Chapter 12

Technology for Teaching: Past Masters Versus Present Practices

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Blended Learning?

Google is an amazing resource. No matter what your question, Google can find you an answer. The answer may not be correct, of course, but you can rest assured that even in the relatively short existence of the Web, someone, somewhere, has posted something pertaining to your question.

Thus, it never ceases to amaze me how often I hear a company claim that its new instructional technology product incorporates some radically new approach to teaching. Don't they talk to educators before they make such claims? Don't they ask someone who has studied instructional technology if such a thing has ever existed before? Don't they even bother to do a Google search to see if anyone else has taken a similar approach?

I guess not. A couple of years ago I was invited to address educators at E-Learn 2002 (Heines, 2002), which was billed as a "World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education." Pretty impressive. As I considered what I would say, I scanned the conference's list of topics identified under "Strategic Focus," and one in particular caught my eye: "Blended Learning." "Hmm," I thought, "I wonder what that is?"

Enter Google. A search on "blended learning" turned up some amazing statements. First, I found a news article on a relatively reputable site, that of the American Society for Training & Development. Jennifer Hoffman (2001) posted an article there that stated:

> Every few months a new trend hits the training industry. One of the latest trends revolves around the application of blended learning

> solutions. *The idea behind blended learning is that instructional designers review a learning program, chunk it into modules, and determine the best medium to deliver those modules to the learner.* [Emphasis added by JMH.]

Hmm. Didn't Robert Mager (1967, 1999) do pretty well back in the 1970s teaching corporate trainers how to "chunk" instructional material into modules? Isn't determining "the best medium" for delivering instruction the very essence of instructional technology design that's been taught in colleges of education for years (Moore & Kearsley, 1996)? This doesn't sound like a very new trend to me.

But the fact that something isn't new never stopped anyone from claiming they own it and, more importantly, trying to sell it! Google found a company that referred to "blended learning" as "our approach" and claimed it as a service mark (EpicLearning, 2001):

> *Our Blended Learning℠ approach is the real difference.* No other learning option combines the synergy of live instructor-led classes and live online coaching with proven self-study programs, hands-on labs, and a network of outside resources. This approach promotes greater retention and accommodates differences in learning styles. [Emphasis added by JMH.]

Promotes greater retention *than what?* They don't say. (Sigh.)

Google also found one refreshingly honest reference to blended learning (Smith, 2001):

> *Blended learning is a fairly new term in education lingo, but the concept has been around for decades.* Essentially, blended learning is ... a method of educating at a distance that uses technology (high-tech, such as television and the Internet, or low-tech, such as voice mail or conference calls) combined with traditional (stand-up) education or training. [Emphasis added by JMH.]

Ah, finally, a bow to past masters. "On the shoulders of giants..." "Those who do not learn from the past are destined to repeat it..." Etcetera. It's been said many times in many ways, but people continue to reinvent the wheel and believe that their applications of instructional technology are totally new.

How About Computer-Based Instruction?

I attended a session at a conference in 1998 in which the speaker asked the audience when they thought the first CBI program had been written. [CBI stands for "computer-based instruction," but various researchers and marketeers refer to sister technologies designed for other target populations as CAI (computer-assisted instruction), CAL (... learning), CBT (... training), CBI, and CBL.] The first respondent shouted "1981." Another called out "1976." Someone guessed "1969." I responded "the early 60s or late 50s." To that the speaker said, "Whoa, can you give me a reference?"

I couldn't quote chapter and verse off the top of my head, but I remembered reading an interview with Ivan Sutherland, an early pioneer of computer-controlled cathode-ray tubes, in which he described a program written by a colleague "in the early days of computer graphics" to help his daughter with math. The computer presented the child with an arithmetic problem and a face on a display screen. If the girl entered the correct answer, the face smiled. If she entered an incorrect response, the face frowned. Successive wrong answers caused the face to cry.

Once home I checked a paper I wrote in graduate school in 1974 and found the interview had been published in *Computer Decisions* magazine in 1971. "The early days of computer graphics" to which Sutherland referred were indeed the early 1960s or even the late 1950s, when he developed the Sketchpad interactive graphics system as a graduate student at the Massachusetts Institute of Technology. Readers may also remember that PLATO was in widespread use at the University of Illinois by the late 1960s (Bitzer & Skaperdas, 1970) around the same time that C. Victor Bunderson was developing the TICCIT system at Brigham Young University (Bunderson, 1973, 1974).

