’Playing Games With Basic Research’

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Today, doing homework means sitting down to fill out a worksheet, flipping through flash cards, or writing an essay. But what if all students had to do was plug in a controller and train their brains by playing games?

It may be an enticing idea, says APS James McKeen Cattell Fellow Richard E. Mayer, but just because kids enjoy games more than conventional lesson plans doesn’t mean educational video games are the way to go; as the sign in his University of California, Santa Barbara, lab says, “Liking Is Not Learning.”

“The problem we have is there are many strong claims for the educational value of computer games, but they’re based on weak evidence,” said Mayer, a Distinguished Professor of Psychology at the University of California, Santa Barbara, during his award address at the 2018 APS Annual Convention in San Francisco.

It all comes down to the issue of transfer, a classic concept that’s been at the foundation of both education and psychological science since the very start, he continued.

For more than 45 years, Mayer’s research has been motivated by a simple question: “How can we help people learn so they can apply what they have learned to new situations?”

In the case of video games, it’s not enough for Tetris just to teach players how to be the best at stacking the game’s colorful blocks at an increasingly demanding pace — those cognitive skills need to carry over into other contexts as well.

Mayer’s “use-inspired basic research” begins with the idea that we construct knowledge and learning through three basic processes. First, students need to be able to pay selective attention to relevant material and understand what parts of a multimedia presentation are important. Next, that information is organized into a coherent structure in the student’s sensory memory, before working memory finally integrates those knowledge structures with each other and with prior knowledge drawn from long-term memory.

“When looking at trying to design effective games, I think we need games that prime these processes of selecting, organizing, and integrating,” Mayer explained.

The Cognitive Consequences of Commercial Gaming

Off-the-shelf games offer players hours of entertainment, but do they offer a cognitive edge as well?

Portal, a popular puzzle-platform game released in 2007, asks players to navigate their way through a series of rooms using a “portal gun” that allows them to manipulate and transport objects based on real-world physics. One might expect that playing a physics-based spatial action game would increase players’ understanding of physics principles or boost their perspective-taking and mental-rotation skills, but Mayer and the students working in his lab found that the effects were minimal at best.

In fact, even playing 15 to 20 hours of Lumosity, a suite of brain-training games advertised as being specifically designed to improve cognition, gave players little advantage over those who played no games at all on tests of attention and mental flexibility.

“Off-the-shelf games aren’t the best way to try and improve cognitive skills,” Mayer said. “They were designed for entertainment generally, not cognitive training.”

What Features Add Value to a Game?

That doesn’t mean video games are completely ineffective as educational tools: Designing games based on proven cognitive principles could still yield results, Mayer explained.

To this end, he and his students created a series of games called Design a Plant. In each version of the game, players are tasked with designing flora capable of surviving and thriving on another planet by selecting different root, stem, and leaf systems. In response to their choices, a character, or “on-screen pedagogical agent,” named Herman the Bug explains how plants grow based on their interactions with different environments.

Herman is designed to interact with participating students in different ways depending on the condition to which each individual is assigned. The agent might communicate through speech in one condition and written text in another. The speaking tone might be conversational or formal. And participants may see the character on screen or hear a disembodied voice.

Students then complete a transfer test measuring their understanding of the botany principles presented in the game.

Findings across this and other games that Mayer has designed and tested in the lab suggest that students respond well to polite pedagogical agents who communicate informally; actually *seeing* that agent, however, may be of little help in improving their understanding of the material. Coaching players by providing them with feedback on the reasons their answers were wrong and prompting them to explain correct answers, on the other hand, were found to bolster performance on transfer tests.

Despite the relative success of socially engaging pedagogical agents such as Herman, Mayer has found that adding immersive elements such as narrative themes to a game can actually hinder students’ performance on subsequent tests. In a game called Cache 17, for example, students were tasked with creating different electrical devices to recover art stolen during World War II. Participants who played the game after viewing an introductory animation about the lost artwork solved fewer electrical problems on average than those who played the game without narrative context.

“I’m not going to give up on immersion yet,” Mayer said. “I think it has a lot of potential. It’s just the games that we’ve used don’t really need immersion.” Features only augment student learning, in other words, when they target a specific skill. Providing captions for spoken dialogue, for example, was found to negatively impact native English speakers' understanding of botany compared with those who played Design a Plant with audio only — but redundant text has been shown to be very important for students learning in a second language.

Mayer said professional developers who view designing games as an art form are sometimes offended by the idea of adding instructional elements to games, or even by the notion of studying them scientifically, but this doesn't have to be contradictory.

"When our goal is to help people learn with games, we should base that on evidence and theory, and I think psychological science has something very important to contribute," he explained.

Games Versus Conventional Media

Rigorous studies comparing educational games with conventional media (such as books, handouts, and PowerPoint presentations) are scarce, however, and the results are mixed.

When Mayer measured the learning of students playing a decimal arithmetic game, he found that they learned better from lining up balloons with decimal values from smallest to largest than from an online tutorial with the same information. On the other hand, students were found to learn more about electrical devices from a PowerPoint presentation than from Mayer's Cache 17.

Playing games with virtual-reality headsets has also become increasingly popular, he said, but there is little evidence that it improves classroom learning.

Still, Mayer noted, research on educational games is only in its early stages, and the possibility that computing power can be leveraged to provide an adaptive resource for students' learning remains.

"We know from learning theory that the only time you really learn is when you make a mistake," he said. "I think that's one of the values of games. It's kind of a low-stakes environment where you can try things and learn from that."