Productive Questions:

Tools for Supporting Constructivist Learning

By Mary Lee Martens

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PRODUCTIVE QUESTIONS, those leading to either physical or mental activity, are not new. Jos Eltgeest (1985) proposed them more than 13 years ago, but their usefulness is still being discovered. Teachers struggling to embrace a constructivist approach to teaching often find themselves stuck when students fail to make connections necessary to arrive at a desired understanding. They are tempted to resort back to dispensing information in the form of hints and/or to reject constructivism outright. Productive questions provide an alternative that, with practice, gives teachers a way out of this dilemma.

Productive Questions

Many questions formulated by teachers have aked students to remember or revisit things that they supposedly learned. Students' ability to do this counted as success. Productive questions, however, have a different goal.

Productive questions purport to take a student *forward* in his or her thinking; they enable a teacher to provide scaffolding for students beginning to build their own understandings. The six types of questions—attention-focusing, measuring and counting, comparison, action, problem-posing, and reasoning (see sidebar, next page)—allow a teacher to meet students where they are and provide the kind of support needed at any given moment. These questions are not intended to be asked in any particular order, but rather to be responses to what the teacher hears and sees happening. The teacher's role becomes more of a monitor and facilitator as students become more actively involved and responsible for their own learning.

Productive questions enable teachers to create a bridge between activities and students.

If strategically asked, productive questions keep students motivated and fruitful in their efforts. Interestingly, it is not only teachers who can contribute to this, students working successfully in groups can often be overheard asking their own productive questions.

Learning About Buoyancy

"Can you find a way to make this clay float?" This was my introduction to a unit on buoyancy that I was sharing with students in a college-level elementary methods class. In terms of understanding this concept, these preservice teachers were remarkably similar to elementary school children. My students did exactly what I have seen many elementary children do. They flattened the clay expecting their "rafts" to float. When this didn't work, they proceeded to make the clay thinner and/or smaller and quickly became discouraged at their lack of success. I noticed folded arms and general disengagement. Elementary school children having this same problem begin to misbehave, get off task, make comments that this activity is silly or stupid, and often show uncooperative behavior. The challenge for me as a teacher was to help students access stored information from their memories in order for them to move forward and successfully meet this challenge.

"What have you noticed that floats?" I asked. Some students began to brainstorm, "boats, tubes, balls ...," while others quietly picked up the clay and began reshaping it. I had just asked an attention-focusing question, and for many students, this was all that was needed. Students who still didn't see how to proceed needed an additional prompt in the form of a comparison question, "How are all these floating objects similar?"

By this time, all of my students had reshaped the clay into some kind of boat or cup-shaped structure and were feeling quite successful. I then challenged them to find a way to support the greatest amount of "cargo." (I used small ceramic tiles for this purpose but any small, uniform items would do.) The students had three trials, and the goal was to improve their design after each attempt.

I noticed that some groups shared

Productive Questions

Attention-focusing questions help students fix their attention on significant details.
Have you seen ... ? What have you noticed about ... ? What are they doing? How does it feel/smell/look?

Measuring and counting questions help students become more precise about their observations.
How many ... ? How often ... ? How long ... ? How much ... ?

Comparison questions help students analyze and classify.
How are these the same or different? How do they go together?

Action questions encourage students to explore the properties of unfamiliar materials, living or nonliving, and of small events taking place or to make predictions about phenomena.
What happens if... ? What would happen if... ? What if ... ?

Problem-posing questions help students plan and implement solutions to problems.
Can you find a way to ... ? Can you figure out how to ... ?

Reasoning questions help students think about experiences and construct ideas that make sense to them.
Why do you think ... ? What is your reason for ... ? Can you invent a rule for ...?

observations (attention focusing) and exchanged ideas about what shape would hold the greatest mass (comparison and/or action questions), while others repeated the same solution taking time only to patch holes and repair minor damage to their sunken vessels. The former groups stayed engaged (in fact, it was hard to get them to stop), while the latter groups lost interest after their second trial and did not even seem interested in trying a third time. I found that when I interjected an attention-focusing question, "What are you noticing about the way you put the tiles in?" or an action question, "What happens if you build higher sides?", the lagging groups became interested and engaged again.

