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Key Concepts in Alternating Worked Examples with Practice

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Topic: How to Organize Your Teaching
Practice: Examples With Practice

Highlights

- Alternating worked examples with practice means providing a solved problem for every other problem to be solved.
- Worked examples act as a kind of tutor by helping students reflect on what they know and identify what they don't understand.
- The benefits of alternating worked examples with practice: students learn ideas more deeply, can transfer more easily, and solve problems faster.

About the Interviewee

Ken Koedinger's background includes a BS in Mathematics, a MS in Computer Science, a Ph.D. in Cognitive Psychology, and experience teaching in an urban high school. This multi-disciplinary preparation has been critical to his research goal of creating educational technologies that dramatically increase student achievement. Toward this goal, he creates "cognitive models," computer simulations of student thinking and learning, that are used to guide the design of educational materials,

practices, and technologies. These cognitive models provide the basis for an approach to educational technology called "Cognitive Tutors" in which are created rich problem solving environments for students to work in and provide just-in-time learning assistance much like a good human tutor does. He has developed Cognitive Tutors for mathematics and science and has tested them in the laboratory and the classroom. In a whole-year classroom study with the Algebra Cognitive Tutor, he has shown that students in experimental classrooms outperformed students in control classes by 50-100% on targeted real world problem solving skills and by 10-25% on standardized tests. His research has contributed new principles and techniques for the design of educational software and has produced basic cognitive science research results on the nature of mathematical thinking and learning. He has authored 93 peer-reviewed publications, 8 book chapters, and 53 other papers and has been a Project Investigator on 16 major grants. He is a co-founder and board member of Carnegie Learning, Inc. and the CMU Director of the Pittsburgh Science of Learning Center (PSLC). PSLC is a $25 million NSF center that provides researchers with "LearnLab," an international resource for creating, running, and mining data from rigorous classroom experiments to apply and advance theories of human and machine learning.

Full Transcript

I'm Ken Koedinger. I'm a Professor of Human Computer Interaction and Psychology here at Carnegie Mellon University. The idea of alternating worked examples is that often, students are given homework problems, for instance, where it's all problems—like 10 problems that they solve and they often don't have enough information. They get stuck when they are at home. Maybe they can ask an older brother or parent, but a lot of research has shown that instead of having 10 problems to solve, if students had every other problem with an example of how to solve that problem—worked-out example of how to solve it such that they had five examples alternating with five problems—they learned much more from that. And that's the key idea and it's actually a very powerful idea because it's very simple to implement.

One thing that can happen with a single example—and this is trying to illustrate why it's important to have multiple examples—is I can get the wrong idea from an example, so let me take a very simple Algebra equation: $3x = 9$. And we all know the answer is $x = 3$, but if I am just learning that, what might I think from that example, $3x = 9$, $x = 3$? Well, one thing I might think is, you took the 3 from $3x$ and you brought it over to the other side and if that's what I look at that example and say, "Oh, I got it," then when I get $4x = 12$, now I say, "Oh, just like the other one, $x = 4$." No, $x = 3$, but the first example made me think that it should be 4, that I just copied that number over. By having two examples, now I contradict that misconception I might have gotten from just one example. And I think that too often the textbook gives us one or two examples, where we can learn from those two examples something that isn't right, that's not going to work in general. So by having more examples, it really helps me to see "Oh, no, I had the wrong idea." The right idea—the deep concept here—is the one that's consistent across all of these examples.

This idea of alternating worked examples and problem solving is really a general idea. A lot of the studies have been in math and science, but this really can work in many areas. The benefits are really of two kinds that the research has identified. One is that students learn these ideas more deeply and are therefore better able to transfer the knowledge to new problems, to future learning opportunities. They are not just stuck locally. Sometimes, students can learn just enough to pass the test, but what this technique is showing is that you can really help students to get more than that, where they really understand what they are doing. The second one is that you learn faster and easier. It's very consistent results across all of these studies, that you get quite big reductions in the time it takes for a student to get to the same or better—as I already said, often you get to a better point—but what's really great about it is you can get to a better understanding in less time, sometimes 20 percent, sometimes like a third less time to get to the same place. And that, I think, is really powerful, not just because we want to make kids' lives easier, but, of course, it would be great if a student can get their homework done in say 20 minutes rather than 30 minutes. But it's also because it gives them more time to actually focus on more challenging stuff.

So, if I am using this as a teacher—so many teachers in math and science courses find that they can't get into the more advanced topics because their kids are struggling so much. Well, if it only takes four weeks when it used to take six weeks, I am going to have an extra two weeks to get into harder ideas and take more challenging topics.

Having a worked example is like having a tutor in a way. Of course, if every kid could have a one-on-one tutor, that's a really powerful thing. But it's even more powerful in some ways because a lot of tutors will say, "Here, solve this problem and I will help you out." But if you're always in this mode of problem solving, so much of your mind is stuck in trying to figure out how to do this problem. But what we really want out of learning is getting the ideas that will help you solve future problems. So, problem solving sometimes creates so much, we say, cognitive load—so much of your thinking or cognition is involved in trying to get it done—that you don't have enough to reflect on what the ideas or concepts or mathematical principles or scientific principles are. An example gives you a little more cognitive headroom, if you will, to focus on understanding the principles.