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Growing Minds: Planting a Lasting Seed Using the Learning Cycle

Jennifer Nicole Prindle
Iowa State University

Lori Marie Ihrig
Iowa State University

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PLANTING A LASTING SEED USING THE LEARNING CYCLE

Jennifer Nicole Prindle, Iowa State University
Lori Marie Ihrig, Iowa State University

ABSTRACT: This article highlights modifying a common early elementary activity to move instruction beyond isolated activities into a full unit of instruction using the learning cycle. The unit is designed to tackle students' misconceptions and deepen their understanding of scientific inquiry and the growing requirements of plants. *This activity promotes National Science Education Standards A and C, and Iowa Teaching Standards 1, 2, 3, 4, and 5.*

It's Not Easy Being Green

What plants need to grow is part of both the *Iowa Core Curriculum* and the *National Science Education Standards* (NRC, 1996). Students at all levels often mistakenly think that plants require soil and food to grow (AAAS, 2009). Although early elementary science instruction addresses what plants actually require for their growth, traditional instruction generally ignores students' misconceptions, has students complete activities where they merely follow directions, and assesses students primarily through recall questions. What follows is an activity, designed for early elementary students, that is far more mentally engaging than what is traditionally found in elementary science education.

The Original Activity – A Seed with No Support to Sprout

In the original cookbook activity found in Figure 1, students simply follow directions and draw a conclusion about how light and water affect plant growth. While this experience is superior to simply being told or reading about the impact of light and water, it does not:

- take into account misconceptions and other ideas students may hold about what is necessary for plants to grow, or
- require students to make decisions they can and should make.

Thus, we modified this activity so that it more deeply addresses science content, fosters inquiry, and promotes problem solving, critical thinking, social skills, and creativity. These and other goals that we have for our students, state and national science education standards, how people learn (Bransford, Brown & Cocking, 2000), and pedagogical research guided the revisions presented below.

Exploration Phase – Digging for Students' Thinking

To prepare students for investigating the growth needs of plants, we first take students outside to observe plants. We do this to establish a concrete experience from which to work, promote detailed observation, and teach students about the importance of recording observations. Early in the school year we have students go outside with whatever materials they think to bring with them, which may be nothing. We provide students a brief period of time for making observations of plants before returning to the classroom.

Once inside we have students divide into small groups. We ask students to discuss the following question with each other and write responses to small whiteboards,

- “What did you notice about the plants you observed?”

We then come together as a class and record student observations on the classroom whiteboard. To elicit all students' ideas, we use wait-time (Rowe, 1986), exhibit encouraging non-verbal behaviors, and write students ideas on the board using their descriptor words. Using students' descriptors without paraphrasing or adding to what they said is important for conveying that their ideas matter and for ensuring you begin building from students' zone of proximal development (Vygotsky, 1986). These teacher behaviors are important at all times in class discussions. To encourage students to quickly share ideas, we use a host of positive nonverbal techniques: leaning forward, counting student ideas on fingers, raising eyebrows, and smiling. If sharing slows and unshared ideas are still on their whiteboards, we ask,

- “What else do you have on your whiteboards?”

This combination of verbal and nonverbal teacher behaviors conveys to students we have important things to accomplish during class and they should not hesitate when sharing. Pushing students to share all ideas also expresses that minimal effort is unacceptable. These teacher behaviors are important at all times in class discussions.

Once students' ideas are exhausted, we question students about the details of their observations. Eventually, students will respond with “I don't remember.” We take this opportunity to ask,

- "What could we do while making observations to better remember what we observed?"
- "What materials could we take with us to help us remember our observations?"

When students explain what materials they need, they are meeting our goals of problem solving and thinking critically. Importantly, they also learn that they must think about what they need and take appropriate action. This may appear trivial, but one reason older students make childish mistakes is that when they were children, they were always told what to do rather than engaged in thinking that would effectively teach them important decision-making skills. Later in the year before going outside, we may simply ask, “What should we be thinking about before we go outside to make observations?”

FIGURE 1

Directions from the Original Activity

Materials:
4 plants
Pencil
Paper

Steps:
1. Label plants 1, 2, 3, and 4.
2. Place 1 and 2 in sunlight.
3. Place 3 and 4 in darkness.
4. Water 1 and 3. Do not water 2 and 4.
5. Observe each day for 2 weeks.
6. Record observations on a chart.

Questions:
1. What is the difference between plants 1 and 3?
2. What is the difference between plants 2 and 4?

Application:
1. What would help plants 2, 3, and 4 grow better?
2. What is necessary for plants to grow?
3. What would happen if plants had light and water but no air?

