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COGNITIVE DILEMMAS
in Higher Education

Advances in cognitive science and neuroscience strongly suggest that the dominant approach to teaching—a concentrated, sequenced focus on specific subjects—is not the most effective form of learning. Research shows that the more varied the learning contexts, the more likely students will be able to retrieve material from memory over the long term. Jamshed Bharucha, provost and senior vice president of Tufts University, where he is also a professor of psychology, neuroscience, and music, notes that the prevailing approach to teaching may seem most organized and efficient from the faculty's perspective. But if the point is for students to be able to manifest knowledge throughout their professional and personal lives, then mixing up material and subjects and approaching problems and principles from multiple, interdisciplinary angles would be more effective than concentrated learning on specific topics. Bharucha urges that the focus of teaching shift away from explicit, declarative knowledge toward implicit, procedural knowledge and principles, which can be retrieved automatically, without thinking, over the long term in the many contexts that we all encounter throughout our lives.

NOTEBOOK

- We tend not to measure learning following the passage of time. When we do, we are shocked. The truth is that abysmal retention is widespread and that robust rapid learning does not predict robust future retrieval.

- If the goal is for students to be able to manifest knowledge throughout their professional and personal lives, then mixing up material and subjects and approaching problems and principles from multiple, interdisciplinary angles would be more effective than concentrated learning on specific topics.

- Albeit perhaps unwittingly, American colleges and universities are promoting more lasting learning than their Asian counterparts by mixing things up. The limitations of Asia's top universities' rigid structures are well known, and many of them are moving to adopt American innovations.

- We have only just begun to scratch the surface of our understanding of the brain—although it is clear even now that, despite its strengths, American higher education should reform how students are taught.

Storage Strength versus Retrieval Strength

Measurement of learning outcomes depends upon when students are assessed as much as it depends upon what is assessed. Educators often measure mastery of a subject at the end of the course of study—immediately following students' review of the material—and pretend that the students go forth with that knowledge intact. We tend not to measure learning following the passage of time. When we do, we are shocked. The truth is that abysmal retention is widespread and that robust rapid learning does not predict robust future retrieval. Moreover, educational systems tend to be packaged neatly into courses and degree programs. While this packaging enables us to feel more organized as educators, it does not map onto how the brain works.

Robert Bjork, a cognitive psychologist at UCLA, distinguishes between storage strength and retrieval strength. Indeed, the two are nearly independent of each other; that is, something can be extremely well stored yet difficult to retrieve. We know that what was previously learned is still in the brain, because if someone is given the opportunity to relearn the same material, the relearning is much faster than the first time around. That means the material is somewhere in the brain but is difficult to access.

Learning is highly context specific, so much so that even the way you were feeling gets encoded with what you learned on a particular day. Your ability to retrieve something that you have learned depends on the similarity between the retrieval context and the original learning context. Most learning contexts in colleges and universities are artificial and tend to be quite dissimilar to the contexts students will find themselves in later in life.

The combination of low retention and context-specific learning yields a counterintuitive phenomenon: When material is presented via less structured formats, with widely varying contexts and from multiple perspectives, it is more likely to be retrievable in the long term, even though it seems less well learned in the short term. Context should be varied in terms of both substance and time; interwoven learning, wherein the same themes reemerge over time, is more effective than concentrated learning. This is the opposite of what most educators believe, because learning that is concentrated in time produces faster improvement and better performance in the short term, when assessment usually occurs. However, Bjork and his colleagues have shown that this improvement is illusory and fleeting. As time goes by, the early positive effect is reversed.

Mixing up subjects and approaching problems and principles from multiple, interdisciplinary angles is beneficial to learners. However, I am also wary of eroding the strong rigor developed within disciplines. Ideally, educators will find ways to continue to foster disciplinary rigor and at the same time bring that rigor to bear in multiple contexts. The goal is to automatically encode disciplinary principles so that they can be readily retrieved in the contexts that students will encounter later in their professional and personal lives.