Sidney Pressey and Thorndike's "Miracle"

Sutherland's colleague may have written the first real CAI program, but it certainly wasn't the first instructional application of technology. It wasn't even the first mechanical instructional application. That honor goes to Sidney L. Pressey, who realized a vision expressed by Edward L. Thorndike way back in 1912:

> *If, by a miracle of mechanical ingenuity, a book could be so arranged so that only to him who had done what was directed on page one would page two become visible, and so on, much that now requires personal instruction could be accomplished by print.*

Pressey realized Thorndike's "miracle" in 1926, when he exhibited the machine shown in Figure 1. This device presented multiple choice questions one at a time by rotating a cylindrical drum on which the questions were printed under a glass window. Students indicated their responses by depressing one of the four keys that corresponded to each choice in the question. In the test mode, no indication of the correctness of the student's response was supplied. In drill mode, all keys except the correct one were locked.

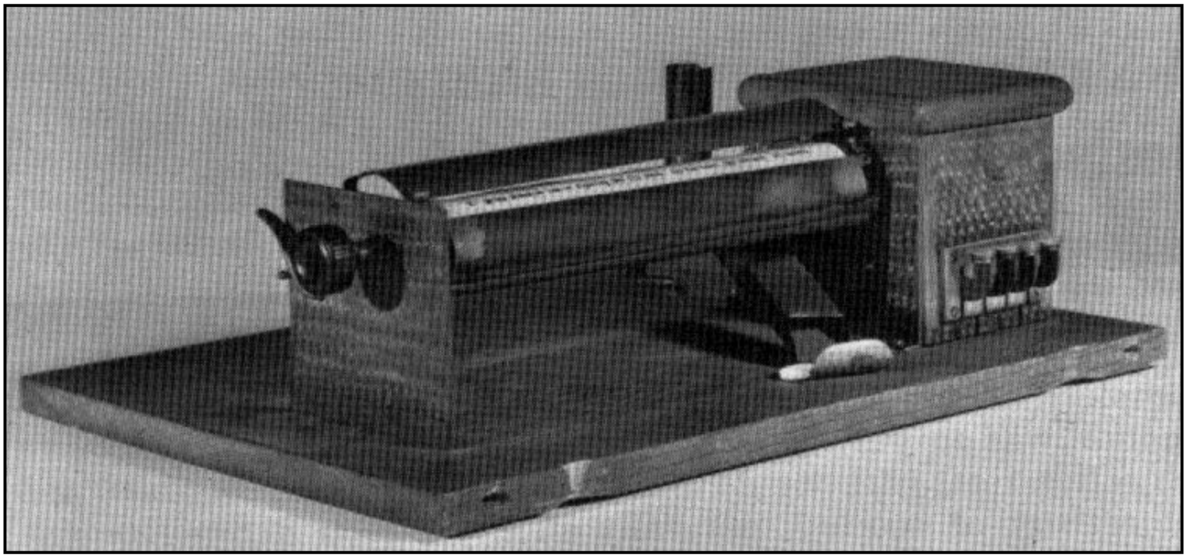

Figure 1. Pressey's 1926 device. (Lumsdaine & Glaser, 1960).

One exciting feature of Pressey's 1926 device was that it automatically recorded all responses. Pressey claimed that he used this information (an item analysis of sorts) to revise his lecture plans, spending more time on concepts that were consistently missed and less on those easily grasped. In a much later paper (1964), Pressey noted that an attachable mechanism existed for the 1926 device that would give the user a candy lozenge when a programmable number of correct responses had been made. This feature is especially interesting because it predates B. F. Skinner's writings on machine reinforcement by almost 30 years. In 1927, Pressey refined the drill mode of his original machine to omit successive presentations of questions which had been correctly answered twice in succession (Figure 2). Skinner adopted a similar contingency in 1958.

As one looks at these devices, one really has to ask how much farther have we come with instructional technology in 78 years? We have larger and networked item banks these days, and we have graphics that Pressey couldn't produce on his cylindrical drum, but how many of today's technological programs use more sophisticated instructional strategies than Pressey's devices? Few, I daresay. And fewer still give teachers the level of feedback provided by Pressey's devices.

