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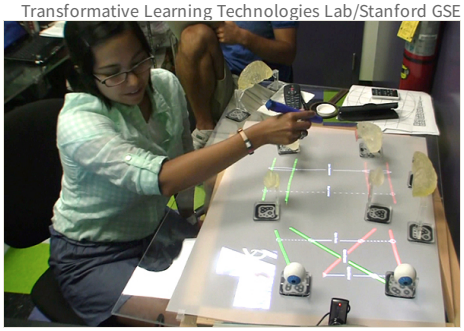
Classes should do hands-on exercises before reading and video, Stanford researchers say

A study from the Stanford Graduate School of Education of how students best learned a neuroscience lesson showed a distinct benefit to starting out by working with an interactive 3D model of the brain.

BY DAVID PLOTNIKOFF

A new study from the Stanford Graduate School of Education flips upside down the notion that students learn best by first independently reading texts or watching online videos before coming to class to engage in hands-on projects. Studying a particular lesson, the Stanford researchers showed that when the order was reversed, students' performances improved substantially.

Transformative Learning Technologies Lab/Stanford GSE



The researchers drew on data gathered from students using the BrainExplorer, a tabletop tool that simulates how the human brain processes visual images.

While the study has broad implications about how best to employ interactive learning technologies, it also focuses specifically on the teaching of neuroscience and underscores the effectiveness of a new interactive tabletop learning environment, called BrainExplorer, which was developed by Stanford GSE researchers to enhance neuroscience instruction.

The findings were featured in the April-June issue of *IEEE Transactions on Learning Technologies*.

"Our results suggest that students are better prepared to understand a theory after first exploring by themselves, and that tangible user interfaces are particularly well-suited for that purpose," said Bertrand Schneider, a GSE graduate student who led the research under the direction of Paulo Blikstein, an assistant professor of education. The two other co-authors of the research paper are Roy Pea, a professor of education, and Stanford undergraduate Jenelle Wallace.

The study draws on data gathered from students using the BrainExplorer, a tabletop tool that simulates how the human brain processes visual images. It features polymer reproductions of different regions of the brain and eyes, as well as cameras and infrared pens.

Students use the pen to manipulate and explore the neural network; by severing and reconfiguring the connections, they can see how perceptions of the visual field are transformed. (Schneider developed the device in collaboration with Wallace as a final project for a course, *Beyond Bits and Atoms,* taught by Blikstein.)

The study involved 28 undergraduate and graduate students as participants, none of whom had studied neuroscience. After being given an initial test, half of the group read about the neuroscience of vision, while the others worked with BrainExplorer. When tested after those respective lessons, the performance of participants who used BrainExplorer increased significantly more – 30 percent – than those who had read the text.

Next the researchers had each of the two groups do the other learning activity: Those who had used BrainExplorer read the text, while those who had read the text used BrainExplorer. All the participants then took another test, and the findings revealed a 25-percent increase in performance when open-ended exploration came *before* text study rather than after it. (A follow-up study showed identical

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results for video classes instead of text.)

"We are showing that exploration, inquiry and problem solving are not just 'nice to have' things in classrooms," said Blikstein. "They are powerful learning mechanisms that increase performance by every measure we have." Pea explained that these results indicate the value for learning of first engaging one's prior knowledge and intuitions in investigating problems in a learning domain – before being presented with abstracted knowledge. Having first explored how one believes a system works creates a knowledge-building relevance to the text or video that is then presented, he said.

The research comes out as the idea of a "flipped classroom," in which students first watch videos or read texts and then do projects in the classroom, has been growing in popularity at colleges and graduate schools. The study's conclusion suggests that the current model of the flipped classroom should itself be flipped upside down. The researchers advocate the "flipped flipped classroom," in which videos come after exploration and not before.

The authors chose neuroscience as the discipline for the study because it is a rapidly changing field that relies heavily on computers rather than paper texts or lectures. But the results extend beyond neuroscience. Similar technology could be projected onto other emerging data-intensive fields such as genomics and nanotechnology, which are quickly making their way into undergraduate and high school education everywhere.

The BrainExplorer system is a proof-of-concept that may have applications in any field where teaching demands visualization and exploration of complex systems. "Part of our goal," the researchers write, "is to create low-cost, easy-to-scale educational platforms based on open source, free software and off-the-shelf building blocks such as web cameras and infrared pens so that our system can be easily and cheaply deployed in classrooms."

The study buttresses what many educational researchers and cognitive scientists have been asserting for many years: the "exploration first" model is a better way to learn. In addition to these published findings, the researchers spoke at an American Educational Research Association meeting earlier this year about another study that used instructional video instead of text and obtained the same results. The team is now conducting follow-up studies.

"With this study, we are showing that research in education is useful because sometimes our intuitions about 'what works' are simply dead wrong," said Blikstein.

The study was funded with support from the National Science Foundation.

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