How Do We Transform Our Schools?

→**Use technologies that compete against nothing**

Teachers, administrators, researchers, reformers, government leaders, parents, and others have long extolled the benefits that computer-based learning could have in schools: Educational video games, often referred to as "edutainment" or "serious" games, could make learning fun and motivating, especially for today's students. Computers offer a way to customize instruction and allow students to learn in the way they are best wired to process information, in the style that conforms to them, and at a pace that matches their own. Computer-based learning on a large scale is also less expensive than the current labor-intensive system and could solve the financial dilemmas facing public schools.

For all these reasons and more, taxpayers, philanthropies, and corporations have spent more than $60 billion to equip schools with computers in just the last two decades. And yet the machines have made hardly any impact. As Stanford professor Larry Cuban has documented, computers have merely sustained how schools already operate. Computers typically sit quietly, unused, in computer labs and in the back of classrooms. True, students do research on the Internet; they type up reports using word processing programs; they might even construct multimedia presentations with them. Teachers sometimes use them to present content. And schools teach computer skills. But computers have not fundamentally transformed the way learning is accomplished or how the

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classroom operates. Computers do not deliver instruction. The teacher is still at the center of the classroom. And research shows that students who have access to computers in school don't necessarily perform better on standardized exams.

That schools have gotten little back from their investment in technology should come as no surprise. Virtually every organization does the same thing schools have done when implementing an innovation. An organization's natural instinct is to cram the innovation into its existing operating model to sustain what it already does. This is the predictable course, the logical course—and the wrong course.

The way to implement an innovation so that it will transform an organization is to implement it disruptively—not by using it to compete against the existing paradigm and serve existing customers, but to let it compete against "non-consumption," where the alternative is nothing at all.

The Disruptive Innovation Theory

To convey what we mean, we first need to explain what disruption is. In every market, there are two trajectories: the pace at which technology improves and a slower pace at which customers can utilize the improvements. Customers' needs tend to be relatively stable over time, whereas technology improves at a much faster rate. Products and services that are initially not good enough for the typical customer ultimately pack in more features and functions than customers can use.

We call innovations that sustain the leading companies' trajectory in an industry *sustaining innovations*. Some are dramatic breakthroughs, while others are routine. Airplanes that fly farther, computers that process faster, and televisions with

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incrementally or dramatically clearer images are all sustaining innovations. Importantly, it does not matter how technologically challenging the innovation is. As long as the innovation helps the leaders make better products that they can sell for better profits to their best customers, they figure out a way to do it.

On occasion, however, we see a *disruptive innovation*. A disruptive innovation is not a breakthrough improvement. Instead of sustaining the leading companies' place in the original market, it disrupts that trajectory by offering a product or service that actually is not as good as what companies are already selling. Because the disruptive innovation is not as good as the existing product or service, the customers in the original market cannot use it. Instead, the disruptive innovation extends its benefits to people who, for one reason or another, are unable to consume the original product, so-called non-consumers. Disruptive innovations tend to be simpler and more affordable than existing products. This allows them to take root in simple, undemanding applications within a new market or arena of competition. Here, the very definition of what constitutes quality, and therefore what improvement means, is *different* from what quality and improvement mean in the original market. Because the definition of performance is so different and the industry leaders' customers cannot use the product, those companies have a difficult time implementing disruptive innovations.

Little by little, the disruption predictably improves. New companies introduce products that for them are sustaining innovations along their trajectory. And at some point, disruptive innovations become good enough to handle more complicated problems and take over, and the once-leading companies with old-line products go out of business. A few examples illustrate how this has happened time and again.

The Tale of the Transistor, a Disruptive Innovation

In 1947, scientists at AT&T's Bell Laboratories invented the transistor. The new invention was not as good as vacuum tubes, the established technology at the time. The transistor could enable smaller, less power-hungry devices; it could not handle the power that the electronic products of that age—tabletop radios, floor-standing televisions, and early digital computers—required. Still, all the vacuum-tube companies like Radio Corporation of America (RCA) saw the transistor's potential and took a license for it. They tried to enhance transistors so that they could produce the power required for the big televisions and radios of that age. Adjusted for today's dollars, RCA and the other vacuum-tube companies spent upward of $1 billion trying to make the transistor work in the market as it existed at that time.