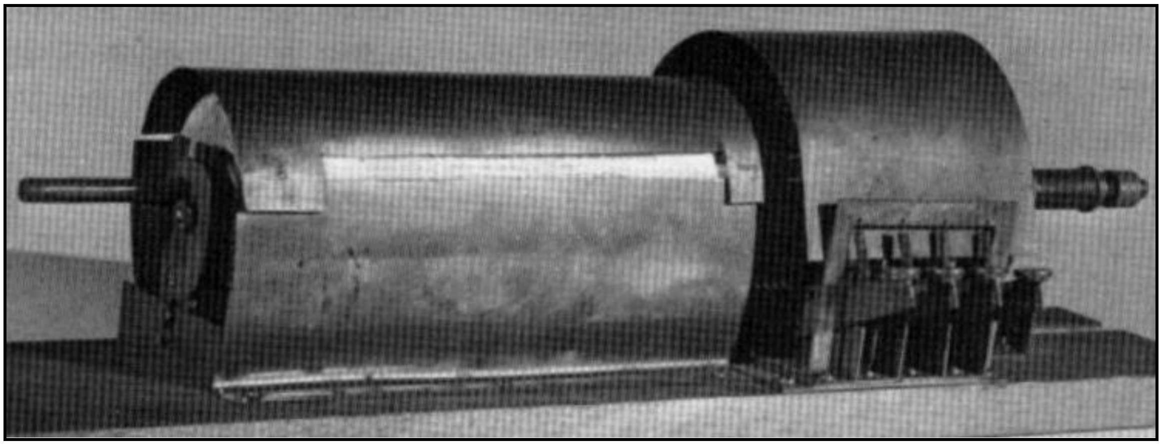

Figure 2. Pressey's 1927 device. (Lumsdaine & Glaser, 1960).

Pressey discontinued much of his research in 1932 due to a lack of funds (he sponsored most of his work out of his own pocket), but before he did he wrote of a coming "industrial revolution" in education and publicized yet another two contributions to the technology of mechanized testing during that same year (Pressey, 1932). The first of these was a generalized answer unit consisting of a 3x5-inch card with numbered answer boxes that students would mark with their responses. By placing a transparent window over the students' cards, the teacher could easily distinguish correct responses from incorrect ones.

Pressey's second 1932 invention was more elaborate. The student's answer cards were pieces of cardboard with 30 rows of five circles each (Figure 3).

Students marked their answers by punching through a circle. The card was then inserted into a machine consisting of 150 holes in the same configuration with spring-loaded pins in the correct answer positions. The device sensed the pins that protruded through the correctly punched holes, printed the number of correct responses on the answer sheet, and kept a running tabulation of the number of correct responses to each item – all at a rate of one answer sheet per second! The tabulated results could be read directly from the back of the machine to provide an instant item analysis to guide class discussion. If produced in modern form today, this device might seriously compete in the classroom market!

Early Research on Instructional Technology

One of the first research studies to investigate the effects of these early testing devices was conducted by James Little in 1934. Using Pressey's 1926 drill device and 1932 test scorer, Little found a significant difference between the final exam grades of students who were immediately informed of their results on preliminary exams and those of students who did not have this feedback. He also found that drill and the use of preliminary exams significantly improved final exam grades. It is interesting to note that Little found drill and immediate feedback to be of greatest benefit to students in the lower half of the scholastic distribution, while Reed, working in 1961, found programmed instruction to be most effective with students in the upper portion of the distribution (see discussion in Saettler, 1968). Little concluded that mechanical test scoring and drill devices have practical applications in the classroom due to their convenience, speed, and possibilities for immediate reinforcement.

