

The Case Against Teaching

BY LARRY D. SPENCE

The excitement in the young man's voice jerked me from my musings about the price of his Abercrombie and Fitch T-shirt. He described a terrific course. Offered by the college of agriculture, it consisted of realistic problems tackled by student teams exploring and using the resources of a research university.

"I have never learned so much in a class," he said.

"I didn't even know I could learn like that."

"That professor must be a wonderful teacher," I responded.

The student laughed. "We did all the work; he just assigned the problems and helped out. He doesn't know how to teach."

I could tell many such stories. If professors don't talk and test, the result is the same incredulous response from students. Everyone knows what teaching is, what learning is, and how to improve higher education. Yet no one is satisfied. Today's graduates cannot meet the demands of workplace or community without several more years of learning on the job. They cannot formulate and solve messy real-world problems, work well with others in high-stress team situations, write and speak forcefully and persuasively, or improve their own performance.

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We won't meet the needs for more and better higher education
until professors become designers of learning experiences and not teachers.

Critics point to large classes, indifferent professors, unprepared students, poor management, weak accountability, and underutilization of technology as causes. They call for more funding to reduce class sizes, expand use of technology, give rewards for teaching, and train faculty to talk and test better.

The great American radical orator Wendell Phillips told a parable about a sage summoned by the emperor of China. The emperor asked the sage what was the most vexing problem blocking improved policies. The sage replied: "The rat in the statue."

"Rat in the statue!" roared the emperor, "What nonsense."

"It is not," said the sage. "Most households keep wooden statues to honor their ancestors. Frequently rats gnaw nests there and pillage the house. Should people preserve the sacred images and suffer the rats or burn the statues to destroy the vermin?"

In Phillips' time the rat was the implicit constitutionality of slavery. In higher education the rat is a set of erroneous assumptions about learning that remains hidden in our hallowed image of the teacher.

As the founding director of the Schreyer Institute for Innovation in Learning at Penn State University, I worked on more than 170 projects to improve learning while reducing costs. Most of them improved learning, but all of them cost more in faculty time and support. Few improvements lasted. We survived such failures by calling them experiments and trying to learn from them. The result of that learning is the following argument:

Premise 1: Teaching is a human endeavor that does not and cannot improve over time.

Premise 2: Human beings are fantastic learners.

Premise 3: Humans don't learn well in the teaching-focused classroom.

Conclusion: We won't meet the needs for more and better higher education until professors become *designers of learning experiences* and not teachers.

Why is this argument important? Education has never been more essential to our survival than it is now. We no longer generate wealth by applying force to nature but with our ideas. Where we once lowered costs through mass production, we do it now through flexible production. The first method repeated one best process and required persuading millions of people that they wanted the same product. The second uses data processing to guide machines that can produce a myriad of product varieties tailored to individual needs. To compete today, companies must devise new processes and create new products. Dependent on employee ingenuity and driven by sophisticated customers, they can command routines for neither.

Flexible production demands people who are creative, critical, and decisive. Having a broad understanding of technology, organizations, markets, and cultures, today's workers constantly appraise and modify their work systems. They

interact intensively using subtle social skills of negotiation, consensus-building, and confrontation (see Berryman and Bailey, in *Resources*).

In an information-rich society, everyone must become a connoisseur of knowledge. If you buy a car, replace your roof, raise a child, take prescription drugs, consult a doctor, invest money, eat food, or try to lose weight you confront a deluge of information. In policy arenas, issues grow more complex. You can rely on experts only at great risk since their narrow focus guarantees ignorance of human needs. This world that clamors for our ideas, dollars, and loyalty simultaneously demands a knowledge of self and science that far exceeds past educational aspirations.

In the past 100 years, the proportion of college graduates has increased from 3 percent to 32 percent of high school graduates. Future demands will likely double that. This burgeoning student body does not need to learn more facts but how to think, decide, judge, create, and learn. The shelf-life of knowledge is also shorter. Where four years of education used to suffice, the 40 years of a working lifetime is now the standard.

Throughout the 20th century, reforms have washed through the education system leaving puddles of improvement. Yet Dewey's laments about the state of education in 1890 sound as if they were written today. Historians of education recount a steady cycle of failed reforms whether based on new technologies, new management and budget procedures, new reward structures, or the new magic of competition.

