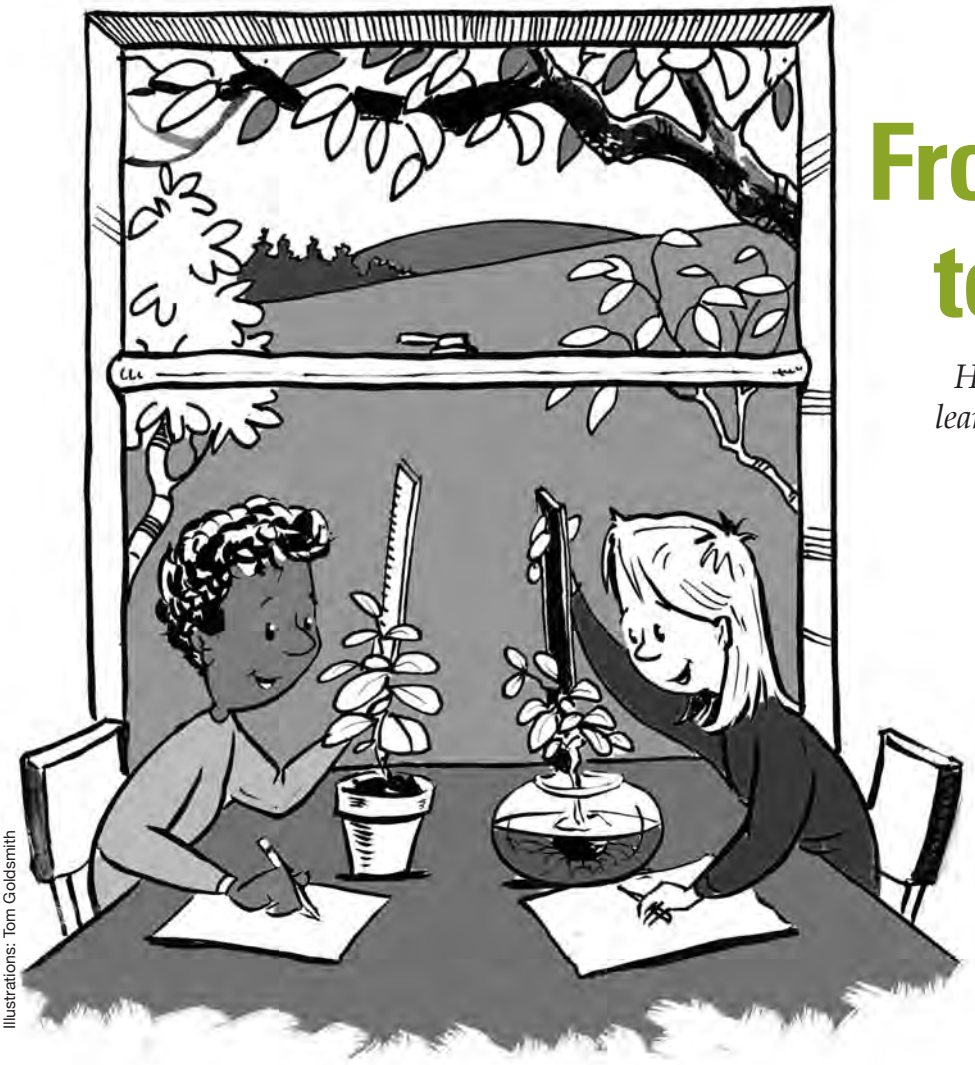

Illustrations: Tom Goldsmith

From Stems to STEM

Helping young children learn about plants through engineering design

By **Lauren Madden** and **Courtney McGovern**

WHEN ENVIRONMENTAL science education starts in the early childhood years, it can help us to grow "green" children, who will naturally mature into "green" adults and citizens. In the early years, the best type of learning occurs when students have a chance to explore how the natural world around them works. Yet, children are always ever curious about the human-designed world as well. Providing children with opportunities to also consider the mechanisms we use to invent and affect our future opens doors to the world of engineering design. Inquiry and design work hand-in-hand to explain how our environment works alongside the role humans play—for good or for bad. In this circumstance we will use the process to reveal ways in which humans can act as problem-solvers in our ecosystem.

Plant growth and development is a common environmental science topic in the second grade. Understanding the processes that plants use to survive and thrive is essential for understanding the role they play in ecosystems. Though many early elementary curricula include some study of plants and ecosystem dynamics, most stop short of including the ways in which humans participate in these processes. While large-scale environmental issues such as deforestation and eutrophication are sometimes covered in plant units at later years, the use of human-designed systems to enhance plant growth, maximize space, and solve the problems related to food deserts are rarely addressed. In line with the need to approach our teaching and learning with hopefulness and as an opportunity for growth and change, the design process can help us to re-frame the roles of humans in ecosystems as builders and creators rather than destroyers of the earth.

The engineering design process includes the following steps: identify the problem, research, develop possible solutions, choose the best solution, create a prototype, test and evaluate, and redesign. The process is continuous – and repetitive – in order to ensure the best possible outcome. It is crucial to introduce this thinking process at the early childhood stages to encourage all students to understand environmental systems and issues, and to be able to create and design solutions. In the following, we present a series of lessons that integrate the engineering design process into the life sciences.

The following lessons explore the ideas presented in the Next Generation Science Standards for early childhood education related to the interdependent relationships in ecosystems and engineering design. This instructional unit is intended to be used with students who have already been exposed to the basics of the plant life cycle. It begins with an exploration of pollination, and an opportunity for students

to create a model flower using the design process. Next, the students will investigate which factors are necessary for plant growth, namely water and sunlight. Finally, the students will create a hydroponic gardening system to explore whether plants need soil for growth, and then research how these systems can be used to address environmental issues.