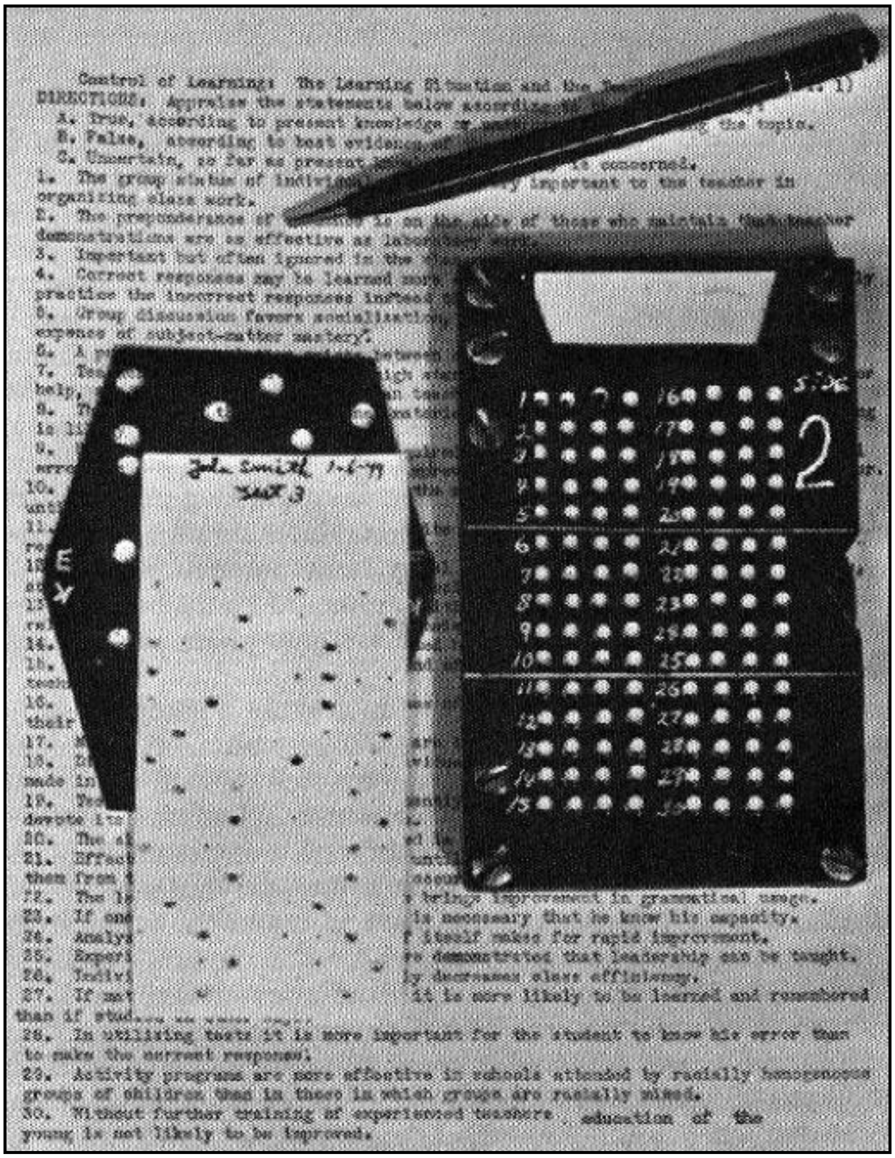

Figure 3. A 1950s version of Pressey's 1932 punchboard.
(Lumsdaine & Glaser, 1960).

Another significant piece of research on mechanized testing during the 1930s was that of John and Hans Peterson, who developed "chemosheets" that students could mark with a damp swab. Correct answers turned blue, while incorrect answers turned red. In 1931, John Peterson published the results of an investigation into the use of the "Self-Instructor and Tester" (chemosheets) in a class in introductory psychology. He used several control and experimental groups which all employed a multiple-choice test as a pretest, posttest, and study guide. The only difference in the groups was that the experimental group used chemosheets to accompany their study guides for reading assignments while the control group used only untreated answer sheets. He found the improvement of the experimental groups' posttest scores over their pretest scores to be significantly greater that the corresponding improvement for the control groups.

The Age of Skinner

It would be impossible to discuss all the various learning devices that were developed throughout the first half of this century. Ibert Mellan reported in 1936 that over 600 inventions had already been patented as educational aids; the earliest on record was by H. Chard, who called his 1809 device a "Mode of Teaching to Read." While a great deal of ingenuity was exhibited in the design of these early testing and teaching machines, it appears they were used only nominally. Widespread acceptance of mechanized testing and teaching in public education would not occur until after World War II.

The beginning of contemporary educational technology is generally agreed to be B. F. Skinner's historic 1954 paper, "The Science of Learning and the Art of Teaching." It can be seen, however, that a great deal of work set the stage for the acceptance of Skinner's approach to education, including Sidney Pressey's, who was 30 years ahead of his time when he began experimenting in the 1920s.

Skinner's first machine, introduced in 1954, grew out of his desire to allow students to construct responses rather than simply select the correct statement in a multiple choice fashion (as in Pressey's devices). This machine displayed questions on a tape, the bottom section of which was hidden from students and contained the answer coded by a series of punched holes. Students indicated their responses by positioning slides on the machine's front panel to appropriate letters or numbers.