Why is education more resistant to innovation than business, agriculture, or communication? Because parents, reporters, citizens, children, politicians, and professional educators share an unshakable image of what teachers and students are supposed to do. A common machinery of schooling prevails from kindergarten through corporate training programs. And these accepted arrangements and practices are what we think a "real" school, a "real" university, or a "real" training program ought to look like. Its assumptions are that teaching is telling, learning is absorbing, and knowledge is subject-matter content. Teachers tell you what to learn and how to learn it. Physical and institutional arrangements are teacher-focused and stimulus-deprived. A bureaucratic schedule of instruction, cottage-industry course design, isolated delivery, rote-detail testing, and an antiquated curriculum complete the picture. This machinery has successfully processed large numbers of students for more than 150 years. It can't be wrong—or can it?

Premise 1: Teaching is a human endeavor that does not and cannot improve over time.

For just a moment, assume that time travel is possible. Plop a medieval peasant down in a modern dairy farm and he would recognize nothing but the cows. A physician of the 13th century would run screaming from a modern operating room. Galileo could only gape and mutter touring NASA's Johnson

Space Center. Columbus would quake with terror in a nuclear sub. But a 15th-century teacher from the University of Paris would feel right at home in a Berkeley classroom.

Think of where we would be if agriculture had never improved—or transportation, manufacturing, communication, or science. Isn't it strange that teaching does not? Sometimes we say it is one of the most important of human endeavors. But there is no Nobel Prize for teaching. Sometimes we say that those who can do and those who can't teach. What kind of an activity is this that we say is important but don't try to improve, that we declare is among the highest of human callings but rarely reward, and that we simultaneously celebrate and ridicule?

We are born to teach. Like speech, teaching is an instinctive and unconscious human ability. Listen to a grownup talk to a baby. When I talk to my grandson, this happens: I raise the pitch of my voice. My intonation becomes singsong and melodic. I slow down my speed and exaggerate the sound of my vowels. I say things like: "Hiiiiiii, Carsooon. Shoow me yoor pretty eeeyes, oooh pretty, pretty eeeyes. Got a biiig smile for granpaa? Hoow aabout a biiig smile?" I sound like an idiot. My grandson loves this talk. He listens. He cocks his head in interest. He smiles and laughs. He shrieks from some secret reservoir of joy and delight. What is going on?

Researchers like Alison Gopnik and her colleagues tell us that "motherese" like this is a universal phenomenon (see *Resources*). Put adults from any culture in the company of an infant and they will raise the pitch of their voices, slow their speech, exaggerate sounds, and talk what sounds like rubbish. Most people aren't aware that they do this. Confronted with recordings of themselves talking this way, people are surprised.

It works wonderfully well. Babies prefer it to normal speech. The short sentences and repetitions with slight variations help children learn vocabulary and grammar. Studies show that the consonants and vowels of "motherese" are clearer and more accurate than in the fast, sloppy talk of adults. This seeming babble thus helps babies solve the particular problems posed by their native languages.

"Motherese" is just one example of the way we respond automatically to children's need to learn about language, objects, rules, and about the multiple and complex nuances of the cultures that they must master in order to survive. In such situations, human beings seem to be unconscious teachers. Adults function as tools that children use on an as-needed basis to solve particular learning problems. Researchers who

watch parents with babies remark on all adults' instinctive ability to give children just the information they need to progress.

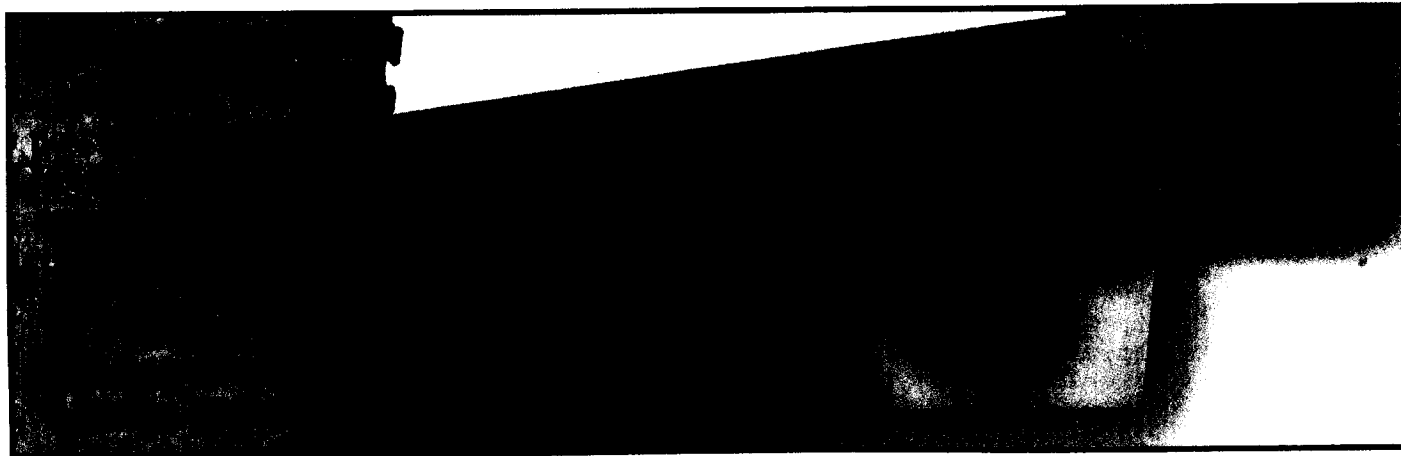
Similarly, we respond with acuity to the questions and performances of other individuals including co-workers, family members, or friends. We are so well designed to teach other people that we can't conceive of teaching any other way. We haven't improved teaching for 4,000 years because it works so well one-on-one that we believe we understand how it works in general.

