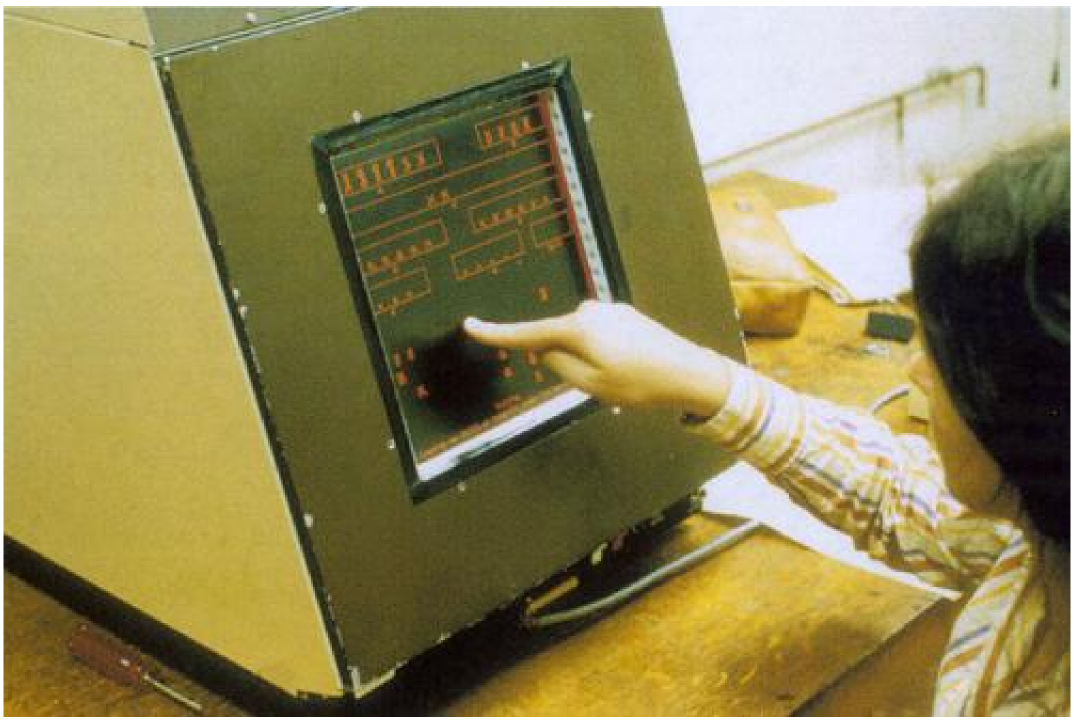
Some "next big things" in teaching technology never quite were

January 8 2015, by Anne E. Bromley



The PLATO machine in the 1960s was a pioneer of e-learning. Credit: Courtesy of Bill Ferster

From 15th-century, one-page hornbooks to "teaching machines" such as PLATO, to massive open online courses, or MOOCs, visionary educators long have trumpeted new technology to revolutionize classroom learning.

So far, however, none of these heralded innovations have received an A, according to Bill Ferster, a research professor in the University of Virginia's Curry School of Education.

Ferster discusses the pursuit of technological innovations to improve education in his new book, "Teaching Machines: Learning from the Intersection of Education and Technology." He analyzes why the ideas rarely became successful and why he remains hopeful that the pace of change today will yield better results in the near future.

"My own reasons for wanting to get involved with educational technology stem from seeing a disconnect between what I know technology to be capable of and its (still) largely unrealized potential for providing meaningful support for learning," writes Ferster, who's also director of visualization for the Sciences, Humanities and Arts Network of Technological Initiatives, known as SHANTI.

Below are excerpts from Ferster's book that present a few examples of teaching machines and programs over the past 60 years that sought to improve learning and make education more efficient.