While RCA's engineers were in their labs working to improve the technology, the first commercial application for the transistor appeared in 1952. It was used in a little hearing aid, an application where the transistor's lower power consumption was highly valued. A few years later, in 1955, Sony introduced the first battery-powered, pocket transistor

radio. In comparison with the big RCA tabletop radios, the Sony pocket radio was tinny and static-laced. But Sony chose to sell its transistor radio to non-consumers, teenagers who could not afford a big tabletop radio. The transistor radio allowed teenagers to listen to music out of earshot of their parents because it was portable, and although the reception and fidelity weren't great, the new device was far better than the alternative, which was no radio at all. The pocket radio was a big hit.

As Sony made a profit on this simple application, it improved the technology. In 1959 Sony introduced its first portable television using the transistor. Again, Sony's TV found a ready market because it competed against non-consumption. Sony's use of the transistor enabled a whole new population of people, whose bank accounts and apartments had been too small, to own a TV. By the late 1960s, the transistor had improved to the point where it could handle the power required to make larger products, and all of the vacuum-tube companies, including RCA, vaporized.

This is a punishing but predictable tale. RCA spent far more than Sony ever did on improving the transistor. But RCA could only service its customers by making transistors more cost- and performance-effective in its existing markets. In the 1950s and early 1960s this was a very difficult technological obstacle for RCA to surmount. Sony went in a completely different direction. It deployed the transistor against non-consumption to create a product that was better than nothing. And that presented a far less ambitious technological hurdle at the outset.

RCA did what nearly all organizations do: it crammed the innovation into its existing model. By doing so, the company added supplemental costs to its operations and transformed nothing. We have observed this pattern in all the disruptions we have studied—it is a law of innovation. And in following this pattern, schools have been no different from other organizations.

Competing against Non-Consumption

How should computer-based learning suppliers transform schooling? They must introduce the technology to compete against non-consumption. When Sony introduced its first transistor pocket radios, it sold them to teenagers who had nothing at all. When Apple introduced its early personal computer, the device was not good enough to compete against the mainframes and minicomputers of the time, so Apple didn't try to compete head–on: it sold the personal computer as a toy for children. Ultimately, the personal computer disrupted the

market for larger computers. When Toyota entered the U.S. market, it didn't start by attacking Ford and General Motors with the Lexus. Toyota introduced a crummy Corona that was cheap enough to allow people who could not afford the Ford

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and GM vehicles to buy cars. Toyota gradually improved its products and has now surpassed Ford in the U.S. market; GM, too, sees Toyota in its rearview mirror.

At first glance there appears to be little non-consumption of education in the United States since students are required to receive schooling. Looking deeper, however, reveals many pockets of non-consumption where students would be delighted with computer-based learning rather than the alternative, nothing at all.

Take Advanced Placement (AP) courses for starters. According to a 2005 report by the National Center for Education Statistics (NCES), 33 percent of schools nationwide offered no AP classes in 2002–03. Those that do provide AP courses today only offer a fraction of the 34 courses for which AP exams are available, because they lack the resources to hire more AP teachers or there is not enough student demand to justify a dedicated course and teacher. But there are many individual students who want to take AP classes for whom computer-based learning would be a welcome option. Credit recovery is another big opportunity. For many students who fail a class, there is no remedial option available. This creates big problems for students moving forward toward graduation as well as a market for such an alternative.

Among the emerging players is Apex Learning, a for-profit company. Apex started off by offering AP courses online. In 2003–04, there were 8,400 enrollments in Apex's AP courses; by the 2006–07 school year, that number was 30,200, a compound annual growth rate of over 50 percent. Apex has expanded to credit recovery by offering online core classes as well. Over its history, Apex has had more than 1 million enrollments and served over 4,000 school districts.

