3 Ways to Support Problem-Based Instruction

Allowing students to find solutions on their own enhances mathematics learning

By William G. McCallum

When I was a child, I enjoyed borrowing puzzle books from the library. One puzzle was "The 12-Coin Problem"—the most difficult of all coin-weighing problems. My mother and I tackled the problem at the same time, but we worked on it separately. She solved it first. I tried and tried, but I couldn't come up with a solution. Later that evening, she found me in my room, in tears. "Do you want me to tell you the solution?" she asked. I said no. I'll always remember the joy I felt when I finally figured it out later that night.

Looking back at that experience, it's no surprise that I went on to become a mathematician. But can all students experience the elation I felt at solving a difficult problem? Is that really the best way to help students learn mathematics? Research says yes. The National Academies' publication "How People Learn" shows that learning is more robust if students have a chance to grapple with a problem before hearing explicit instruction on it. Both components—and the order in which they happen—are important.

Try and Try Again

Implementing problem-based instruction in mathematics classrooms means believing all students can solve problems on their own and giving them a chance to try. Here are a few ways to support students in their efforts, without giving away the ending:

1. **Cultivate positive attitudes about effort.** One of the first steps in implementing a problem-based approach in the classroom is cultivating the right attitudes and beliefs. Many students—and parents—think that mathematical knowledge and skills belong exclusively to "math people." Yet research shows that students who believe that effort is more important than innate talent learn more.

   In the words of the National Research Council report "Adding It Up," we want students to develop a "productive disposition—[the] habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy." Give students the opportunity, time, and space

to work on problems on their own, and they will soon believe that anyone can do mathematics, and that perseverance results in understanding.

2. **Implement instructional routines.** Instructional routines are a good idea for the same reason all routines are: They let people know what to expect, giving structure to time and interactions. When students and the teacher regularly complete interactions in a particular order, they don't have to spend as much mental energy on classroom choreography, easing the burden on teachers and freeing students to focus on the academic task at hand. Furthermore, a well-designed routine can launch student conversations and introduce new ways of thinking about mathematics.

   For example, Notice and Wonder is an effective routine that's often used as a warmup exercise. When it asks students to reflect on figures, equations, and other mathematical representations, some will notice mathematical things; others will notice nonmathematical things. The latter learn to think mathematically by hearing from the former without being told that their answers are wrong.

   Another resource is the book *5 Practices for Orchestrating Productive Mathematical Discussions* by Margaret S. Smith and Mary Kay Stein, which can help teachers structure classroom activity so each student has a chance to try the problem, share their solution with others, and see one or more correct solutions.

3. **Resist the urge to intervene too quickly.** As it was difficult for my mother to leave the room when I was wrestling with The 12-Coin Problem, it is difficult for a teacher not to intervene when a student is struggling. There are things teachers can do, however, to help children work through a problem without tearful frustration. First, teachers can help students understand what the problem is asking without telling them how to solve it. Asking questions is also a great way to help students get unstuck without offering so much assistance that they lose ownership of the solution.

Increasing Student Learning

Although there are many kinds of rich, engaging problems available, problem-based instruction does not mean that a teacher has to work with any particular type of problem. A teacher might choose to run a problem-based classroom using only old-fashioned word problems or choose a core curriculum designed to support problem-based instruction. Further, a teacher might have a preference for digital or print materials, or open educational resources. Not all materials provide good support for problem-based instruction, but any can be used to some effect; it ultimately depends on the teacher to implement it.

No matter what problems or curriculum a teacher chooses, students should have the opportunity to take an active role, individually and in groups, to see what they can figure out before having things explained to them or being told what to do. The ultimate purpose with a problem-based curriculum is to impact student learning and achievement—and research shows that students learn best and retain what they learn better by attacking problems by themselves first. P

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