A distinguished researcher in, and incisive critic of, higher education recently filed this entry on the Internet:

I believe we would all agree that the absolute best teaching-learning-assessment model is the one-on-one Socratic apprenticeship model with unlimited time with the student. But, ever since Socrates took on two students rather than only one (in order to double his income), teachers have had to make compromises in their teaching techniques. All of the educational research since that time has been focused, essentially, on the problem of how to compensate for these compromises and still get students to learn....

The problem is this: You can't. The telling-teacher approach works one-on-one because it is unconsciously attuned to student responses. Every step in scale beyond one-on-one decreases effectiveness. Student numbers like 50, 100, and 300 or more in a classroom, are not a compromise but a disaster. When professors don't have enough time or energy to attend to everyone individually, they practice a superstitious ritual aimed at the imaginary individuals they think they see out there. Because humans can learn under almost any circumstance, a small number still succeed. But that apparent elite fools us into thinking we are effective. Worse, these students become the next generation of professors.

This phenomenon isn't unique in human history. Medicine didn't improve for thousands of years until it became science-driven in the early 20th century. Much as ancient physicians once did, teachers practice a craft of imitation and habit. Their success depends on their interpersonal skills and willingness to exploit themselves and their families in order to carve out extra time to spend with individual students. Sitting on committees to review professors for teaching awards, I read recommendations like "X" is enthusiastic, "X" is devoted to her students, "X" is adored by his students, "X" goes out of her way to work with students, and so on. No one found this unusual. I asked,



“Would you hire a lawyer, a brain surgeon, or a bricklayer on these grounds? Would you follow advice that said, ‘Have surgeon Slickcut do your heart bypass. He’s enthusiastic?’”

If members of another profession—say surgeons—were like college teachers, they would perform in isolation without apprenticeships, learning to cut and sew by trial and error. They would know anatomy but be ignorant of biology. They would hold colloquia discussing incision tips and suture innovations. To demonstrate the quality of their work, they would ask surviving patients to fill out bubble-sheet questionnaires with items like: “Does the surgeon demonstrate a commanding knowledge of his field? Is the surgeon well organized? Did she show respect for patients?” No one would look at survival rates.

Combining the attributes of a talk-show host with vaudeville shtick, award-winning teachers entertain and inspire. University publicity flacks use phrases like “classroom pizzazz,” “high-velocity learning,” “the magic of great teaching,” and “lessons coming alive.” Outstanding lecturers cover every free inch of floor space during their presentations, come to class with carts piled with enough props for an opera, sport eye-slammng costumes, and give “high-voltage” performances. Another version is the researcher who discovers wonders in the laboratory and bursts into the classroom blood-stained and breathless to regale students with his latest discovery in biotechnology. Images like these abound in nearly every alumni magazine in the country. According to these stories, the keys to classroom success are energy, gadgets, and wisecracks. Students testify to fun and entertaining classes. Nowhere in the descriptions of these outstanding teachers is there any discussion of what students learn.

The nearest analogy I can imagine would be a baseball game played without anyone keeping score. The best players would be the most enthusiastic and spectacular. Potential players would give talks about their philosophy of hitting, fielding, or pitching, but never any demonstrations. The best fielders would juggle the ball for minutes, and the best pitchers would excel in windups, but turn away without watching the results of their delivery.