During our first visit outdoors, students typically only *looked* at plants. So before going outside again, we ask students,

- "What senses did you use in making observations of the plants?"
- "What other senses could we use?"
- "How can you use those senses when observing plants?"
- "What is the value of using our other senses in making observations?"
- "How will we keep track of our observations?"

Students will usually suggest taste, but even if they don't, we ask,

- “What might be some problems with using the sense of taste to observe plants?”

Students often state the plant could taste yucky or make them sick. At this point, to ensure students' safety, we explain that they cannot use their sense of taste and we confirm the location they are visiting is free of plants that are unsafe to handle (e.g., poison ivy).

When we go back outdoors, students observe in groups of two so all students are actively involved in observing and recording and have someone to talk with about their observations. Back in the classroom, we ask students,

- “What can we add to our existing list on the board?”

After a while, we may have a student come to the board and write while we walk around the room to see if students still have written observations they have not shared. If so, we have students look at the ideas in their notebooks and elicit more responses from the group. Then, we return to the notion of using multiple senses to get students to deeply consider the benefits of extending their observations beyond their sense of sight. We also return to the benefits of recording our observations by asking,

- "What are the advantages to using all of our senses when collecting data?"
- "What do you notice about this list of observations compared to the list of observations when we didn't keep careful records?"

We then tell students that careful observations and record keeping are both important for many things in life, science, and the investigation they will conduct in the coming days. We ask paired students to first write what they think plants need to grow. When students complete this task, we compile a class list of their ideas on a large construction paper flower that we have placed on a classroom wall with each petal displaying a unique idea. Figure 2 displays common student responses, but have plenty of petals for a plethora of student ideas. Because we know students mean many things when they say the word “food,” we ask, “What do you mean by food?” Instead of writing food on a petal, we place each student idea for the word food on individual petals.

As the unit progresses and students conduct investigations to test each idea, they determine the veracity of several of their ideas. Ideas that students find are not essential for plant growth are then depicted as fallen petals. This graphic word wall creates a concrete representation of students' thinking. Students see their misconceptions fall from the flower as a reminder that they are letting go of some ideas, while others are being supported, reinforced, and remain intact on the plant.

After students throw out ideas, students also write individual predictions of what a plant needs to grow in their science notebooks. Questions to guide their predictions include,

- “Why do you think (soil, water, light, etc.) is necessary for a plant to grow?”
- “Why do you think the plant will or will not grow?”
- “What experiences led you to your prediction(s)?”
- “How do those experiences relate to all plants?”

These prompts help determine misconceptions and the depth of student experiences supporting them, informing what we need to take into account to promote conceptual change.

To promote student thinking about how to investigate their ideas, we distribute small plastic bags with sprouting lima beans wrapped in wet paper towels. To prepare sprouted lima beans, purchase dried lima beans from a grocery store. Then, simply place the seeds between wet paper towels in a large sealable plastic bag. Remoisten the paper towels, as needed, and in 2–3 days the seeds will sprout. Before having students observe the beans we first ask,

- “How should these beans be handled in a safe manner?”

As a class we share and discuss these safety considerations. Once the safe handling of seeds has been discussed, students are then directed to observe their lima beans and record their observations to their dry erase boards.

FIGURE 2
Sample construction paper flower for student responses.

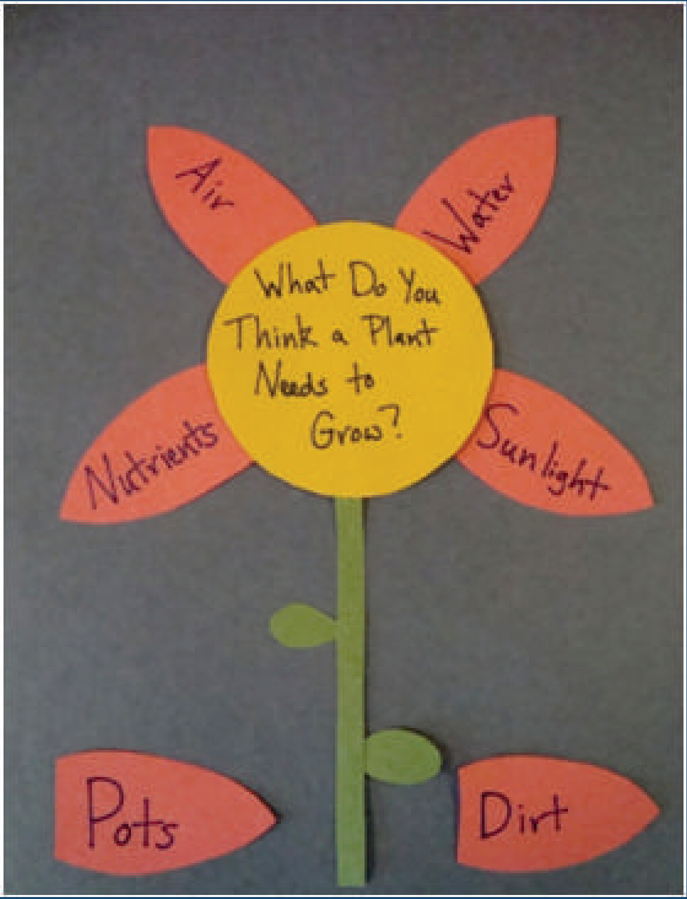

Photo by Jennifer Prindle

As students observe the sprouted lima beans we circulate around the room to listen in on student observations and ask clarifying questions. We might ask,

- “How does this sprouted bean change your thinking about what plants need to grow?”

