The Science of Science

Discovery learning may or may not be effective: let's find out!

By Sharon Begley

It is conventional wisdom in science education that the best way to give students a deep and enduring understanding is through "discovery learning".

Although the term has no precise, universally-accepted definition, it basically means that the teacher gives the kids a goal and the requisite materials and then tells them to go to it, with the hope that they will uncover principles such as Newton's laws of motion.

In contrast, using "direct instruction", teachers explicitly present information to students. "The idea is that students who acquire knowledge on their own can apply it more broadly and extend it better than if they are told or shown that same knowledge," says David Klahr of Carnegie Mellon University in Pittsburgh.

To test this claim, he and a colleague compared how well the approaches taught 112 grade 3 and 4 students a core scientific concept: to discover how one thing affects another, change only one variable at a time.

Specifically, the kids had to figure out how to design good experiments that would reveal what properties of a ramp (steepness, length, smoothness) affect how far a ball will roll.

The goal was to learn that if you compare a ball rolling down a short, steep, bumpy ramp to one rolling down a long, flatter, smooth ramp, you can't tell if the extra distance comes more from length, angle, or surface.

To do that, you must change only one property at a time − varying steepness, say, while holding the length and the smoothness constant.

Students receiving direct instruction were explicitly told to change one property at a time and were given explanations. The discovery learners got neither. In both cases, the kids worked with ramps and balls, so everyone did hands-on science.

The result: not only did more kids master the control-of-variables lesson from direct instruction, but − and this strikes at the heart of the claims for discovery learning − the latter approach did not give kids a deeper, more enduring knowledge.

Those who learned the one-variable-at-a-time idea through direct instruction extended and applied their newfound knowledge just as well as those few who discovered it by themselves.

"I'm not saying kids never benefit from discovering something on their own," says Professor Klahr. "But, especially for complicated, multi-step procedures, there are just no data that discovery learning offers any benefit."

Supporters of discovery learning say that Professor Klahr's study was too extreme, and that in real life students doing discovery learning get more guidance from their teachers.

But that just raises another question: what ratio of discovery learning to direct instruction is ideal? Once again, no one knows for sure.

The mismatch between claims about the best way to get kids to learn and what well-designed scientific studies show is striking. Recognizing that, in 2001, the U.S. Department of Education called for making education "evidence-based".

Like evidence-based medicine, it means using only teaching methods that are shown to work in solid studies (analogous to clinical trials of new drugs).

Or, as Professor Neville says, "we need the education equivalent of an FDA that would not allow schools to implement a practice unless it had empirical support."

There's a gap in education's research base: well-controlled studies with large numbers of students that account for factors such as the superior knowledge and extra training of teachers in some classes, or even high expectations of student achievement.

Without such controls, observations are inconclusive about what really makes the difference in how well kids learn.

Just because a drug looks as though it will cure some disease, based on experiments in test tubes and mice, doesn't mean it will. "Sometimes", says National Academy of Sciences education expert Lisa Towne, "basic principles don't translate as expected" − not into drugs, not into classrooms.

Grover Whithurst, director of the U.S. Education Department's Institute of Education Sciences, is trying to bring evidence to bear on education decision-making.

There are already some robust principles of learning science. "Time-on-task" matters; students have to put in the hours. Students need challenges − instruction that aims just beyond what they already know.

Also, teachers must address students' misunderstandings before introducing new information, teach facts and ideas in context rather than in isolation, and have students monitor their own learning.

To be sure, there are small, pilot studies galore of science-instruction methods. In many, hands-on, inquiry-based learning, in which the kids actively think about topics, comes out on top. But this approach, as well as other principles of learning, cries out to be tested in large, randomized, controlled "clinical" trials.

"Optimistically", says Dr. Whitehurst, "in five to ten years we might know" the most effective ways to teach science.

Medicine is finally becoming evidence-based. Surely, it is long past time for education to do so, too.

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