Little changed since Horace Mann’s design of 1847, our classrooms reveal hidden assumptions: you don’t have to learn to teach, and everyone begins an expert. Beginning professors thus work in isolation without the criticism, advice, or example of their senior colleagues. Each struggles to learn the same lessons of classroom management. This arrangement guarantees not only the reinvention of the wheel, but

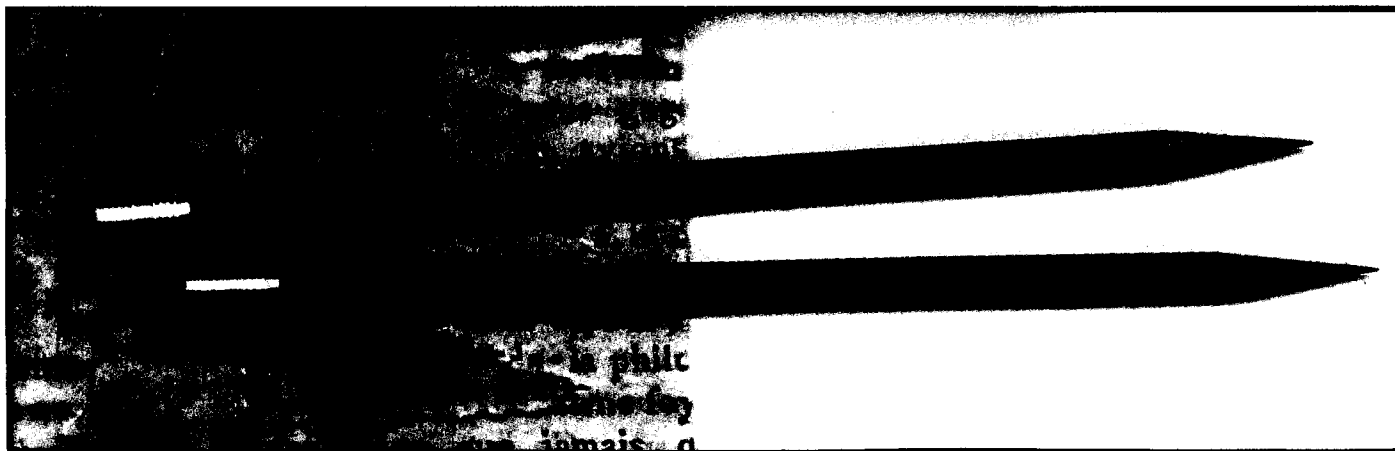
the reinvention of the flat tire. We graduate thousands of new K-12 teachers each year from our universities. Within five years, two-thirds have left education. Such a failure rate underlines the poor environments for and the limited possibilities of successful teaching.

Professors are trained to do research. Then we are told to teach our discipline. And we do. We talk, give quizzes, exams, and assignments. If we are teaching political science, we say “political science” from time to time. We assign grades with minute distinctions. We have office hours. We advise. We get good at being professors—mostly by repeating the behaviors we witnessed while we were students. We know what professors do—they talk, they demonstrate, they write on blackboards or overhead transparencies, and they sometimes ask questions that only they know the answer to. The most advanced use e-mail or CD-ROM textbooks and PowerPoint slides.

The sociologist Lionel Lewis concludes that teaching requires little creative thought (see *Resources*). College teaching, Lewis claims, merely involves some defining of basic terms and ideas, some exercises or drills, some paraphrasing and commentary on texts, and some supplementary materials borrowed from books. A former provost, who really believed that universities should improve their teaching, nevertheless told me on one occasion that teaching made people dull; only research kept brain fires burning.

There is no market for university teaching. Despite pious wishes and table thumping, the correlation between time in the classroom and income is negative. The more you teach the less you earn. That is the market’s stinging rebuke. Periodically, a foundation will have some experts look at this situation. Teaching must be rewarded they declare, so that professors will do it better and more frequently. Academic labor markets ignore them. K-12 teachers fare somewhat better using unions and collective bargaining—tools they borrowed from unskilled workers. If teaching is a knowledge-based profession that shouldn’t be necessary.

The reality is professors who fret over incoherent exam answers, incessant student whining, soporific classrooms, and schedules indifferent to learning. They start semesters with unrealistic goals, work themselves into stupors trying to achieve them, swill bitter coffee, and stagger toward finals in a frenzy of self-exploitation. To keep sane, they work overtime with the most motivated students. If there is a heavenly list of impossible jobs, college teaching is somewhere in the top 10.