Smaller, rural schools are another example of non-consumption. Because of limited resources, including numbers of teachers and students, those schools struggle to offer breadth in the curriculum. Regulations in No Child Left Behind that require districts to have "highly qualified"

Learning at a Distance (Figure 1)

The percentage of American schools that reported pro-viding students with access to online distance learning in 2005 was already surprisingly high.
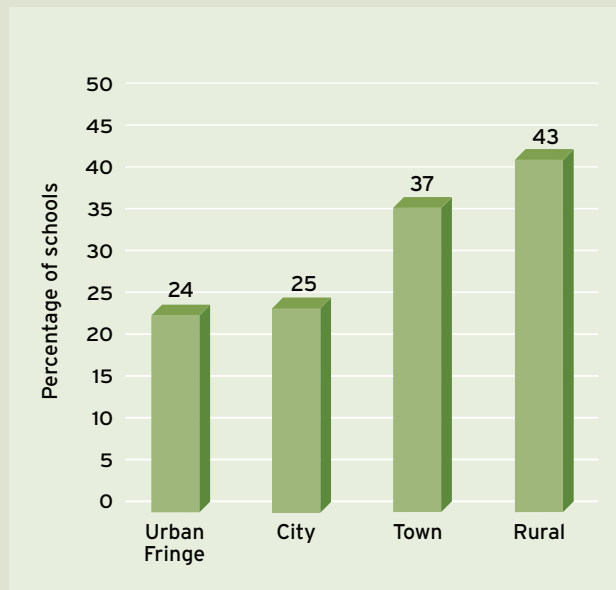
SOURCE: National Center for Education Statistics, 2006, "Internet Access in U.S. Public Schools and Classrooms: 1994-2005"

Just Like Being There? (Figure 2)

In 2003, two-way interactive video was the most common technology for online distance courses in the United States.
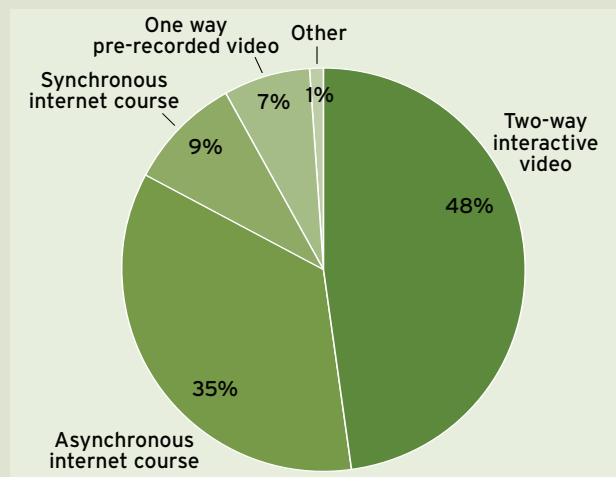
NOTE: One-way pre-recorded video is not interactive. Two-way interactive video enables instructors and students to see and hear each other. Synchronous Internet courses are conducted in real time, with participants communicating directly. Asynchronous Internet courses are self-paced; interaction occurs intermittently.

SOURCE: National Center for Education Statistics, "Distance Education Courses for Public School Elementary and Secondary School Students: 2002–03"

teachers in each subject have further constrained these schools' offerings. As a result, there are many classes that are not taught, and many students who would treasure the opportunity to take them. Many advanced courses—those math courses that follow algebra and geometry, honors English classes, and science courses more advanced than general biology—are missing in thousands of schools. A 2007 U.S. Department of Education report indicated that more than 25 percent of high school students attend schools that make no advanced courses available to them at all!

More than twenty-five states now have organizations providing web-based courses. Utah's Electronic High School started up in 1994 and has expanded rapidly. One-third of Utah high school seniors last year had taken a class online. In Florida, the Florida Virtual School (FLVS) has also been a leader in the field. From its small beginnings in 1997, FLVS served 52,000 students in 92,000 individual course enrollments in 2006–07. The Georgia Virtual School, which opened in 2005, had 4,600 students enrolled by the 2006–07 school year.

