When learning about plants, elementary students are typically given set directions on how to plant seeds and make their plants grow. To enable our class of first-grade students to build their own knowledge and encourage constructivism, we decided to take this set of prescribed activities and make them more inquiry-based. In traditional “cookbook” experiments, students are told the outcome of an experiment and are expected to follow directions that do little more than confirm the outcome. Inquiry science ranges from limited inquiry, in which teachers provide much of the direction, to open inquiry in which students design experiments around their own questions (Banchi and Bell 2008).
Cookbook activities are a good point from which to develop inquiry lessons. You can move your class from limited inquiry through the continuum to open inquiry by altering the lessons to give increasingly more control to students. We believe that by allowing students to create their own knowledge, they will have a better understanding of plants and science inquiry. Within a given lesson, some aspects may need to be teacher directed, whereas other areas can be controlled by the students—it largely depends on the purpose of the activity. In our case, the goal was to meet the standards regarding the needs and life cycles of plants. We used limited inquiry when planting the seeds because we wanted to be sure all students had plants, but once the seeds had germinated, we used less structured inquiry to allow students to take control of the plants’ growth by determining factors such as how much sunlight, water, and space they would provide. We taught this lesson over the course of several weeks, one day per week for about an hour each day; it could be broken down into smaller increments if necessary. In addition, extensions and some assessments were done on different days.

**Day 1: Stir Up Interest**

To promote interest in plants, we read a silly book that had a speck of factual information: *Elizabite: Adventures of a Carnivorous Plant* (Rey 1942). The students found the book about the adventures of a carnivorous plant funny and it definitely worked to stir up interest in plants. We talked about what was true and false in the story, including that some plants capture and break down insects for nutrients. Next, we asked the students why it is important to learn about plants. Most of the children knew at least one way in which plants are important; answers ranged from plants being pretty to plants giving us food and medicine.

We then used a KWL chart to preassess what students knew about plants. Although some of the children were aware of things such as plants providing us with oxygen, others knew little. We told the class we would add to the chart as we learned more over the next few weeks. We then began another column—What do you want to know about plants?—that yielded some interesting questions, such as “What is the difference between a plant and a weed?”

Using a KWL chart not only worked well as a preassessment, it also enabled us to note student misconceptions and further acted as a catalyst for introducing information we planned to present. For example, one student stated that plants come from seeds, a perfect opener for the start of the unit—seeds.

In a cookbook lesson, children are often shown the parts of seeds and given the proper terminology. Using open inquiry, our students investigated the characteristics of seeds, using lima beans (we used frozen lima beans that had thawed overnight) as an example. We gave each student a lima bean and a magnifying lens and asked them to use their observational skills to explore their seed. Students could ask for materials if they needed anything. Not surprisingly, some students squashed their seeds to see what happened, so we made sure we had extra seeds available. Some students added water, others cut theirs using a plastic knife. One child asked about the thin covering of the seed, which prompted others to also examine that feature. We took a break after some exploring to see what the class had discovered. One student asked whether the covering was there to protect the seed. We told the class that yes, protection is one function of this structure. We then asked the class what we do to protect ourselves from things like cold temperatures, and when a student answered “wear a coat,” we responded, “This is the seed coat.” Magical! (Protection in general, not protection from cold, is the function of the seed coat.) After more sharing, the students conducted further explorations of their seed. A student observed the “baby plant” inside. This stirred much interest, so we cut the seeds open for everyone to see the embryonic leaves and stem. They also recognized that there was food in there for that “baby plant.” After the class finished exploring the seeds and we discussed their observations, we showed the students a diagram illustrating the parts of a plant seed and described the functions of the parts, including the seed coat, embryo, and cotyledon.

We finished the lesson with an assessment. Students answered the following: “What is a seed?” and “What are the parts of a seed?”

**Day 2: What Plants Need**

After a quick review, we asked the class again to think about what plants need. We knew that we could not provide enough support to have the whole class plant seeds at the same time, so we set up three stations and divided the class into three groups.

At the first station, students were given magnifying lenses to observe different types of seeds, including sunflower seeds, peanuts, apple seeds, and lettuce seeds. (Be sure to check for peanut allergies before bringing peanuts into the classroom, and remind students that we never eat in science class.) Students looked for the embryo and cotyledons.

At the second station, students were given a lima bean and worksheet. We asked them to label the cotyledon and embryo and describe what each does (Figure 1, p. 42).

At the third station, students planted their seeds. In a cookbook lab, students are instructed to take their seeds, plant them at a particular depth, and water them in a particular way. With this unit, our intent was for the children to build their own knowledge about the needs of plants. We wanted the students to experience planting their own seeds, but we needed the plants to germinate, so we used a
more directed approach for this part. We used radish seeds because they germinate and grow quickly. We explained to the children that we would be experimenting on these plants, and when you experiment, you can only change one variable.

