How students learn from their mistakes

August 25 2020, by Ross Brenneman

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An fMRI-based study of error-monitoring shows that students who are focused on monitoring their own learning process, rather than on getting right answers, learn better over time.

The process by which people learn to recognize errors and correct

themselves is called error-monitoring. How children engage in the error-monitoring process can teach us about how they interact with and learn from surprising information they encounter in the world.

And a new brain imaging study offers the first evidence that the way students develop error-monitoring is linked to how they are taught in school. The study compared 8-12 year-old students from Montessori schools to similar students educated in traditional schools. While traditional schools emphasize getting the right answers and avoiding mistakes, with the teacher at the helm, in the Montessori method, teachers guide students toward materials specially designed for students to discover for themselves what they are meant to learn. This means that mistakes provide as much information as correct answers, and so should be valued by students.

Students in the study were asked to solve math problems while an fMRI tracked brain activity. Only Montessori students showed coherent changes in brain activity following errors, suggesting that they were engaging with the errors strategically to learn. Traditionally-schooled students, by contrast, showed coherent activity only after correct answers, and the activity pattern suggested that they were trying to memorize that event.

Though both groups got the same number of problems right, the Montessori students skipped far fewer and got more wrong, making them learn the task more efficiently by the end.

Mary Helen Immordino-Yang, a professor of education, psychology and neuroscience at the USC Rossier School of Education, and who co-led the analysis, says the study shows that in traditional teaching methods, "we're potentially teaching kids to curtail their natural curiosity and exploration to try to memorize correct answers, but not to try to use information from the world to figure stuff out." Immordino-Yang is also

the director of USC Rossier's Center for Affective Neuroscience, Development, Learning and Education.

The study builds on previous evidence to suggest that educational systems which prioritize correctness over engaging deeply with content may be less beneficial to student development. In other words, are educators setting students up to hew toward being concrete achievement-oriented thinkers, as compared to reflective thinkers who are self-directed?

The research could have wide-ranging implications, such as whether grading practices need re-assessing. "If a grade means you have successfully defended a substantial piece of work after an iterative process over time, and now you've reached a milestone, that can be OK," Immordino-Yang says. "But grading generally provides summative feedback of where you're at now … whether you're done or not and what the outcome was. Effective, transferable learning is instead about the process." The work also shows how emotionally traumatized children may have a harder time learning in traditional schools, since they may be especially averse to making errors.

Immordino-Yang says that the researchers don't think the benefit to students is related to Montessori schools specifically, so much as to certain learner-centered features. The research team hopes to conduct further studies of different instructional types, such as progressive performance-based practices that encourage students to debate and discuss various ways of thinking about a problem."

More information: Solange Denervaud et al. An fMRI study of error monitoring in Montessori and traditionally-schooled children, *npj Science of Learning* (2020). DOI: 10.1038/s41539-020-0069-6