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Premise 2: Human beings are fantastic learners—mastering millions of details of language, objects, human behavior, and the patterns of relations among those details. And, they learn all of the time.

Survival drives us to learn. We aren't faster, stronger, or more prolific than other species, but we do learn better. We thrive from the Arctic Circle to the equator, in desert dearth to teeming swamps. We make do under the most absurd political regimes and poorly designed organizations. We do this by learning all of the time, from the womb to the tomb. The practice of our classrooms denies this ability, assuming that learning is difficult, painful, and restricted to a few smart people.

In my high school the hardest class was senior chemistry taught by David Beckmyer. I skimmed the textbook and barely passed the weekly quizzes. I loved "Davey's" (that's what we called him when he wasn't around) knowledgeable and theatrical demonstrations. In the laboratory I was a whiz. At exam time I read the textbook as an interesting guidebook and achieved the highest grades.

This bothered Davey. Beckmyer didn't like my "attitude." He made exams harder. He tried to trick me in the labs with bizarre compounds. At the end of the semester we took a long national standardized multiple-choice exam. Setting a school and regional record, I ranked in the 99th percentile. Davey called me to the office. I thought he would announce that I had won either the American Chemical Society or the Bausch and Lomb Science award.

Instead he said: "Spence, you are some kind of idiot-freak. You have a photographic memory. I don't think you know anything about chemistry. If you think you are going to get an award, you're wrong. You don't deserve it."

I left in dazed disappointment. But I thought: photographic memory—that's great. I won't have to study any more. In the fall, when I started college I applied Davey's theory. The night before each test, I read the text, expecting it to be burnt accurately into my mind. By October, I was failing every subject but gym. What had happened to my photographic memory?

It had never existed. What both Davey and I overlooked was *how* I learned chemistry. When I was 12 years old, I had a friend who liked to blow things up. Billy loved fireworks, which were illegal in Pennsylvania. He loved explosions and the whistle of tin cans flying through the air. He asked me to help him build fireworks. I agreed and in a few weeks we were making our own gunpowder. Near a local dump we set off bombs and rockets, to Billy's great delight.

Fascinated that we could do this with charcoal, sulfur, and saltpeter, I set up a laboratory in the furnace room at home. Over the next two years I learned to build my own batteries, a rectifier so I could tap into the doorbell wiring and convert

it to direct current, and a hydrolysis apparatus to manufacture oxygen and hydrogen—that fabulous exploding gas. I spent hours at this, until my father discovered me producing and bottling chlorine, which I planned to sell to poison rats.

When I entered Davey's chemistry class, I had learned through many failed experiments—non-exploding rockets, blown fuses, and stinging fingers. I understood and retained detailed knowledge of reactions and molecular structures because I had a complex set of experiences that provided a context into which they fit. I learned, but not in the read-the-principle-and-apply-it way that Davey wanted. If you had asked me how I was learning, I would've shrugged my shoulders. The powerful learning seemed like magic or cheating because it had not been taught, it was not hard, and it was wonderful fun.

Learning begins with curiosity. I was curious about how to make an explosion and I started with what I knew. I knew gunpowder exploded and that it was in my dad's .22-caliber shells. Billy and I began by collecting and taking .22 shells apart. The dangerous process was long and morally destructive. Then, one sleepless night, I remembered castaway pirates used charcoal to make gunpowder. The next step seemed obvious. I went to the library determined to find a recipe for gunpowder.

Notice how quickly Billy and I began experimenting. We actually failed our way to large and satisfying blasts. Researchers now know that even babies start out with complex models or theories of reality. Like scientists, they predict. When their predictions fail, they change their models. Children, as Roger Schank points out, are failure machines—and that makes them powerful learners (see *Resources*). Watch children. Their play is a form of inquiry and questioning. They expect results and when they don't happen, they question and revise their actions and expectations.

A human brain is the most complex structure that we have ever encountered. It contains about 30 billion nerve cells. In the cerebral cortex alone there are one million billion connections among the 10 billion cells. The possible connections are unimaginable numbers—10 followed by a million zeros. We don't yet understand exactly how this complex mass learns. We know that the brain is a fantastic device for forming generalized patterns out of experience. It guesses order out of chaos.