One other sizable market for computer-based learning is home-schooled and homebound students. The number of home-schooled students was 850,000 in 1999; home-schooling groups now estimate that number has risen to

around 2 million students. There are also many students who cannot attend any or some of the school day for a variety of reasons. For them, even simple forms of computer-based learning can help ensure they don't fall behind (see Figure 2).

Predicting Growth

When a new approach or technology substitutes for the old, the pace of substitution almost always follows an S-curve, as depicted on the left side of Figure 3. The initial adoption is very slow, and then at some point the world flips and the substitution proceeds rapidly. The problem is that the S-curves are sometimes steep and other times gradual, so it is hard to know when the rapid adoption will begin. But there is a way to forecast the flip. First, one must plot the percentage of market shares held by the new, divided by the old (if each has 50 percent, the ratio will be 1.0) on the vertical axis. Second, the vertical axis needs to be arrayed on a logarithmic scale—so that .0001, .001, .01, .1, 1.0, and 10.0 are all equidistant. When plotted in this way, if disruption is truly happening and there is an S-curve developing, the data will fall on a straight line. Sometimes the line slopes upward steeply, and sometimes it is more gradual. But it is always straight. The reason is that the mathematics linearizes the S-curve. When the

Sunny Skies Ahead (Figure 3)

Current growth trends indicate that 50 percent of all courses in grades 9–12 will be taken online by 2019.

Estimated and projected online enrollments of U.S. public school students in grades 9-12
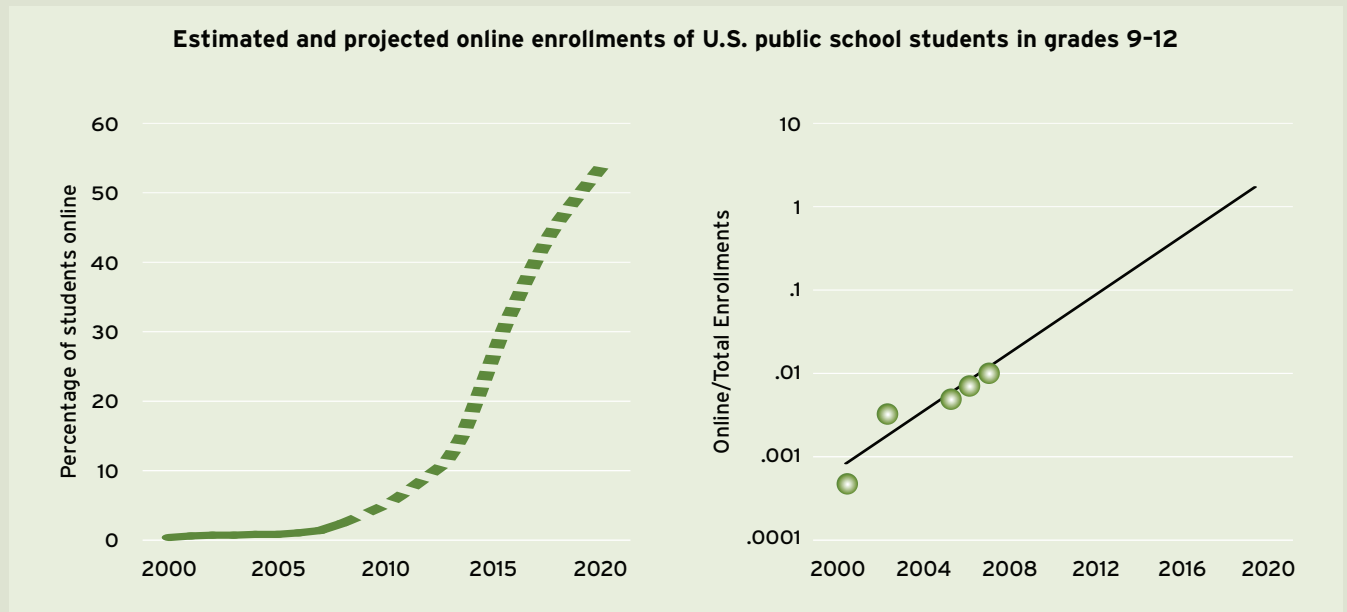
NOTE: Value of 1 on the logarithmic graph indicates 50 percent market share (50%/50% = 1).