First, students filled their pots about 3/4 of the way with soil and labeled them with their names. Then we asked the students what else the plants need. After answering water, students misted their soil with a water bottle until their soil was damp. The amount was not measured at this point. Then, students selected how many seeds they would plant, between 3 and 10. The control pot (planted by the teacher in the same way as students planted theirs) had four seeds, so if they chose more than four, this was their only variable. Then they pushed down their seeds and watered some more. This was a big day that actually went a lot more smoothly than we had anticipated. Having two people and enough spray bottles so that students could have their own was a big help. We told students to record whether they had planted more than four seeds; however, next time we will have them record on the pot the number of seeds planted to make it easier.

**Day 3: The Plants Emerge!**

Within a week, the plants had germinated and the students were excited! We pulled one of our plants out of the soil and asked students to identify the parts. “What’s next for the little plant?” we asked. Students responded that it would grow. Then we asked the children what would happen after that. One student answered that the plant will produce a flower, another that it would make a radish. Using guiding questions, the students recognized that the plant would eventually produce seeds. This provided a good review of the life cycle of a plant.

Now that the seeds had germinated, it was time for students to experiment with their plants. They were each given a chart to record their variable and the growth of the plant (see NSTA Connection). We reminded the children that they could only have one variable in an experiment.

Students who had planted less than four seeds could select to give their plant a 1/2 cup of water and introduce a variable by selecting to put it in the sunshine or shade. Alternatively, we let the students use water quantity as a variable by allowing them to select either 1/2 or 1/4 cup of water (to ensure that they were testing only one variable, if students selected 1/4 cup, the plant had to go in the sunshine). This is unlike a cookbook lab, in which children are told how much water and sunlight to provide. The intent here was for the students to test the different amounts of things the plant needs, to learn that plants need just the right amount of each. We showed the children how to measure the height of their plants and fill in the chart. They would complete the chart over the next few weeks. The students needed a lot of guidance with this. To speed things up, once a student was proficient, he or she helped the others. Then the children put their plants outside, either in a sunny or shady spot depending on the water quantity and number of plants they had selected.

Unfortunately, a few days after this, we had a terrible rainstorm and the plants were decimated. This led to a teachable moment though—too much water is not good for some plants!

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Assessments for this part of the lesson included ordering pictures of plants at different life stages and labeling the parts of a plant.

**Day 4: Starting Over**

To make up for the lost plants, we used vinca plants, an annual flower that grows quickly. We did not use radish seeds again because we did not have time to wait for the seeds to germinate. We planted the vinca using the student charts so their variables were kept intact. For example, if a student had planted a large number of seeds, we used five plants in a pot, and for the other pots, we used two plants. Students made new measurements, placed them in the same area they had before (sun or shade), and continued watering as before (using 1/2 or 1/4 cup), charting their plants’ progress as they measured them every other day.

After two weeks, we looked at the results as a class. In a cookbook lab, the teacher would tell the students why the plants were or were not doing well, but before we could even ask about the plants, our students took control of their learning. For example, one child had about 5 plants in his pot, and his plants were not only shorter than those of the other students, they were not doing well. It was obvious to the class that he had too many plants in his pot; indeed, someone said there was not enough space. We asked the class: “If they don’t have enough space, what might the plants not get enough of?” Students answered “light,” “water,” and “nutrients”—always going back to what plants need ... and the right amounts! The children then subtracted their start and finish data to see how much their plants grew, and we graphed that information. Once it was graphed, we asked students what they saw in the data. Students noted some plants grew really well, others not so well. Students looked at the variables chosen. In doing this, students discovered the needs of vinca plants—lots of sunlight and water and less than five in a pot. We were afraid that some students might feel bad about the lack of growth in their plants, so we asked the students to think of other plants, like a cactus. “Would a cactus do as well with that much water?” “What about ferns that grow in the shade. Would they like a lot of sunlight?” This brought us to our standard: Plants need the right amounts of air, water, space, nutrients, and light. As an assessment to this part, we asked the students to answer the question: “What do plants need to grow?”

Throughout the lesson we went back to our KWL charts, and added information to each. We answered the “What do you want to know?” questions throughout the unit. When possible, we answered questions by observation. For example, to answer the question “what is the difference between a weed and a plant?” we went outside where we found what we all agreed was a weed, and then pulled it from the ground, roots and all. Then we pulled what we agreed was a plant, and asked the students what they saw as the difference. They could not find any differences, so in a great “aha” moment, they realized they were the same! For the more factual questions, such as “what is the biggest plant?” we used the internet; it would have been great if the questions spurred other investigations, so we could include more open inquiry, but that was not the case. In the future, we could spend more time having students adapt their questions to create investigable ones.

Children can learn through inquiry at a young age, and it is important to allow children the opportunity to explore their own ideas as much as possible at this early age when they are so curious about the world around them. Our class learned not only about the needs of plants but also how variables work. Students were able to construct their own knowledge and were engaged throughout the unit—as a result, they learned more.

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**References**


**Connecting to the Standards**

This article relates to the following *National Science Education Standards* (NRC 1996):

**Content Standards**

**Grades K–4**

**Standard A: Science as Inquiry**

- Understanding about scientific inquiry
- Abilities necessary to do scientific inquiry

**Standard C: Life Science**

- Characteristics of organisms
- Life cycles of organisms
- Organisms and environments