Students Learn Better When The Numbers Don't Talk And Dance

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Most teachers believe that students learn better when abstract concepts are taught using concrete materials or examples -- but a new study suggests they may be wrong.
Researchers found that when college students were taught an artificial form of mathematics and physics, they learned it better when it was presented using simple, abstract symbols – such as plain stars and raindrops -- rather than more visually engaging and concrete 3-D objects that moved dynamically on a computer screen.

The students were also more successful in applying what they learned to new situations when they were taught with abstract symbols rather than concrete objects, said Vladimir Sloutsky, co-author of the study and professor and director of the Center for Cognitive Science at Ohio State University.

The results of this study suggest that teachers may need to rethink one of the most widely accepted truisms of their profession, said Sloutsky, who is also associate dean of research at the university's College of Human Ecology .

“Many teachers believe that concrete materials make learning more fun for students, and that will increase their motivation and help them understand the concepts,” he said. “While this may be true, in many cases, the concrete materials also interfere with what they are trying to learn.”

A real-life example of how concrete materials may be used inappropriately is a common tactic for teaching children about numbers and letters. Books and educational television shows often present letters or numbers with human features such as faces, which dance and talk.

While some believe this makes the concepts more approachable, the authors believe Sloutsky said it simply confuses young children.

“Instead of learning that letters and numbers are symbols that can be used in many different ways, children in this example see them as very concrete examples of humans.”

The belief in the value of making the abstract concrete is widespread, however. For example, 84 percent of secondary school mathematics teachers in one survey said they believed concrete materials in their classes help students learn.

Sloutsky conducted the study with Jennifer Kaminski, graduate student at Ohio State and Andrew Heckler, assistant professor of physics at Ohio State . Their results were published in a recent issue of the journal Psychonomic Bulletin & Review.

For the study, the researchers did three related experiments.

In one, 30 undergraduate students were taught a novel, artificial mathematics and a novel, artificial science. Half of the students were taught the math first and then the science, and the other half were taught the science first and then the math.

The math used simple, abstract symbols such as raindrops, stars and snowflakes. Students learned, for example, that combining a star and a snowflake resulted in a raindrop. They were then tested in their knowledge of this new, artificial math. All of the training and testing was done on a computer.

The science portion used much more concrete symbols – this portion of the experiment used 3-D objects that moved across the computer screen. Students were shown two of these 3-D objects moving towards each other and colliding to form a third, different object. The rules of this science portion were exactly the same as the math portion – only the objects were different. Again, they learned this new science and were tested on what they learned.

Results showed that most participants successfully learned both the science and math portion. However, participants who learned the math first did significantly better on the science portion than did those who did the science portion first.

“This suggests that knowledge presented in the more generic, abstract format helped students better learn the more perceptually rich, concrete format,” Sloutsky said. “If they learned the science portion without the benefit of learning the more abstract math portion first, they did not do as well.”

A second experiment involving 30 undergraduates was nearly the same except for one crucial difference – the math symbols were replaced by images of 3-D objects, such as swords and goblets. In this experiment, the math objects were more concrete than those in the science condition because they were real-life items. Real items such as swords or goblets make poor symbols because it is difficult for people to interpret them as something other than what they are.

In this second experiment, contrary to the first, students did better when they learned the science first and then the math. But the key was that, just like the first experiment, learning with less concrete symbols helped students when they had to use their knowledge in new situations that were more concrete. “Students were better able to transfer what they learned when they were taught using more abstract symbols,” Sloutsky said.

Moreover, students also did better when tested on the science concepts than they did on the math concepts. “That suggests concreteness of objects hinders not only transfer of knowledge but learning itself,” Sloutsky said.

To confirm this finding, the researchers conducted a third experiment in which 81 students – all different from those in previous experiments -- learned the same artificial math as used previously. In this case, they were separated into four groups, each of which learned from a different set of symbols, from very abstract and simple to intricate photos of real objects. In general, even though the learned material was otherwise identical, students who used the most intricate, concrete symbols did poorer on testing than those who learned using the most simple, abstract symbols.

Overall, the results suggest that students may often benefit when knowledge is presented in abstract, generic forms.

There are many reasons why concrete may not be better for learning, according to Sloutsky. For one, concrete objects have more “perceptual richness,” meaning there is more for students to look at and process. That means there is more to distract students from what is important.

Also, concrete symbols are less “portable.” For example, a child can use a stick – a relatively abstract item – and imagine it is a car, or a space ship or a flower. However, it is more difficult for a child to take a toy train and pretend that it is a flower.

“Less structured entities make better symbols, and these generic symbols are easier to learn," he said.

Source: Ohio State University

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