SOURCES: National Center for Education Statistics; Babson Survey Research Group; North America Council for Online Learning

pace of substitution is plotted in this way, one typically can tell before the new approach accounts for 2 to 3 percent of the total what the slope of the line is. That makes it easy, then, to extend the line into the future to obtain a sense of when the new innovation will account for 25 percent, 50 percent, and 90 percent of the total. We call this line a "substitution curve."

When we plot the education data for online learning over the traditional approach, the data since 2000 fall on a straight line, as shown on the right side of Figure 3. According to the North American Council for Online Learning, online enrollments in 2000 were 45,000; they had grown 22 times by this most recent year to roughly 1,000,000 enrollments. About 70 percent of these enrollments have been in high schools. Even with this rapid percentage growth, however, online courses accounted for just 1 percent of all courses in 2007. If one projects linearly into the future based on data through the year 2007, it would appear that not much change is on the horizon. But when viewed from the logarithmic perspective on the substitution curve graph, the data suggest that in about six years 10 percent of all courses will be computer-based, and by 2019 about 50 percent of courses will be delivered online. In other words, after a long period of incubation,

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the world will be poised to begin adopting computer-based learning at a much more rapid pace.

This is happening because computer-based learning possesses technological and economic advantages compared to the traditional school model. Economically, while estimates vary depending on circumstance, many providers have costs that range from $200 to $600 per course, which is less expensive than the current schooling model. For

computer-based learning to continue its disruptive march into education, legislatures must not fall into the trap of allocating the same per-pupil funding to computer-based learning that school districts receive. The reason? Disruptions rely on asymmetric motivation, in this case, gradually taking on courses that the incumbent is relieved not to do and happy to hand off. Directly targeting a school district's funds evokes a competitive response that clamps down on the innovation. And technologically, computer-based learning has the potential to scale quality with relative ease—a dramatic advantage.

Computer-based learning has another technological advantage that is crucial to its expansion: one can customize it to meet different students' needs. Currently, according to reports, computer-based learning works best with the more motivated students; over time, it will become engaging and individualized to reach different types of learners. If growth continues, it will be because computer-based learning itself will have improved to better meet these different needs.

Further Improvement

The current commercial system in education moves through five steps: 1) the writing of concepts in textbooks, 2) the adoption decisions by districts and states, 3) the delivery of the content by teachers, 4) some individual help from teachers, and 5) assessment. The most crucial stages that determine what learning products reach students are the first two.

In the first step, people delineate the concepts and methods that schools will teach in textbooks and other instructional tools. The economics of the textbook business are scale intensive: the fixed costs of writing, editing, and setting up to print and bind a book are the same, whether 1,000 or 1 million copies are sold. This means textbook companies benefit by selling to a large, monolithic audience; customization in their business is not desirable.

At the second step, committees at the district and state level make decisions about which of these textbooks to adopt. Again, this step is far more amenable to a large-scale product. Curriculum experts who make these selections tend to be trained in the dominant pedagogical paradigm of that field, so, consciously or not, they tend to pick books that match that dominant paradigm. Furthermore, administrators have centralized this decision-making process out of concern for quality and cost. With a full district or state behind

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a decision, administrators can negotiate better prices for a uniform district-wide product. They realize that no single text can be effective for each student because different students learn differently. But they can ill afford to have thousands of different texts, each paced to the style and skill level of an individual student. Forced to choose a single text for all students to use, the best they can do is to find a one-size-fits-as-many-as-possible solution.

Admittedly, textbook publishers pack in features to appeal to different types of learners, as they hope to reach as broad a range of learning styles as possible. But textbooks by their very nature are fixed and static. Adding materials to a textbook increases its size, weight, and complexity. Many a student drags home a backpack full of fat texts containing hundreds of pages he will never read. Although software also increases in size and complexity with additional features, the student does not have to deal with this increased complexity directly. Programmers can build multiple paths into a program to adjust for a student's progression. The student need not see whole swaths of the software that are not relevant. Integrated software solutions can both build large-scale offerings *and* customize for different learners. But this will not be inexpensive, or accomplished without disruption.

