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America Can Teach Asia a Lot About Science, Technology, and Math

By JAMSHED BHARUCHA

There is a sense of urgency in America today, reminiscent of the "space race" rhetoric of the cold-war era, that we must get our act together in science, technology, engineering, and mathematics education because the Asians are coming. Many people believe that higher-education institutions in countries like China and India produce professionals in those so-called STEM fields far more effectively than our institutions do, thus posing a major threat to our nation's global competitiveness. According to last year's report of the federal Commission on the Future of Higher Education, "While U.S. higher education has long been admired internationally, our continued pre-eminence is no longer something we can take for granted. The rest of the world is catching up, and by some measures has already overtaken us."

The panel, known as the Spellings Commission, for the U.S. education secretary, Margaret Spellings, who convened it, has called on American colleges to help improve our international position by demonstrating learning outcomes in ways that can be easily compared across institutions, and then, on the basis of those benchmarks, changing how they teach. But amid the commission's concern about our global competitiveness, it would be a mistake to infer that Asian institutions do a better job teaching in STEM fields. In fact, what we know about how the brain learns suggests that Asian colleges should become more like their American counterparts, not the other way around.

The extraordinary talent pool of Asian scientists is not the result of a superior educational system, but rather of the fact that a larger proportion of top students in Asia choose to enter STEM fields in college or graduate school and have the requisite preparation. Several cultural factors account for that phenomenon, none of which have to do with the way we and other countries run our institutions or teach our students.

India, where I grew up, is a case in point. It has an educational system in which students, starting in the ninth grade, must choose irrevocably whether to take courses in science or business or the social sciences or in the arts and humanities. As a result, Asian institutions often cover more advanced material within a given subject, such as those in the STEM fields, simply because students must specialize early and have little access to courses outside their disciplines. Our American liberal-arts system explicitly eschews such an early focus and produces more broadly educated citizens, with specialization occurring at the doctoral level — precisely the point at which Indian universities are weakest.

In addition, Asian cultures value science and engineering as status fields, and every child with scientific aptitude is steered — if not pressured — to follow that path. In the United States, business and finance traditionally have attracted a much larger proportion of the best students,

including those who start out in science or engineering, than in Asia. As the liberalization of the Asian economies gradually broadens the range of career options and lures many would-be engineers into business, the short supply of technical professionals is likely to shrink even further — leading those nations to the same predicament that motivated the Spellings Commission to wonder how America can increase its global competitiveness.

Finally, although the Spellings report cited a rapid growth in higher-education capacity overseas, India has a shortage of top-tier engineering colleges, which generates fierce competition for admission. Only students who score in the top 3 percent on the national entrance exam get into one of the seven Indian Institutes of Technology.

Meanwhile, a confidential report of India's National Assessment and Accreditation Council, which became public last summer, found 90 percent of the country's colleges and 68 percent of the universities to be of middling or poor quality. India's prime minister called for "a flexible approach to curriculum development," "more-effective pedagogical and learning methods, and more-meaningful evaluation systems" — dimensions along which American universities excel. The council also found many continuing vacancies in faculty positions, a lack of qualified candidates to fill those positions, and a dismal infrastructure for technical education.

In other words, although there may be an explosion of new institutions in Asian countries like India, the challenges are daunting. American institutions should not feel rushed into making reckless changes because of the mistaken view that they are about to be surpassed.

The Spellings report also encouraged colleges to pay more attention to research on learning in cognitive science and neuroscience. And, as it turns out, our colleges' pedagogical style is usually much closer to the cognitive ideal than that found at our Asian counterparts. If we truly want our nation to be internationally competitive, we should build on our educational strengths, while we work to better understand how the brain learns.

Characteristics that distinguish our institutions include small classes; the encouragement of class participation, original thought, and intellectual risk taking; supervised research and written assignments; and the freedom to challenge accepted wisdom. In contrast, Asian colleges are steeped in a tradition of rote memorization, scripted studying ("mugging," as Indian students refer to the last-minute effort to shove knowledge into their brains before exams), little or no written and oral communication, and subservience to accepted authority.

Why is the American approach more effective? A brutal fact about learning, one that people rarely confront, is that most students' ability to remember and retain what they learn is terrible. We assess mastery of a subject at the end of a course of study and pretend that the student goes forth with that knowledge intact. We tend not to measure learning following the passage of time. When we do, we are shocked.

We can all relate to the experience of forgetting things we once knew well. At an alumni reunion, a former student came up to me and exclaimed, "Professor, remember me? I took your course on memory!" He had been one of the best students in the class, and he would no doubt have scored well on any measure of learning outcomes administered at the time. As I often do

with former students (an amusing but sobering exercise), I asked him what he remembered from my course, at which point this poised, articulate, and successful graduate waxed incoherent.

Most of what we have ever learned is still encoded in our brains, but often buried where we can't easily find it when we need it. We know that it's still there, because the process of relearning something is much faster than learning it the first time.