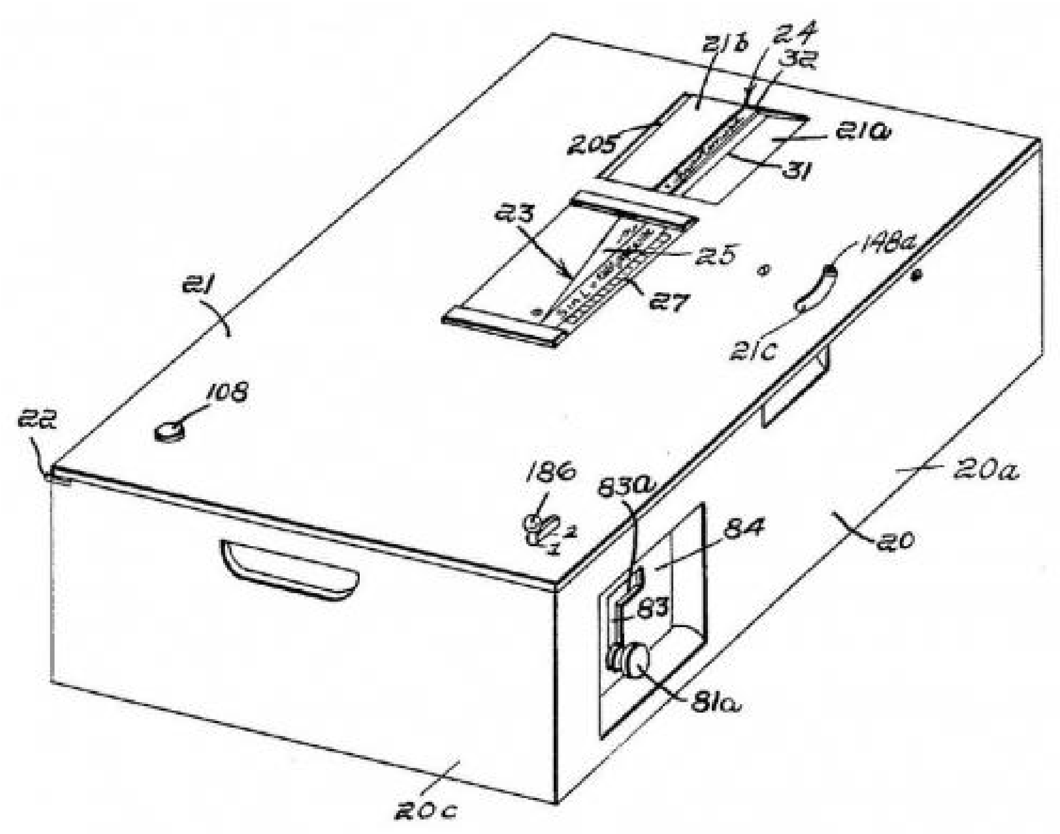
Skinner's Machine-Reinforced Feedback

While attending a back-to-school event at his youngest daughter Debbie's school in 1953, influential psychologist B.F. Skinner watched as her teacher taught fourth-grade arithmetic. After writing the problem on the blackboard, the teacher would walk up and down the aisle, occasionally pointing out the children's mistakes. Some students finished quickly and sat bored while others continued to work the problems. The teacher collected the papers, graded them and returned them to the students the following day.

This immediately gave Skinner insight into some problems in the pedagogy, as well as an idea toward their solution. Skinner knew that a corrected paper seen 24 hours later could not serve as a reinforcer and did not present a good scenario for learning. Understanding the value of using mechanical devices in his experiments with pigeons, he created a crude prototype over the next few days, using a series of cards containing questions, within a box with sliders to "dial in" the answers. It was his first teaching machine.

Believing that learning occurs when desired behaviors are systematically reinforced, Skinner theorized that learning could be accomplished by programming, where the student is led in a directed manner through the content by taking many small steps, each step requiring a response. The student receives immediate feedback for that response and moves forward to the next step only if his answer is correct. In this way, the student controls the pace of learning and only moves forward when the content is fully mastered.

It's not clear that [his teaching machines] represented the best pedagogical technique to teach all kinds of content material. In fact, they worked best only in very specific areas such as mathematics. Additionally, the idea of slowly shaping a student toward an answer has led many people to question whether the broader context of the topic can be understood by using such small steps.



A diagram of the second generation of Skinner's teaching machine in the 1950s. Credit: Bill Ferster

Enter PLATO, the First Successful Computer in Education

The Programmed Logic for Automated Teaching Operations – PLATO – system, begun in 1960 at the University of Illinois, introduced a more interactive and conversational relationship between the "instructor" and the student. While never commercially successful, PLATO was developed for over five decades. It was a pioneer in e-learning, and it contributed many innovations to computer-aided instruction and computing in general, including online forums, touch screens and plasma displays.