We have learned more about learning in the last 30 years than in the rest of human history combined, due to the efforts of cognitive scientists. The cognitive sciences comprise contemporary efforts to understand the nature of knowledge, thinking, and learning involving the disciplines of philosophy, psychology, artificial intelligence, linguistics, anthropology, and neuroscience. These efforts are ongoing and far from definitive. However, early formulations give us fresh ways to understand human learning.

The findings of cognitive science contradict the notion that the mind registers reality like a tape recorder or a camera, and that learning is merely absorption. Instead, the mind builds

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mental constructions that help us order experience. The brain *represents* rather than records reality. Even sight is an act of construction and depends as much on brain processes as on the actual world it seeks to represent. Like an artist, the brain selects, discounting most signals, and seeking constancies that make up our images of the world. From sound and light waves, combined with previous models, it constructs information like "The cat is eating a mouse." And it creates knowledge like "Cats eat mice" that can be used later to predict and control.

Learning is an active process of making changes in the mind's representations by reasoning about the world—not just taking it as it comes. Learning means breaking, making, and remolding connections in our brains. The physical structure of the brain and the inferred representations of the mind depend not only on innate processes, but also on prior experience and knowledge. Everyone has a different brain configuration because everyone has a unique body of experience. Imagine a theory-driven robot that navigates the world by generating maps and acting upon them. When it fails—hits something or careens off a curve—it changes its internal maps until these become quite accurate, detailed, and useful, but never complete. Though our brains work like this, we aren't robots. This gives us another advantage: Learning is self-rewarding and gives us pleasure, just as eating, sleeping, or having sex does.

How do we know when someone has learned? Learning is what researchers call a latent variable. We can't (yet) look into brains to see new connections being made, so we have to infer them from what people do. One-on-one, a teacher can ask, listen, and watch for changes in performance. Problems emerge when we try the same thing with 18, 25, or 100 students. We never have time to query each student or watch each one's performance to infer learning with accuracy. Thus, testing raises its ugly head.

Our testing practices assume that students' brains are homogenous and that they all learn the same things. But that can't be true. Time limits force us to ask students to regurgitate terms, definitions, and formulas a few times a semester and infer learning from the results. This focus on brute recall disrupts learning.

Maybe assessing learning is not as tough as we think. We all know when we have learned. Students know whether they have learned outside the classroom and they recognize it when they are not learning inside. I often hear the remark: "I learned a lot in that class, but my grades didn't show it." Our faith-based testing and assessment practices contradict what we know about how people actually learn.

Premise 3: Humans don't learn well in the teaching-focused classroom.

As a brand-new tenure-track professor, I was shocked that students in my upper-division political science courses seemed never to have encountered basic concepts of economics. I con-

cluded that the economics faculty was incompetent. Then I found that few students could write a persuasive essay, an organized paragraph, or a succinct sentence. I concluded that the English department was incompetent. In my fourth year, I discovered that my former students were just as ignorant of political science. I had taught them. I had tested them. They had passed the tests. But they could not remember what they had learned.

Educators call this a knowledge-transfer or retention problem. A less deceptive name might be failure to learn. Research over many decades shows that individuals frequently do not transfer what they learn in class to what they do in the everyday world. And they do not transfer what they learn in the world to the classroom. More surprising, they don't even transfer what they learn in one class to the next (see Berryman and Bailey in *Resources*). Weeks, months, years after students have apparently learned a subject they cannot recall it. Is it learning if students can't use or remember it? Studies over the last 50 years have reached the conclusion that most students "can't rise above the rote, factual level to think critically or creatively. They can't apply what they know flexibly and spontaneously to solve ill-structured, ambiguous problems that require interpretation" (see Bruer in *Resources*).

Self-deception is fundamental to classroom teaching. Professors typically base grades on three or four data points—two mid-term exams, a project or paper, and a final. A minimal set of observations guarantees that grades won't reliably measure student learning. So disappointing do they find the results of assigning questions or tasks that require real understanding, application, or reasoning that most professors quit. Instead, they indicate what will be on the exams and provide the right answers ahead of time. The system sorts students by degree of compliance and rewards teachers who act tough, but who prudently don't demand understanding.

Few defend this. But the more you teach the more you overlook the phenomenon and celebrate the scattered achievements that occur instead. Some students learn on their own, or by connecting with professors to obtain one-on-one interaction. Professors steal time to work with individual students who are persistent and bright. But most students work for the best grades with the least effort—a practice that actively encourages cheating. Large introductory courses, in turn, invite cramming and minimize the risks of learning. Each student and professor works the system to his or her best advantage. The best learning therefore occurs outside the daily classroom grind.