Pollination

This lesson is a guided exploration of the engineering design process and includes both whole class and small group work. Begin by showing a video such as Disney's *"The Beauty of Pollination"*.[1] Then ask your students if they could tell what was happening in the video. Since the students are young, they probably have little prior knowledge about pollination. Tell the class only that it was a video about pollination without explaining what pollination is.

1. Display a large picture of a flower in the front of the classroom with labels that can be stuck to the picture. Give each student a handout of the same picture but leave blank spaces for them to write in, instead of labels. Review the parts of the flower with your students, when the students discover a new part, have a volunteer go up to the picture at the front of the room and put the correct label on it. As the student puts the label on, the other students can write down the part on their own handout. This represents the "Identify the Problem" phase of the Engineering Design process.
2. Ask for volunteers to use puppets/props at the front of the classroom to act out the pollination process. Read a story about pollination, such as Gail Gibbons' *The Honeymakers*.[2] As you read it, the student puppeteers are to act out what was said. The story represents the "Research" phase of the design process.
3. Have students break into groups to brainstorm different pollinators.
4. Using the remaining three phases of the design process, each group will create their own flower and choose how it is going to be pollinated.
5. Each group will present their flower to the class.
6. Conclude with a brief review of the plant life cycle to connect the idea of pollination to seed and plant growth.

Investigating Plants

This lesson is a scientific-guided inquiry that allows students to explore needs of plants. Students will work in three groups to pot in soil the exact same type of plant. One plant for each group. The students in each group will have various jobs that change every day; one student for example will be responsible for watering the group's plants.

1. One plant will sit in the sunlight and should be given water regularly.
2. The second plant will be placed in a dark area of the room where there is no sunlight, such as a closet, and given water.
3. The third plant will be placed in the sunlight, but will not receive any water.
4. Students should make daily journal entries recording what they notice about the three plants. Have them record things such as color, size, growth, etc. Students should also measure their plants with a ruler.
5. Once a week have students briefly share what they have observed.
6. After three to four weeks, students and the teacher will discuss what they noticed over the course of the observation. Students should be able to determine that plants need both water and sunlight in order to grow.

Hydroponic Gardens

This lesson returns to the engineering design process and allows students to build off of their prior knowledge and experiences. Begin the lesson by asking the class if it is necessary to use soil in order for plants to grow. Record the number of students who think it is necessary and the number of students

Next Generation Science Standards

K-2 Engineering Design

- **K-2 ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of new or improved object or tool.
- **K-2 ETS1-2.** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- **K-2 ETS1-3.** Analyze data from test of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Interdependent Relationships in Ecosystems

- **2-LS2-1.** Plan and conduct an investigation to determine if plants need sunlight and water to grow.
- **2-LS2-2.** Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

who do not. Ask the students, who do not think soil is necessary, why they think that and how that could be possible.

1. Split the class up into groups of three. The class will go to the computer lab to conduct research, where they will find the answers to the following questions when they are researching:
   - Can plants grow without soil?
   - If a plant does not need soil, what does it need?
   - What is a hydroponic garden?
   - What materials are needed to create a hydroponic garden?
2. Ask your students to share their results and write their ideas on the chalkboard. Explain what a hydroponic garden is if the students haven't provided a comprehensive answer and then ask the class to share what materials they might need in order to create a hydroponic garden. Tell the class that they are going to create a class hydroponic garden and have the students discuss some of the problems they might encounter.
3. In the same research groups, students will begin sketching ideas for a hydroponic garden. Ask them to discuss all of the ideas and decide on the best sketch for the group. The group will then present their best idea to the class and explain why they think it is the best idea. Choose the best design from amongst all the groups and have the class make it.
4. The class will all sketch the final design. Ask each student to write down what makes it the best design. Have them collectively decide which materials are necessary to create the hydroponic garden.
5. With the help of your class, set up the hydroponic garden (supplies should run approximately $50). The class will keep a journal of the garden, including the steps of how it was built. After the garden is built, students will reflect if anything was changed during the building of the garden that was not in the original plans. Make decisions about spacing of seeds early and plant the seeds as a whole class. Lettuce and other leafy green vegetables are a good choice because they grow quickly from seed, and can be eaten. Have students record in their journal every four days, such things as plant size, colors, and pictures. They should use rulers to measure plant height. If a student has a camera, he or she can take photographs of the plant's growth. Otherwise, students will draw their observations in his/her notebook.
6. Over the course of the activity, the teacher will lead students on webquests[3] and library research trips to investigate the following question: How do hydroponic systems help people to solve problems?

Closure: After about five weeks, students will record one last observation of the plants in the garden. Have a class discussion of what was done well with the garden and what could have been done to improve on it. Have students take some time to sketch a redesign of the garden. Students will explain why they made certain changes and why it is better than the original.

All too often, the role of humans in earth's ecosystems is viewed only from the negative perspective. Yet, time and time again, we learn that when children are raised to "think green" they make choices that promote strong and healthy environments. By incorporating engineering design into a simple unit on plant growth, students are able to see the role of humans as problem-solvers and innovators, rather than ecosystem destroyers. It also encourages students to explore challenging questions and consider different perspectives, while exploring the familiar topic of plants and their role in ecosystems. All in all, adding an engineering design perspective to this topic allows us to paint an optimistic picture of our future environment.

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Endnotes

1. Disney's *The Beauty of Pollination*, http://video.disney.com/watch/the-beauty-of-pollination-wings-of-life-4da84833e06fd54fff590f49

2. Gibbons, Gail. (2000). *The Honey Makers*. Turtleback Books.

3. An example hydroponics webquest http://azteacher.net/past_students/mickelson/webquest4.htm