The cognitive psychologist Robert A. Bjork distinguishes between the storage strength and the retrieval strength of memory and learning. Retrieval strength decays with neglect — use it or lose it. In other words, the more often we rehearse, practice, review, or use something that we've learned, the more easily it will be retrieved.

But learning and memory are highly context-specific, so the ability depends upon how closely the retrieval context matches the learning context. The more varied the learning context, the more likely it is that the learning will manifest itself in one's thinking in the future — which is the object of education.

Variability of learning contexts also applies in time. If a principle, skill, or fact is retrieved or rehearsed during a certain number of episodes, future performance is stronger if those episodes are spread over time and interwoven with the retrieval of other items. Even though we may immediately see faster improvement and higher peak performance when learning is concentrated in time, Bjork and his colleagues have shown that such improvement is temporary. As time goes by, the effect is reversed.

Finally, we learn more effectively when we generate the material to be learned than when we passively receive it. Doing independent projects or supervised research, writing papers, giving presentations, framing issues anew, and meeting professors outside class are more active than listening to teachers and taking tests.

That is why our system of higher education, perhaps unwittingly, promotes retention: It mixes things up. Students have more choices in any given semester, the sequencing of courses is often interrupted, and professors differ in their approaches to the same material. The engagement with the course material is more frequent and more varied, including examinations, papers, class discussion, comments on course Web sites, independent projects, team projects, and supervised research. Even when taking exams, a student is likely to encounter a variety of formats among instructors, including the distinctly American take-home exam.

The norm in Asian universities is to have large lecture courses with exams at the end of the semester, followed by exams at the end of the degree program. That approach provides an additional retrieval opportunity separated in time, which is good.

But in other respects, the Asian system lacks the diversity of contexts that promotes enduring learning. In fact, recognizing that the exams function more as selection filters than as learning-assessment instruments, many top Asian universities are already moving to adopt American innovations.

So what sometimes seems like an anything-goes system of American higher education that needs to be grabbed by the scruff of the neck may actually be cognitively preferable. That's not to say there isn't a gap between what is being done and what needs to be done. In many respects, our pedagogical methods and ways of organizing education are woefully arcane and in need of reform. But straitjacketing the curriculum and the pedagogy to yield higher test scores on assessment measures at the end of the course of study could undermine our ultimate objectives. In fact, the Spellings Commission's focus on developing common templates for reports of learning outcomes at the college or graduate level could make us less, not more, competitive.

What then, should we be doing?

The Spellings report correctly recommends increasing investment in STEM fields, fostering innovation in teaching, enhancing the internationalization of our campuses to prepare our students for global interaction, and relaxing immigration requirements for qualified international students. It also calls for better college preparation in high school, where the greatest gulf exists between the American and overseas systems.

Beyond that, we should rethink the convenient packaging of our educational system, which makes us feel organized as educators but reduces opportunities for students to learn important principles in diverse contexts. The existing organization of universities into schools, and schools into departments, while important for building rigorous methodological traditions, fails to prepare our students for the complex societal problems that exist in radically multidisciplinary contexts. Communication is poor between humanists and scientists, between pure and applied scientists, between those involved in research and those involved in application and policy, and between the academy and the world beyond.

As one small step to ameliorate that, Tufts University has just begun a seminar program in which faculty members from several schools jointly lead a class of undergraduate, graduate, and professional-school students in studying a complex societal problem — for example, AIDS or climate change — from many angles. At the end of the course, students place a collaborative information product online, projecting their knowledge beyond the academy.

In a seminar on climate change, for instance, students in economics, engineering, medicine, and international affairs would be challenged to revisit the fundamental methodologies, principles, and theories of their disciplines in new contexts. That, coupled with the active nature of the collaboration on a written product, should make it easier for students to retrieve things they have learned in particular disciplines.

Colleges should also expand opportunities for students to work with faculty members on research or to pursue creative work in other active learning settings. And the ultimate remedy to the limitations of how education is packaged is to seek ways to advance lifelong learning opportunities for alumni long after graduation — so that academic material can be revisited over time and in the enriched contexts of life experience.

As for the threat of international competition, American colleges should seek partnerships with Asian institutions to exploit the synergies that arise from our mutual advantages. Asia produces a

richer pipeline of scientists and engineers entering college, while America provides a richer learning experience. In medicine and other health professions, we have a strong pipeline through the undergraduate years, but subsequent training in medical school is getting too expensive to produce the number of professionals needed for the future. Without creative international partnerships in those critical areas, the United States will simply default to importing health professionals to fill the gap. Marrying our educational strengths would be of greater benefit to both economies.

An understanding of how the brain learns suggests that we build on the more varied and innovative approaches of American higher education rather than revert to national templates measuring specific learning outcomes. Meanwhile, as higher education becomes more integrated globally, we should embrace that process, not fear it.

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Section: Commentary
Volume 54, Issue 20, Page A33