Thus far, I had used different kinds of questions in response to what students were saying and doing. I asked more challenging action questions to those students who seemed ready to go further in their thinking and posed attention-focusing questions to those students who needed help in activating pieces needed to solve the problem successfully.

I deliberately stayed away from reasoning questions. Asking "Why do you think?" prematurely would only cause my students to shut down. They weren't ready to think about *why* when they were still coming to understand that changing the shape of the clay changed its properties. However, they *were* gaining in understanding; their success in building boats and then improving the capacity of their creations was clear evidence that this was true.

At the elementary level, the fact that changing the shape of an object changes its properties is an age-appropriate understanding. Why this occurs is probably too abstract and beyond the ability of most students to grasp. I do, however, eventually ask the reasoning question, "Why do you think the clay can float when shaped like a boat but not when it is the shape of a ball?" It is important to note here that the question is "*Why do you think*?" and not just "*Why*?" The wording (if truly meant) encourages children to *do* science—that is, to use evidence to create an explanation.

If students overlook some piece of evidence in coming up with their theories, an attention-focusing question invites them to look again. Students often suggest that spreading the clay over a greater surface makes it float. Asking them to compare what happened when the clay was shaped like a ball and when it was made into a raft (comparison question) helps students to think about what else might contribute to the explanation.

A second- or third-grade student (the grade level at which this activity is normally taught) should not be expected to arrive at an adult understanding of buoyancy. Understanding the fact that changing the shape makes a difference lays an important foundation for understanding that will proceed easily when abstract thinking comes into play a few years down the road.

For brighter children who are ready for more of a challenge, there is no reason to hold them back. Productive questions that cause these children to notice the correspondence between changing the shape of the clay and the changing level of the water might enable them to begin to think about displacement and actually move close to an advanced understanding of buoyancy.

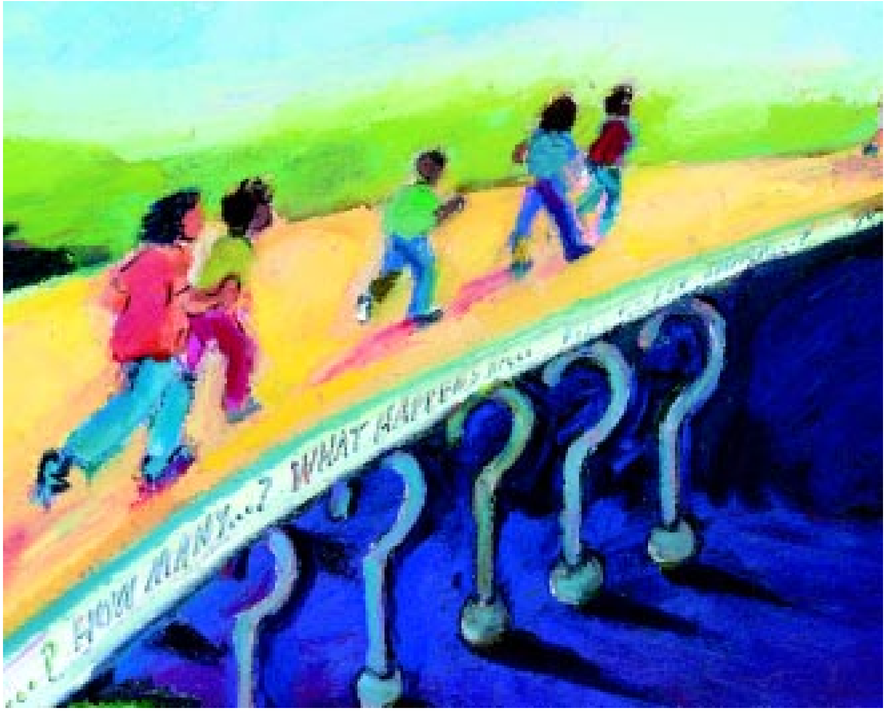
Students Understanding Levers

The following is an example of a teacher using productive questions with fifth-grade students. The teacher asked her students if they could find a way to balance two pennies on a ruler using just one penny as the counterweight. Some children, using a pencil for a fulcrum, began to experiment by moving the position of the pencil.