How We Learn

Cognitive psychology helps to describe how knowledge is organized in the brain. Knowledge tends to be organized around reference points, which function like hooks. When we learn, we learn best if the new information can find some hooks to hang on. Thus, teachers need to engage students' preexisting knowledge so that they can hang new material on it. The dilemma is that learning requires both preexisting hooks and new hooks. For some skills, such as what linguists call "universal grammar," the hooks are biologically specified—but the vast majority of our knowledge must be learned. A corollary dilemma is that older students have more hooks as a result of their longer experience, yet learning is faster at earlier ages. How do we reconcile this dilemma, so often expressed in lay terms as a lament that education is wasted on the young? One clear answer is to avoid packaging education as a distinct phase of life that ends upon entry to the workforce. Not only does lifelong learning help retrain older workers for new jobs, but it also capitalizes on the benefits of older learners' preexisting knowledge.

Most of our knowledge is implicit rather than explicit. That is, we're not conscious of it and we cannot describe it verbally. Often we don't even know we have it. The use of language is an implicit form of knowledge: The grammar we all are taught has very little to do with the syntax that we actually use when we speak. Syntax just comes out automatically, and all human beings—unless they have some genetic dysfunction or brain damage or have been isolated from language—have powerful, full-blown syntax in accord with the linguistic community in which they were raised.

If they are well learned, cognitive skills become implicit, like motor skills. Whether it's critical or moral reasoning or an analytical skill, optimally, the skill becomes implicit and automatic, like riding a bicycle. I can't describe how I ride a bicycle, and I certainly wouldn't try to explain it to a child. I wouldn't start with a classroom lecture on how you turn and how you stop and how you go; rather, a child needs to get on a bike to learn to ride it and the nervous system figures out the rest. How that works is completely opaque to the rider.

The ability to manifest learning is a skill similar to a physical motor skill. It takes the form of implicit knowledge: knowing *how to* as opposed to *what*. We are not conscious of and cannot easily explain such knowledge. Ideally, we would seek to manifest our learning of critical reasoning and

other cognitive skills as effortlessly as a good skier navigates a mountain or a musician plays an instrument. Unfortunately, though, education tends to be focused almost entirely on explicit knowledge—things that can be declared or articulated—and greatly underestimates the key role of implicit knowledge in manifesting our education throughout life.

The spectrum of conscious human experience is extremely dense, far more so than the categorical structure of language that we use to describe it. Humans actually can discriminate millions of colors, for example. We are able to distinguish astonishingly fine gradations of color but can name a relatively small number of colors. That is, the categorical structure of language vastly underdetermines the density of the spectrum of perception. The arts attempt to express some of the density of the spectrum of experience that language cannot. I believe that artistic experience is ineffable and offers humans a means to capture perceptions and communicate in ways that language simply cannot. Indeed, history shows that the arts are the center of culture in society and drive its development. As such, the arts should be a fundamental part of our educational system, which presently is dominated by language—that is, what we can write and speak about.

The American Advantage

Concern about the competition American higher education faces today in a globalized world is widespread. China and India are devoting massive resources to higher education, particularly in the STEM fields—science, technology, engineering, and mathematics. They threaten to surpass the United States in the competition for economic domination and jobs in the global workplace.

I would argue that, for a number of reasons, the threat of global competition is not as dire or immediate as it may seem. In addition to the contextual nature of learning discussed earlier, we know that the brain learns more effectively when it actively generates the material to be learned than when it receives it passively. American colleges and universities, whether intentionally or not, tend to mix up the curriculum in ways that are likely to promote more lasting learning than their Asian counterparts. Undergraduate students in the United States have a large variety of classes to choose from and the freedom to structure their own courseloads. American teaching styles and assessment methods vary from one instructor and class to another, and traditional written exams and papers are often combined with more active methods such as class participation, group projects, individual research, and even online discussion groups.

In contrast, Asian universities tend to focus on large lecture courses without a great deal of active student participation. Written exams are given at the end of each semester and as a capstone to a degree program. The same examinations are taken across an entire university system—in some cases across an entire nation—and are more effective at filtering out the top students in a class than at assessing learning or retention. Sitting for an exam at the end of a degree program does provide an additional opportunity for retrieval, but overall, the traditional system of higher education in Asia does not promote active learning or variation of learning contexts. These limitations are well known, and many of the top Asian universities are changing to a more innovative, American style of teaching as they seek to do precisely what we are seeking to do: gear up for the global economy.