After the slides had been set, the student turned a crank. If the response was correct, the machine advanced to the next question. If incorrect, the crank would simply not turn. Thus, knowledge of results and reinforcement (the positive movement of the crank) were both immediate. One version of this machine (circa 1960) is pictured in Figure 4.

Figure 4. A 1960s version of Skinner's 1954 teaching machine.
(Lumsdaine & Glaser, 1960).

A typical set of frames that might have been used with such a machine to teach a third or fourth grade student to spell the word "manufacture" is shown in Figure 5.

The shortcomings of this machine were quickly apparent. While the device seemed to function well for short answers, it did not allow complex responses. Skinner introduced another device in 1958 that addressed this problem (see Figure 6). This machine consisted of a large disk covered by a panel with two windows and a lever. A question was presented in one window, and students wrote their responses on a blank part of the disk exposed through an open slot in the other window. When they moved the lever, the correct answer was revealed in the question window while the response just written was moved under a transparent shield so that it could be read but not changed.

An adaptable feature of Skinner's 1958 machine then came into play: the *students themselves* decided whether their responses were correct by comparing them to the printed answers. If they judged their responses correct, they moved the lever horizontally, causing a hole to be punched in the disk. This hole would cause the question to be skipped on subsequent revolutions of the disk. When the disk turned freely, students knew that they had answered all of the questions to their own satisfaction. This machine was very similar to Pressey's 1932 testing device, except that the responses were constructed rather than multiple choice and evaluated by the students rather than the machine.

Table 1. A SET OF FRAMES DESIGNED TO TEACH A THIRD- OR FOURTH-GRADE PUPIL TO SPELL THE WORD "MANUFACTURE"

1. **Manufacture means to make or build.** ***Chair factories manufacture chairs.*** **Copy the word here:**

   □ □ □ □ □ □ □ □ □ □ □

2. **Part of the word is like part of the word factory. Both parts come from an old word meaning** ***make*** **or** ***build.***

   m a n u □ □ □ □ u r e

3. **Part of the word is like part of the word manual. Both parts come from an old word for** ***hand.*** **Many things used to be made by hand.**

   □ □ □ □ f a c t u r e

4. **The same letter goes in both spaces:**

   m □ n u f □ c t u r e

5. **The same letter goes in both spaces:**

   m a n □ f a c t □ r e

6. **Chair factories □ □ □ □ □ □ □ □ □ □ □ chairs.**

Figure 6. A typical set of frames for Skinner's 1954 teaching machine intended for use with third and fourth grade students. (Lumsdaine & Glaser, 1960).

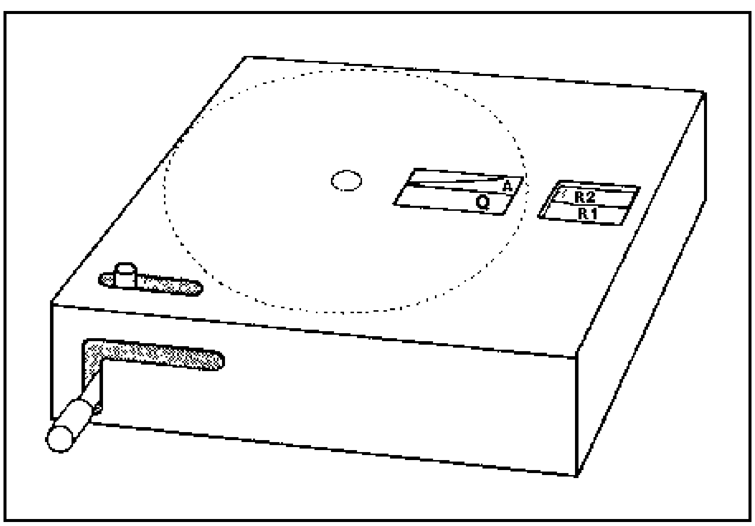

Figure 6. Skinner's 1958 improvement over his 1954 device. (Lumsdaine & Glaser, 1960).

Skinner concentrated very heavily on the construction of learning programs for his machines. His aim was to teach and question in such small steps that the learner would be led smoothly to complex behavior through carefully conditioned responses. Part of a sample program to teach high school physics students about the emission of light from an incandescent source is shown in Figure 7.

