

Confuse Students to Help Them Learn

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By Steve Kolowich

If you had to pick a single word to explain how Derek Muller ended up in a Perth hotel room arguing with an empty chair, it probably would be "confusion."

About a decade ago, Mr. Muller, then a doctoral candidate at the University of Sydney, wanted to figure how out to make science videos that students would learn from, not just watch. So he did some experiments. He got a handheld camera and rudimentary animation and editing software, and recorded some educational videos aimed at teaching basic physics concepts.

In some videos, he had an actor explain the concepts straightforwardly, with simple drawings and animations. When he showed the videos to a group of undergraduates, the students described them as clear, concise, and easy to understand.

In other videos, he included more ambiguity. Instead of one actor delivering a well-articulated monologue, Mr. Muller filmed two actors, a "tutor" and a "student." The student character would struggle to wrap his head around the concept. The tutor would provide some leading questions but no clear answers. Finally, after some back-and-forth, the student would get it right.

None of Mr. Muller's students called this kind of video clear or concise. Some of them called it confusing.

But when Mr. Muller analyzed the results of tests he administered to the students before and after showing them the videos, he noticed something odd: The students who had watched the more confusing videos learned more. The students who had watched the more-straightforward videos learned less, yet walked away with more confidence in their comprehension.

Mr. Muller's findings fly in the face of the truism that clarity is the best way to make a lesson stick. This is a timely bit of counterintuition. Short-form lecture videos are in vogue. Some universities are building studios to make videos with high production values for their experiments in online education and hybrid teaching. Naturally, many professors use the medium to present ideas clearly and with authority.

In a 2011 video summarizing his research, Mr. Muller questioned whether all that polish was actually working.

"It seems that, if you just present the correct information, five things happen," he said. "One, students think they know it. Two, they don't pay their utmost attention. Three, they don't

recognize that what was presented differs from what they were already thinking. Four, they don't learn a thing. And five, perhaps most troublingly, they get more confident in the ideas they were thinking before."

Confusion is a powerful force in education. It can send students reeling toward boredom and complacency. But being confused can also prompt students to work through impasses and arrive at a more nuanced understanding of the world.

"Common wisdom holds that confusion should be avoided during learning and rapidly resolved if and when it arises," wrote a team of researchers in a paper published earlier this year. While this might be true when it comes to superficial tasks such as memorizing facts and figures, "Confusion is likely to promote learning at deeper levels of comprehension under appropriate conditions."

In other words: If teachers want students to learn the really important stuff, like comprehending difficult texts and modeling complex systems, they should put their students in confusing situations.

Sidney D'Mello, an assistant professor of psychology and computer science at the University of Notre Dame, and Arthur Graesser, a professor of psychology at the University of Memphis, were on the team that wrote that paper. In recent years the two professors have conducted a number of experiments probing the fragile dynamic between confusion and learning.

In a typical experiment, the researchers placed undergraduate psychology students in front of screens showing two animated, artificially intelligent bots. Each student was then given a research study and asked to assess its scientific merits while engaging in a three-way conversation with the bots. Mr. D'Mello and Mr. Graesser tried to "induce confusion" by programming the bots to contradict each other and call on the student to intervene.

Not surprisingly, the students who had gotten mixed messages reported being confused more often. But they also showed "significantly higher learning gains" than those who had discussed the problems with more agreeable bots.

Confusion works, except when it doesn't. It does not fuel learning, say researchers; it merely signals cognitive events that coincide with learning. More is not necessarily better.

Confusing students on purpose is more like loading the elastic of a slingshot: It creates tension that can propel them into higher altitudes of understanding; pull too far, though, and the elastic will snap.

This is where harnessing the power of confusion becomes difficult—and risky. Some students are likely to snap sooner than others. "We still don't know how soon to rescue them from the confusion," Mr. Graesser told *The Chronicle* in an interview, and the right answer undoubtedly varies from student to student. Researchers say that confusing students works only if instructors can track and moderate the confusion.

There's the rub: Detecting confusion is hard, especially in the moment. So is controlling it. For an instructor standing before a sea of faces, it's virtually impossible.

Technology could provide a solution. Mr. D'Mello and Mr. Graesser have been experimenting with "affect-aware technology"—software that attempts to read facial cues and adapt to a student's level of confusion. The technology is still in the early stages, but Mr. D'Mello says reading emotional signals in humans could be an important next step for software that responds to the needs of individual learners.

In the meantime, Mr. D'Mello says, instructors should think about when slick, cohesive lectures or tutorials might be the wrong way to teach.

"One can imagine a world," he and Mr. Graesser wrote in a book chapter summarizing their research, "where interventions that expose misconceptions might be cherished instead of chastised, complexity might be a valuable substitute for clarity, and less cohesive texts and lectures might replace the polished information deliveries of textbooks and formal lectures."

After completing his doctorate at Sydney, Mr. Muller decided he wanted to create educational videos based on his dissertation research. That's how he ended up arguing with the chair in the Perth hotel room.

"Why do you have to disagree with everything that anyone says?" says Mr. Muller to the chair. He is young, with a slight build and a neatly trimmed beard. He addresses the chair with a playfully exasperated tenor. "You just like arguing!"

Later, he would edit a duplicate of himself into the chair, and cut the film together to create the illusion of a back-and-forth between two Derek Mullers. The video is for Veritasium, an educational-film company he founded. The idea was to create films about science that meet people's misconceptions head-on.

The question at hand: Are people always lighter in the morning? One Derek says Yes, but the other Derek has some questions.

Mr. Muller spends several minutes soliciting explanations of strangers who believe people weigh less in the morning. An elderly woman at a cafe thinks some of her mass "evaporates" overnight. A younger woman standing near a sand dune guesses that food mass is "compressed" by digestion. Another says that the missing mass has been converted to energy, adding something vague about "ATP."

It's all a bit confusing.

Mr. Muller does not bring in any actual scientific exposition until the fifth minute of the video. He then uses that science to rethink the theories posed by the strangers earlier. Finally, he explains his own theory: People do lose mass at night, but they are lightest after evacuating their bowels.

Many of Veritasium's films are shorter and easier to follow than this one. The company often takes aim at concepts that are totally new to people, Mr. Muller told *The Chronicle* in an email interview. When there are fewer misconceptions to debunk, it makes more sense to explain things straightforwardly.

But there is another reason: People don't like to be confused, he says. When you're running a business, confusion is not always a strong selling point.

"These days I have a double bottom line—educating and making a living so I can keep educating," he said.

"Sometimes I feel the latter objective interferes with the former because people generally prefer videos that make them think less," he says. "Ambiguity is not usually a nice feeling."