Need help growing lima bean sprouts?

We recommend the instructions at http://www.ehow.com/how_2060670_grow-seeds-indoors-soil.html

When students claim that they no longer think dirt/soil is necessary, we ask,

- “How can we find out if other plants will sprout without dirt?”

Exploring the role of dirt is a good place to start because students typically think dirt is necessary as plant food. If students believe they know plants do not need dirt to grow because the lima beans did not need dirt to sprout, we ask,

- “How might a plant sprouting in dirt compare to a plant sprouting without dirt?”

To encourage students to start designing investigations we ask,

- “What could we do to test our ideas about dirt and plants?”

We have students work in pairs to draw or write their procedures on individual whiteboards. As students work, we move amongst the students listening to what they say and observing what they write. Our interaction is primarily directed at understanding their thinking and seeking elaboration of ideas and what they place on their whiteboards.

After creating procedures, students present their plans to peers. Following each presentation, we prompt,

- “What questions, concerns, or comments do you have for this group about their plans?”

If students are reluctant to share, we use the think-pair-share strategy, asking students to talk with their partner to come up with one question, concern, or comment to share with the group. Providing opportunities for student questioning and discussion meets our goals of social development and critical thinking. Sharing is also a great opportunity to explicitly address the collaborative nature of science. After all have shared their ideas, we ask the class to consider what most all proposed procedures have in common, and then have students link the common procedure to how it will help answer the questions about the role of soil in plant growth.

Once students have shared their ideas, we ask students to consider how many seeds they should plant, the necessity of materials requested, and how to,

- use materials properly and safely,
- transfer materials, and
- clean up work areas and themselves.

We address these topics through questioning because students' answers let us know their ideas and understanding. When necessary we scaffold with further questioning to desired ends. For example, if students say we should plant 10 seeds, we might ask,

- “Why would we need ten seeds?"
- "How might using fewer seeds be beneficial?"
- "Why should we not just use one seed?”

Following peer review and safety discussions, students revise their procedures. We encourage students to revisit the predictions they made in their science notebooks based upon ideas shared by their classmates. To ensure safety, all procedures are teacher approved. An example of a student generated procedure and questions we might ask to help groups refine their procedures is provided in the Text Box on the next page.

Because students have seen the lima bean sprouts in the paper towels, they often generate procedures based on using paper towels to keep the seeds moist. Some students may even suggest simply placing the seeds in water. This may work depending on the seeds. However, we encourage at least one group to use moist paper towels bunched up in a cup with the seed making contact with the moist paper towels. If students do not mention putting the seeds in sunlight or providing daily water, we ask questions such as,

- "We are testing if soil is necessary, what other things will we want to make sure the seeds have plenty of?"
- "If we put our seeds in moist paper towels and leave them in the dark, why might they not grow?"

Sometimes students will use these questions to propose a multidimensional experiment. That is, they will suggest setting up two plantings: one to keep the daylight and one to keep in the dark.

After students set up investigations, they make initial observations. To encourage more accurate record keeping we ask,

- “How will we remember our setup?"
- "How will we remember what the seeds look like each day?”

To encourage young students to use a combination of pictures and words to record thoughts, we ask,

- “How is using both pictures and words in our notes helpful?”
- “What would be the problem with using only one or the other?”

TEXT BOX 1
Example of Teacher Guidance to Refine Student Strategies

Often, students will initially suggest growing seeds in small plastic bags and comparing those to seeds grown in flowerpots with potting soil. Students often don't realize how a pot hinders their observations. Through the process of presenting their ideas to their peers, the appropriateness of this procedure is generally questioned by a group of students. If not, we ask,

- *“What might be a problem with comparing seeds grown in small plastic bags to seeds grown in flower pots?”*

We may follow this question with,

- *“How will you know if the seeds grew differently because of the soil or the flower pot?”*

This type of questioning generally leads students to designing investigations where they are comparing seeds inside of plastic bags with wet paper towels. One set up has potting soil inside of the paper towel while the other set up does not. At other times, students design investigations where they use plastic containers (e.g. disposable cups) for each set up – one with potting soil and the other with wet paper towels.