Others solved the problem by moving either the load (two pennies) or the counterweight (one penny). As individual children experienced success, the teacher quietly whispered, "Now can you balance three pennies (then four, five, etc.) using just one? And what are you noticing?"

This teacher began the lesson with a problem-posing question and then shifted to attention-focusing questions as she endeavored to help the children make sense of their experiences. Many children initially met the challenge through trial and error. It was critically important for the development of conceptual understanding that the students were led to the point of being able to articulate the pattern they were observing.

However, not all children were able to meet the initial challenge. There were some who randomly moved the pencil and/or the pennies (or both) and looked around in frustration as the enthusiasm of classmates grew in proportion to their successes. The teacher responded to the less successful children with a more structured action question. "What happens if we place the load at one end and the counterweight at the other and move the fulcrum closer (from the center) to the two pennies?" At this point, the teacher was leading the children to be able to meet the challenge successfully. This was necessary in order for these children to begin to notice the pattern and then develop an understanding of the fact that levers enable us to do work with less effort by applying force over a distance.



ELIZABETH WOLF

A teacher's own style and knowledge of students' abilities should determine how much structure to set when using productive questions for learning science.

The teacher's style was to begin the lesson in a very unstructured way. Students were free to adjust either the position of the fulcrum or the load and counterweight. The teacher was skilled enough in observing and listening to her students to make appropriate use of productive questions regardless of how students approached the problem. Many teachers would prefer to set tighter parameters, as did this teacher in response to students who were not successful at first. A teacher's own style and knowledge of students' abilities should determine how much structure to set. All students, however, can profit greatly from the strategic use of productive questions.

This was not the only activity the teacher used to develop an understanding of the benefit of this type of simple machine. Other activities involving teeter-totters enabled the teacher to use comparison questions to reinforce the relationship pattern between force and distance. These activities took a lot more time than merely telling students about levers.

(continued on page 53)

National Science Education Standards

The techniques discussed in this article relate to Teaching Standard B: Teachers of science guide and facilitate learning (National Research Council, 1996, p. 32). In doing this, teachers

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.
- Challenge students to accept and share responsibility for their own learning.
- Recognize and respond to student diversity and encourage all students to participate fully in science learning.
- Encourage and model the skills of scientific inquiry, as well as the curiousness, openness to new ideas and data, and skepticism that characterize science.

(Productive Questions,
continued from page 27)

There is no doubt though that these students **understood** and **will remember** what they learned by doing and making sense of what they did as their teacher served as facilitator and guide through her use of productive questions.

A Bridge to Understanding

There are many teachers who engage students in hands-on activities and assume that since the children enjoy the activities, learning is occurring and understanding is developing. Few children, however, are able to construct understanding simply by engaging in an activity. Productive questions enable teachers to create a bridge between activities and students. They make it possible for **all** learners to arrive at understanding.

Resources

Eltgeest, J. (1985). The right question at the right time. In W. Harlen (Ed.), *Primary Science: Taking the Plunge.* Portsmouth, NH: Heinemann.

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

Sink or Float Kit—Grades 2 and 3. Delta Science Module #38-738-3133, Delta Education, P.O. Box 915, Hudson, NH 03051-0915.

***Also in* S&C**

Maxim, G. (1997). When to answer the question "Why?" (What Research Says) *Science and Children, 35*(3), 41–45.

Ward, C. (1997). Never give 'em a straight answer. (Teaching Teachers) *Science and Children, 35*(3), 46–49.

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