Intrinsic Programming

Despite the improvements in Skinner's 1958 machine over his 1954 device and the care with which he tried to program his instruction, many problems still existed. For example, while students were rewarded for correct responses, they received no feedback or explanation when their responses were incorrect. This may have served satisfactorily with the minute steps of the 1954 machine, but the open-ended nature of the 1958 device led to problems in interpretation.

Norman Crowder (1960) attempted to remedy this shortcoming with a technique he called "intrinsic programming." The basic premise of this approach was that students' responses should determine what material is presented next. The device Crowder used was simply a textbook in which material was presented a paragraph or so at a time. At the end of each discrete section, a multiple choice question was presented with a page number following each choice. Students turned to the pages that corresponded to their choices. If they were correct, new material was presented. If incorrect, review or reinforcement material was found. This scheme was used throughout the entire book, which Crowder termed a "TutorText." [It has also been called a "Scramble Text" elsewhere in the literature.]

Crowder not only developed a random-access film reader to automate his TutorText by presenting pages of text stored on 35mm film, he also developed a variety of instructional strategies dealing with the sequence in which material was presented to help people understand how to use TutorText effectively. Figure 8 shows a simple sequence in which single alternative frames exist to reinforce concepts that seem difficult to some students. Figure 9 extends this approach to alternative sequences consisting of multiple frames. Figure 10 depicts a simple "wash-back" sequence, in which students struggling with a concept are routed back to earlier parts of the program for review. Figure 11 is just the opposite: a "wash-ahead" sequence that moves students along faster if they grasp concepts quickly. Finally, Figure 12 diagrams a complex strategy in which incorrect answers are weighted for seriousness and the student may be "washed back" one, two, or three steps depending upon how he or she answers.

Table 2. PART OF A PROGRAM IN HIGH-SCHOOL PHYSICS

The machine presents one item at a time. The student completes the item and then uncovers the corresponding word or phrase shown at the right.

SENTENCE TO BE COMPLETED	WORD TO BE SUPPLIED
1. The important parts of a flashlight are the battery and the bulb. When we "turn on" a flashlight, we close a switch which connects the battery with the ______.	bulb
2. When we turn on a flashlight, an electric current flows through the fine wire in the ______ and causes it to grow hot.	bulb
3. When the hot wire glows brightly, we say that it gives off or sends out heat and ______.	light
4. The fine wire in the bulb is called a filament. The bulb "lights up" when the filament is heated by the passage of a(n) ______ current.	electric
5. When a weak battery produces little current, the fine wire, or ______, does not get very hot.	filament
6. A filament which is less hot sends out or gives off ______ light.	less
7. "Emit" means "send out." The amount of light sent out, or "emitted," by a filament depends on how ______ the filament is.	hot

Figure 12. A program for Skinner's 1958 device designed to teach concepts in high school physics. (Lumsdaine & Glaser, 1960).

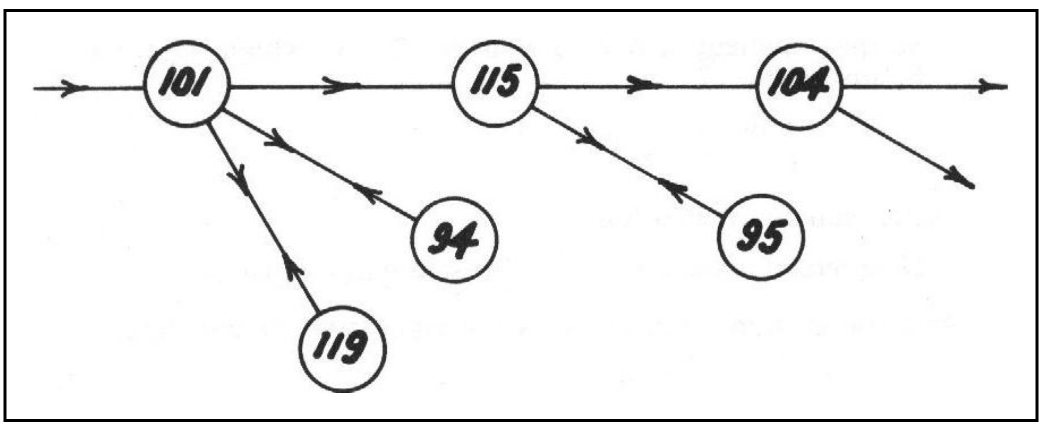

Figure 8. A simple intrinsic programming sequence in which single alternative frames exist to reinforce concepts that seem difficult to some students (Crowder, 1960).