My own response when confronted with this situation was to employ classroom strategies that emphasized problem-solving, teamwork, extensive homework, and classroom discussion. The gains in learning seemed small at first. But a hidden factor began to improve those results. As my courses became more demanding of student time and effort, most students avoided them. My drop rate reached a steady 20 percent. By the end of the 1980s I was teaching mostly honors and other

highly motivated students in small classes. Working hours increased as my ambition for better learning caused me to spend more time with individual students. I reduced my research efforts to keep up with demand. But after several exhilarating but exhausting years, I reached a limit that I couldn't budge.

Thinking myself a victim of less inspired colleagues and indifferent administrators, ("It's the system," echoed in my head), I began agitating in 1990 for innovation and improvement in undergraduate education at Penn State. With colleagues and administrators I worked to discover and disseminate innovative instructional practices. Such trouble-making landed me the position of the founding director of the Schreyer Institute for Innovation in Learning in 1995.

On assuming my new position, I learned that my dismal conclusions about student learning were not unique. Instructors complained that students could pass tests on a given subject, only to lose their learning the next semester. Surveys showed that students studied, on average, less than 12 hours per week and only worked hard to cram in the few days before exams. Bright students passed tests with high scores but weren't able to formulate or solve realistic problems. Professors bewailed student ignorance of the rules of inference and argument, their poor repertoire of cultural and historical ideas and examples, their lack of motivation, and their propensity to cheat.

Nearly everyone had ideas about the causes of these dismal results. So we tried a lot of things, including teaching critical reasoning, problem-solving, and understanding by adding new courses, using new techniques, or creating new motivations.

We found, though, that professors frequently embraced collaborative, cooperative, or active-learning techniques, but abandoned them after several semesters. We couldn't tell if any of these techniques actually improved learning. But we could document that, at least at first, they pleased both students and faculty members. Over time, though, the faculty effort required, and the meager improvements produced, doomed them.

The morgue-like atmosphere of the traditional college classroom itself forces faculty and administrators to try to improve teaching. Scarcely an institution of higher education exists without a spanking-new center for excellence, innovation, or technology in teaching and learning. Unfortunately, the persistent image of "teaching" channels most efforts into devising fancier ways to do the same old talk and test. The "talk" is now frequently in the form of dreary online text, juiced with charts and pictures. The "tests" are equally tiresome student PowerPoint presentations. Teachers still try to guess (or just make up) what students need to learn, and nervously jam more content into their courses. They reaffirm the ideals of one-on-one teaching extrapolated to multiple learners while using the buzzwords of learner-centered instruction.

What we do when we teach classes and not individuals goes against most of what we know about how people learn. Refuted theories of human learning—associationist, behaviorist, and the ancient image of magic funnels channeling knowledge into student brains—are petrified in our current classroom practices and designs. We have organized classrooms around a bad idea—that of mindlessly amplifying one-on-one teaching.



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A lot of technology in education looks like

bolting an internal combustion engine on the back of a horse and buggy. We get something more exciting and noisy, but the rig can't go any faster.

These conditions keep the "sage on the stage," even if she tries to escape to the side to guide.

Conclusion: We won't meet the needs for more and better higher education until professors become designers of learning experiences and not teachers.

"The best way to predict the future is to invent it," goes an old engineering saying. Throughout higher and K-12 education, teachers, cognitive scientists, and technologists are at work turning our new insights about learning into new kinds of classrooms, curricula, and practices. Our future lies in creating educational environments and experiences that will support our inborn human desire and ability to learn by doing. Better learning at lower cost is possible if we redesign education around the way people really learn.

There are two ways that humans learn—one-on-one and on their own. One-on-one learning will continue to occur naturally in the home, in graduate schools, and in working apprenticeships—indeed, anywhere there are kids or curious adults who want to find out how to do things, and parents, friends, or mentors willing to help them.

The alternative is expert-designed learning spaces and experiences, where numerous students can learn on their own, driven at their own pace and guided by their own interests. Using emerging information technologies, such environments can serve many thousands of students at low per-capita costs. The new task for faculty is to form teams to invent and create such learning environments.