To create the first PLATO system, founder Don Bitzer used a 1950s vintage ILLIAC (for Illinois Automatic Computer). The ILLIAC used 2,800 vacuum tubes, weighed over 5 tons, had only 64,000 bytes of memory, cost over $1 million to build in today's dollars and could perform 1,300 calculations per second. (To get some perspective on this, my Macintosh Air weighs about 2 pounds, has 8 billion bytes of memory, costs around $1,000 and can do an astounding 30 million calculations per second.)

Bitzer used a television that could display interactive text and graphics and a 16-button keyboard that displayed directly on the screen. Students used PLATO by reading the information on the screen. When a response was required, they typed it on the keyboard, and the answer appeared instantly on the screen. If the answer was correct, the system passed the student to the next screen in the lesson; if it was wrong, the system presented a remedial question on the material.

PLATO was designed to augment classroom instruction, typically for only an hour per day, and by all accounts, it was an effective tutor. The NSF funded a $1 million evaluation of PLATO in 1978, conducted by the Educational Testing Service, and while it fared well on ratings of student effect, ETS summarized, "In light of the overall evaluation, it can be concluded that PLATO had no significant impact on student achievement."

Intelligent Tutoring Systems Tried to Match Human Tutors

Reaching the effectiveness of one-to-one human tutoring has been the gold standard of educational technology since 1984. The philosophical and technological framework the researchers used to build these new intelligent tools was the emerging field of artificial intelligence. Most of the Intelligent Tutoring Systems, developed from 1969 through the '90s, begin the instructional process by determining what the student already knows, typically through an assessment. Comparing what the student needs to know with what she already knows, it delivers the pedagogically appropriate unit of instruction to the student.

Researchers began to look into a more sensitive method to diagnose not merely if answers were wrong, but why they were wrong. Diagnosing wrong answers turns out to be an exceedingly difficult, time-consuming and expensive problem to solve; it requires tediously connecting by hand a large number of potential wrong answers with specific remedial instruction.

More recent research efforts are using a big-data approach with machine-learning and statistical techniques to automatically supplement some of the tuning. It would appear that the early systems were not executed well enough to become mainstream, but they should, nonetheless, provide a rich foundation for future teaching machines to draw lessons from, as these systems begin to use the computer's power for more than simply delivering instruction.

Are MOOCs the Answer?

If one is to believe the press, from obscure educational journals to the *New York Times*, the teaching machine for the start of the 21st century is the MOOC. Massive open online courses are the latest contender, where courses from commercial companies and prestigious universities such as Stanford University, the Massachusetts Institute of Technology and Harvard University are offered online to huge numbers of participants, often thousands at a time. There are those who view MOOCs as the savior to managing the ever-spiraling cost of higher education, and others who see them as sowing the seeds of the demise of the university as we know it. The truth, of course, lies somewhere between.

It is important to see some of the potentially threatening innovations such as MOOCs in the same way that their providers see them: as experiments. Daphne Koller, co-founder of venture-capital-funded MOOC developer Coursera, views the MOOC as an unprecedented opportunity to use the large numbers of people to scientifically test what works by doing controlled experiments she refers to as "A/B testing," where a change is made to instruction for some population of students and not for others.

In the future, A/B testing, coupled with the large number of learners that the MOOCs amass, may create an ideal experimental laboratory for evaluating the effectiveness of a wide variety of techniques beyond the size of the video, for obtaining empirical evidence for different pedagogical methods, and for gaining insight into how people learn.

One of the more concerning issues about the commercial MOOC providers is the source of their funding, venture capitalists. Venture capital is provided by investment firms to fund early-stage companies. These firms typically invest in a large number of startups with the assumption that 90 percent of them will fail, but the 10 percent that thrive will yield a return on investment of at least 300 percent. This strategy has been extremely successful in the high-technology sector. Venture capital firms provide a strong support network to help guide new entrepreneurs, but their model has its darker side.

If the company underperforms or takes longer to deliver, it can find itself among the "walking dead," with just enough capital to stay in business but not enough to grow, closed down completely or merged with another of the firm's portfolio of funded companies.

Modern for-profit, e-learning universities have a quick mechanism via the Internet, but the burden of correcting papers and answering questions is done on a one-to-one basis that is not easily scaled. MOOCs have an even tougher problem to solve. The number of students participating makes individual attention a physical and financial impossibility. MOOC providers are experimenting with some more innovative solutions, such as calibrated peer review and automatic essay scoring.

Provided by University of Virginia

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