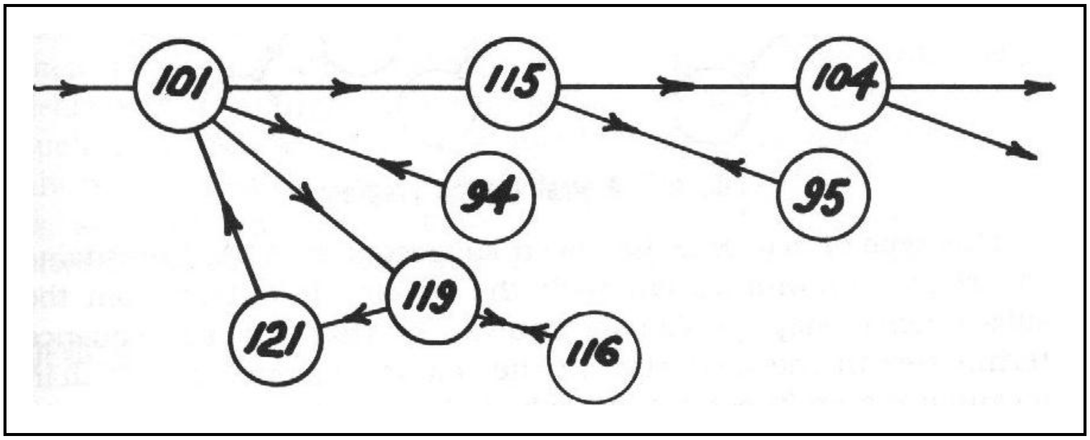

Figure 9. Alternative intrinsic programming sequences consisting of multiple frames (Crowder, 1960).

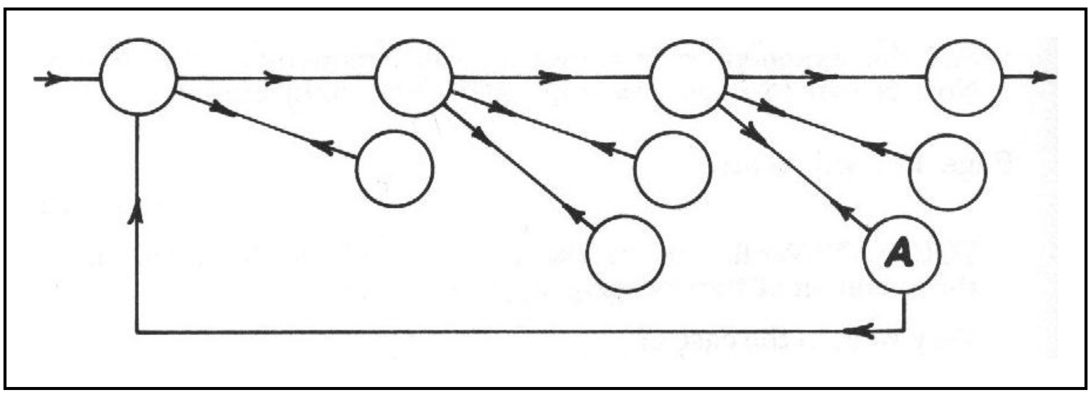

Figure 10. A simple "wash-back" sequence in which students struggling with a concept are routed back to earlier parts of a program (Crowder, 1960).

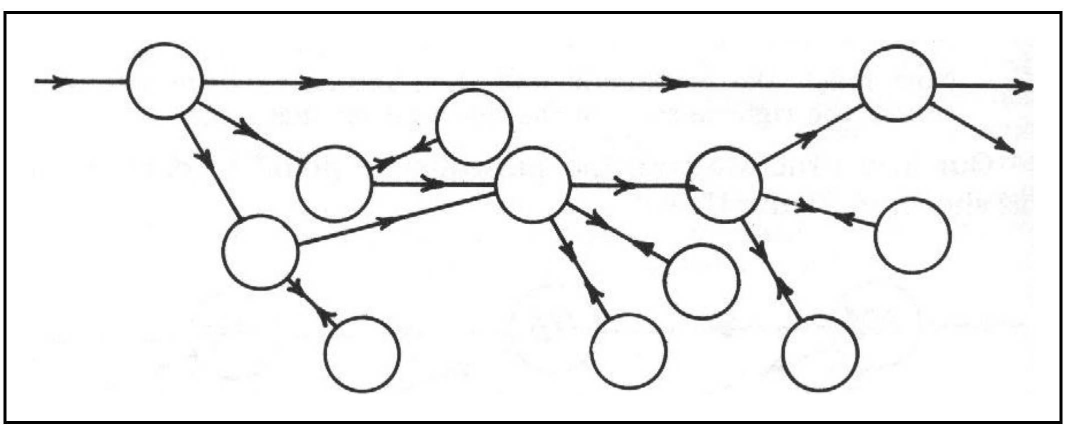

Figure 11. A "wash-ahead" sequence that moves students along faster if they grasp concepts quickly (Crowder, 1960).