But doing so won't be easy. While everyone is concerned with education today, usually the talk centers around more money, more tests, more gimmicks, and more technology. The current cant is that technology will "transform" education. We put computers in schools, connect schools to the World Wide Web, and translate traditional courses into Web formats. But this expenditure usually only buys technology that replicates the same old approach to teaching based on trying to cram information into empty brains. A lot of technology in education looks like bolting an internal combustion engine on the back of a horse and buggy. We get something more exciting and noisy, but the rig can't go any faster. Information technology will transform education only when we unhitch the horse.

Imagine a university as a kind of learning bazaar. Faculty members work with technologists and cognitive instructional specialists to design scenarios incorporating the latest research. Students can enter these environments at virtually any time they wish, in order to try out their knowledge, fail without risk, and seek coaching when and if they need it. Professors might cycle through periods of intense research, learning-environment design, and coaching. Some talented professors might specialize entirely in either design or research without penalty. Students would spend some of their days (and nights) on the computer, working with interdisciplinary teams on authentic

problems, conducting research with faculty, or even joining learning-design teams. Boundaries between campus and society would be porous. Many students and faculty would engage in learning activities off campus. Citizens, managers, and public officials, in turn, might frequently be seen on campus to participate in design teams, as coaches and as learners.

The Internet and World Wide Web prefigure this new kind of university. Already, the intellectually hungry constantly log on to learn. Their experience exposes traditional classrooms as academic dust bowls. Imagine instead a smorgasbord of learning objects and modules that learners can put together to create their own individual paths of inquiry. Some younger learners may want to live in communities of peers while they do this. Others, in diverse communities, may want to stay at work and participate largely virtually.

We are already building this future. For some it seems vivid and compelling. For others it is fantasy. Some will experience it as their worst nightmare—undergraduate education without the stentorian lecture, the straitjacket curriculum, and students sorted according to docility and verbal facility. But two pervasive demands drive my conviction that it will indeed occur. The first is the compelling need of business for graduates who are constant, active, and adaptive learners. That need is profit-driven, which in our society means it is real. Howard Block, of the Bank of America, says that learning is "almost the sole source of competitive advantage" in our rapidly changing economy. A 1999 report from Merrill Lynch estimates the global market for training and education to be \$2 trillion annually. The domestic U.S. market is around \$740 billion. Of that market, K-12 accounts for \$360 billion; higher education, \$237 billion; and corporate and government training, \$98 billion.

Unfortunately, corporate training is just as teaching-centered as our schools. As Schank writes, you can sum up the problem with business training in five words: "It is just like school" (see Schank in *Resources*). The money and effort now spent on training are not paying off. Once businesses realize this unalterable bottom line, the drive to find new ways for employees to learn will decisively break the teaching-as-telling prejudices of current corporate human resource departments.

A second impetus is an emerging generation of students that is sometimes referred to as the twitch generation. Kids raised in the visual and highly interactive environments of today's sophisticated computer games are used to this mode of learning and its joys. Expecting learning to be about doing, to relate to their interests, to be fun, and to pay off immediately, they strongly resist traditional teaching. Instead, they treat typical classroom assignments like the throwaway instructions you get with a new computer. They read, regurgitate, and toss. As John Katz points out, "Their digital world is much more vital, colorful, and engaging than their educational one" (see Katz in *Resources*). As a result, they slack and cheat in school. Only the bribe of credentials keeps students at what they see as meaning-

less tasks that we set. Consequently, they concentrate on getting their diplomas with as little effort and time as possible.

You can find examples of the education of the future in many primary schools, sometimes in middle schools, rarely in high schools, and more rarely still in universities and corporate training programs. Examples are in charter schools, in the learning software designed by Roger Schank and his associates, in the tutorial designs of Alfred Bork, in the Math Emporium at Virginia Tech, in the multimedia work of Vanderbilt's Learning Technology Center, and in problem-based learning curricula at institutions such as Penn State's School of Information Sciences and Technology, the University of Delaware, the University of San Diego, and Samford University. Building this future goes on in pockets all over the place, however starved for funds and thwarted by traditions.

I sincerely hope that universities will eventually lead this effort—though such change will happen whether they do so or not. The cognitive scientists work there. Their faculties witness firsthand the failures of the current system in the mis-educated students whom they must try to teach. There are too many students, too few teachers, and too little money for traditional institutions to survive unless they reinvent their operations. We are hovering on the edge of a transformation of undergraduate education from a practice based on habits, hearsay, and traditions to a science-based practice—similar to the transformation of medicine in the 20th century. I'm convinced that we will be successful. But only if we remember the motto that has guided my work in the last decade: "It's not the teaching, it's the learning, stupid." □

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