally, they can observe change over time, make predictions, and record and analyze data.

Figure 8: A one-on-one exploration of roots and soil.

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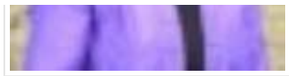
Figure 9: Early literacy skills can be developed and enhanced through journaling and data collection. Even the youngest learners can feel successful.

Figure 10: Teacher candidates discuss and reflect on the day's activities with a small group of students.



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Chuck Gibilisco May 27, 2017 at 6:45 pm #

Extremely well thought out and great presentation! Hope to duplicate your efforts in Quilcene

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