Disruption tends to be a two-stage process. Those who initially create the integrated alternative can sell the new products through the existing commercial system. As the technology matures, less expensive solutions emerge. At this point in the disruption, the commercial system typically changes. Disruption of the commercial system enables less expensive solutions to reach new markets and take root.

To illustrate why the existing commercial system almost never remains in place, let's revisit the story of Sony and the transistor. RCA and the leading vacuum-tube companies of the time sold their products through appliance stores. Appliance stores made most of their money not from selling televisions and radios, but from repairing the burned-out vacuum tubes in the products they had sold. When Sony introduced its pocket transistor radio, the corporation tried to get the appliance stores to carry its products, too. But the appliance stores refused. Why? Because Sony's solid-state products contained no vacuum tubes that would burn out. Luckily for Sony, however, discount retailers Kmart and Wal-Mart were emerging at that time. They had not been able to sell vacuum tube-based products

because they couldn't service them in the aftermarket. The fit was perfect: products that needed no service, sold through a channel that could offer no service. By the mid-1960s, it wasn't just Sony that disrupted the vacuum-tube companies; suppliers of miniaturized solid-state components disrupted the makers of high-power components; and the discount sales channel disrupted the appliance stores. One entire commercial system disruptively displaced the existing commercial system.

Direct to the User

So in education, too, a new chain will likely emerge to disrupt the old. Where might this take place? The education software business will have to develop a disruptive distribution channel to reach students. To get an idea of what this might look like, think about the transformation currently happening in the pharmaceutical business. Historically, companies marketed drugs to doctors and hospitals—by professionals to the professionals who were most highly qualified to judge the efficacy and economics of the available therapeutics. This is very similar to how companies have sold textbooks.

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Anyone who watches television now, however, sees a dramatic shift taking place in the way companies market drugs. Increasingly, companies are marketing drugs to the patients themselves, in hopes that they will then call their physicians and ask for a prescription for the drug they learned about on TV. Why is this happening? One reason, of course, is that doctors are becoming so busy that more and more of them simply can't make time during their day to see the drug companies' sales reps. Perhaps a more profound reason, however, is that many patients are in better touch with their personal health—especially as it relates to chronic diseases—than we've given them credit for. Sometimes learning of the availability of a solution to a problem

helps the patients diagnose the problem themselves, and then they can tell their physician about it. Web sites like D-Life (for diabetes) and Crohns.org have emerged to help patients and their families diagnose what's wrong, evaluate possible solutions, and then teach each other techniques for living with their diseases.

Similar solutions will emerge for education software in the big areas of non-consumption outside of school, like personal tutoring, home schooling, and afterschool programs. A student struggling with a certain concept, or her parent or teacher, will be able to log on to a web site where she can find a software solution that another student, parent, or teacher developed for that specific challenge. By means of such sites, students will teach students, parents will teach parents, and teachers will teach teachers. Parents and teachers, moreover, will be able to diagnose why children are not learning and find customized instructional software written to help students who closely match their child in learning style. As content is used over time, users will rate it, as they rate books on Amazon.com and movies on Netflix. That will not happen en masse until the technology has matured, but as it does, people will gradually link together various modules to form more comprehensive classes. And then end users will pull this content, rather than have school systems push it to them from on high. With users building the content and using open-source tools, the software will be far less expensive than if it had been commercially developed from scratch.

No one knows for sure what the education world will look like in the future. But if the path we are on continues, ten years from now we are likely to have a completely different discussion about the impact computers have on schooling and on learning. The only way to get to that point, however, is by not repeating the mistakes from the past. Pitting computer-based learning directly against teachers or continuing to cram it into schools will not work. Producers of computer-based learning software must introduce it disruptively, by letting it compete against non-consumption initially. And software makers must customize the software for different learning types while other entrepreneurs find new channels to reach students. If all this happens, those who have extolled the benefits of computer-based learning might finally be able to see its promise materialize.

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