We work together at the large classroom whiteboard to create category titles and decide what observations to include in each category. This discussion is spurred by the question

- “What title should we put above our observations from yesterday?”

As the first student suggests a title, we write it verbatim on the board. Often, students will begin to suggest edits to the initial title. We record students' edits exactly as they are stated. If students do not suggest and debate edits, then we ask,

- “What title should we put above today's observations?”

To create informative, precise titles based on students' suggestions, we ask,

- "How can I tell yesterday's observations from today's?"
- "How will we remember which observations are of our beans versus other plants?"

As the school year continues, we move toward asking students how we should record our observations and ideas, and then ask students to provide a rationale for their ideas. This, in time, results in students who make appropriate decisions and understand what makes them appropriate.

Once investigations are running, students then begin designing tests for other particular variables from the construction paper flower petals. For each variable, we follow a similar process as above. The process goes much more quickly because students' understanding of needed decision-making and rationales is much greater.

Concept Development Phase – Planting the Seed of Understanding

Once students have collected enough data so that consensus might be reached as to the importance of most variables, we identify basic needs of plants by holding a scientific conference. The conference addresses each investigation of a particular variable one at a time. For example, students create and present a poster for their soil investigation. After all groups present, we draw out the similarities, differences, and the basic needs of plants by asking,

- "What did you observe was the impact of [insert the tested variable]?"
- "How can you explain any differences between the results of different groups?"
- "Based on everyone's investigations, what can we conclude about [insert the tested variable] as a basic need for plants?"

These questions move students to identify that plants need water, sunlight, and air to grow. Students experience plants growing when these needs are met, but if any of these three needs are not met, the plants do not grow. To summarize our learning we revisit our construction paper flower. We ask students to explain why certain petals remain and others have fallen to the ground.

Students just experienced plants growing when these needs are met, but they often still experience cognitive dissonance as they wonder, “What about food?” The issue now becomes, if plants do not need soil, why do they grow in soil and why do we plant crops in soil? In other words, if plants do not need soil, what is the role of soil?

It is crucial that the concept development phase does not end until students have wrestled with these questions. You may need to share and discuss additional examples and support materials, such as readings, to link to what students have just experienced to accurate scientific ideas. Students will come back to the notion that there is food in soil; they may even employ some sophisticated vocabulary and say that plants get *nutrients* from soil, when they are really still thinking about “food.”

We address this student idea and conclude by stating plants actually make their own food and do so in an interesting, complex process they will learn about in future science classes. We stop at that point because photosynthesis is too abstract of a concept for students who are pre-operational-to-concrete thinkers.

Application Phase – Watching Students' Thinking Grow

To apply what they have learned and as a form of assessment we have students design a greenhouse and explain how the greenhouse meets the basic needs of plants. Students draw a picture of the basic needs for a plant to grow and explain why they chose each item. Drawing allows students to show what they know despite possibly not being proficient in written English.

This approach meets Iowa Teaching Standard 4, and it also helps students understand that text is not the only way to communicate. This assignment requires students to apply a deep, robust understanding of science content and effectively communicate their understanding.

The Teacher's Role – Keep 'em Thriving

The teacher's role is crucial to creating student experiences and concept development that reflect how students learn, challenge misconceptions, promote classroom goals, encourage deep conceptual understanding of key science ideas, and address national and state standards. However, as Clough and Kruse (2010) state, the difficulty of letting go of time-honored pedagogical practices makes teaching as, and through, inquiry difficult for many teachers.

Effectively teaching science requires that teachers understand students' thinking and asking questions that effectively bridge from those ideas to desired ends. Simply telling students how to set up investigations and what acceptable answers are is far easier, but overwhelming research makes clear these time-honored approaches are largely ineffective. What this means is that how teachers interact with students really *does* matter!

Teaching science through inquiry is more mentally demanding of students, and that is why they learn more from the approach when teachers effectively scaffold to desired ends. Teaching science is also more mentally demanding of teachers, but the reward of seeing students' interest and understanding blossom is well worth the effort.

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***Jennifer Nicole Prindle** is an undergraduate in Elementary Education at Iowa State University working toward a K-8 Science Endorsement. She has a bachelor's degree in Health Promotion and Fitness Management which is being used in her coaching of freshman cheerleading at Ankeny High School in Ankeny, Iowa. Contact Jennifer at jprindle@iastate.edu.*

***Lori Marie Ihrig** is a doctoral student in Curriculum and Instruction at Iowa State University. She previously taught for seven years in the Williamsburg Community School District in Williamsburg, Iowa. Lori has another article published in the Iowa Science Teachers Journal on the topic of leading a biological investigation using living aquatic invertebrates. Contact Lori at lihrig@iastate.edu.*