Learning Outcomes

Education is about shaping the brain. The more we learn about the brain, the more it should inform the educational environment that we provide. We have only just begun to scratch the surface of our understanding of the brain—although it is clear even now that we should reform how we teach. Today, calls from outside the academy to account for our efforts and assess learning outcomes are loud and clear and, some would say, threatening. The danger is that in responding to these calls we attempt to distill the purposes of education down to a short list of readily measureable objectives—and in the process lose the opportunity to be far more expansive in how we think about education. That is not to say that we shouldn't assess outcomes; indeed, assessment is crucial to gauge the effectiveness of efforts to improve. The challenge is first to be clear about what we are trying to accomplish, and then to assess those aspects that lend themselves to assessment.

Some advocates of assessment argue that we in higher education ought to measure learning outcomes only over and above what is taught in specific courses. Critical thinking skills, for example, are put forth as a key product of multiple courses to be measured. While important, that view sells higher education short to the outside world. There is indeed a tremendous amount of learning within each course that could be demonstrably measured. Ideally, assessment measures will strike a balance between course-specific material and value-added learning that emerges from the educational experience as a whole.

Education and Social Neuroscience

Two advances in the burgeoning field of social neuroscience should be kept in mind when thinking broadly about the purpose of higher education.

The first concerns diversity and discrimination. A Tufts faculty member, Nalini Ambady, did a study involving Asian American middle school girls to whom she gave a math test. Before the test, the girls were given a form to complete that seemed like a straightforward background questionnaire, except that a few questions were slipped in: For one group, selected at random, those questions tended to highlight their ethnicity, for example, What kind of food do you eat at home? Where are your parents from? For the other group, selected at random, the questions highlighted their gender. And then they all took the math test.

The girls whose Asian American identities had been highlighted on the questionnaire performed better on the test than those whose female identities had been highlighted. The result illustrates stereotyped susceptibility. All the explicit and declarative knowledge one receives from an education is not enough to suppress it, because these things happen fast, and they happen automatically. Functional MRI imaging allows us to see what's going on in the brain when they occur.

These stereotypes are actually categorical representations that form in the brain automatically over a lifetime, as the brain processes and assesses how different groups of people perceive each other. It is very difficult to undo, but it is our responsibility as educators to try. We have evidence that it is possible. A well-known series of studies flashed pictures of black faces and white faces to subjects in an fMRI machine and measured activation of their amygdala, the circuit in the brain associated with fear, flight, and vigilance. In the first study, the black faces activated white subjects' amygdala more than the white faces did. In later research, when the faces were presented to subjects more slowly, this difference was significantly reduced, and increased activity was measured in the frontal cortex, associated with control and regulation. This result suggests that it may be possible to mitigate the effects of implicit attitudes despite the automatic activation of the amygdala.

These findings have enormous implications for education, including cross-race interactions between professor and student, which are complicated. Many faculty and students would deny that they stereotype, but the implicit, procedural knowledge that has been wired in by the environment tells us otherwise. The good news is that it is possible to educate students to see others not as members of racial and ethnic groups but as individuals. However, research also shows that students who identify strongly with a racial or ethnic group learn better in college. That poses a difficult dilemma: How much do we want to break down group barriers that may actually help students within them to be more successful?

Fascinating social neuroscience work has also been done about the processing of moral reasoning, arguably another broad objective of education. The research supports what philosophers have known for millennia, that is, there are both rational and emotional components to moral reasoning. Indeed, it appears that the components are separate (though interacting) systems that evolved at different times, the rational having evolved much more recently than the emotional.

The emotional moral system kicks in first, very quickly. When one is presented with a moral dilemma, or encounters someone who has done something, the emotional reaction is very quick. The rational explanation follows, producing wonderful sounding principles that typically are *post hoc* rationalizations of the initial feelings of disgust or pleasure or whatever they may have been.

The emotional system drives the rational system, but similar to stereotypes, it is clear that education can help the rational system inhibit the dominance of the emotional component of moral reasoning. One can learn, for example, to understand that initial disgust may be misplaced and in fact is not necessarily an indicator that something is morally wrong. These findings and the implications they have for teaching moral reasoning and ethics are only just beginning to scratch the surface of what there is to know about how our brains reason.

Conclusion

A dirty little secret about learning is how much and how quickly we forget. Rather than requiring students to master discrete packages of explicit knowledge and then move on, a more effective model for retention would vary learning contexts in both substance and time. Although American universities sometimes seem to lack consistency compared with their Asian peers, that very disorganization may be just what cognitive and neuroscience research indicate is the most effective way to teach. As we learn more about how the brain learns and retains knowledge, we should continue to adapt our pedagogical approaches accordingly.

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