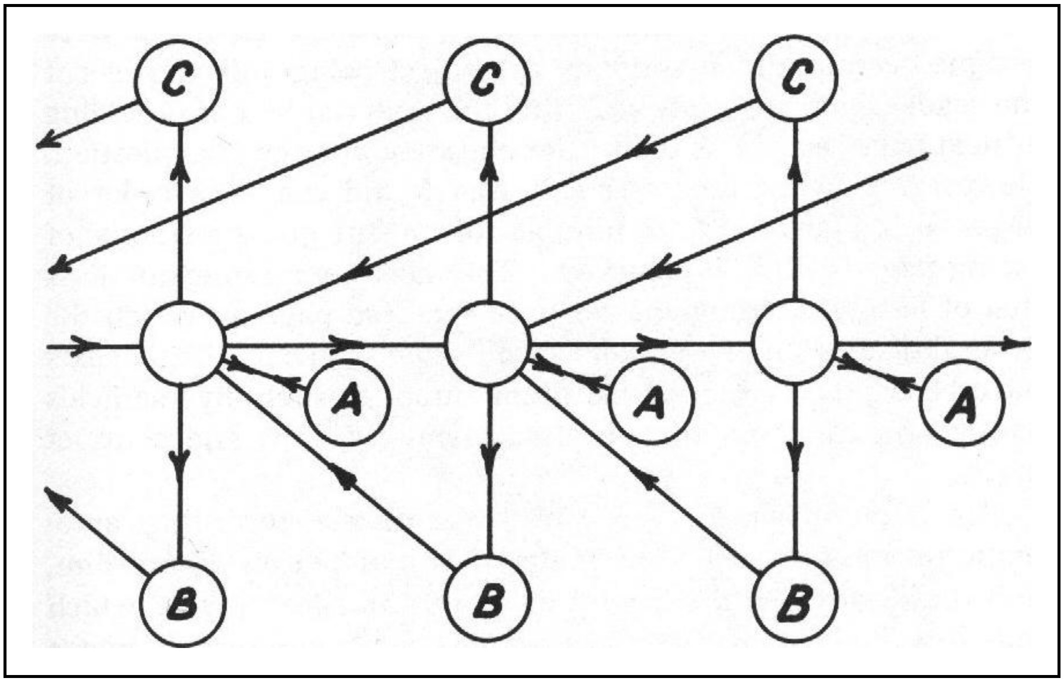

Figure 12. A complex strategy in which incorrect answers are weighted for seriousness and the student may be "washed back" one, two, or three steps depending upon how he or she answers (Crowder, 1960).

The main advantage of intrinsic programming was that it does not waste the time of the fast learner with unnecessary repetition. Its disadvantage was that it required a large textbook to present even a relatively small amount of material. With computers, of course, such size considerations are not an issue. One simply has to be willing to invest the effort to implement alternative paths through the material, a feature built in to virtually all authoring systems but often unused by developers. I can only guess that this is because they do not understand the principles, do not have the training to use the authoring system's advanced features, or are simply under too much time pressure to implement alternative paths.

Today's Technology for Today's Instruction

Given the perspective of these pre-computer-age teaching devices –- their grounding in instructional theory as well as the cleverness of their implementation –- educational technology newcomers may better understand why some of us old-timers continually encourage developers to "put the C back in CBI" (Heines, 1988). It is common to hear us lament that while today's programs can present beautiful multimedia programs that we didn't even dare dream of back in the days of PLATO and TICCIT or the early days of the PC, at their instructional heart these programs are little more than electronic page-turners.

In a recent conversation with a representative of one of the leading CMS vendors about their testing subsystem, I asked about the system's capability to analyze the data it stored and present it to teachers. [CMS stands for "course management system," another new term applied to a capability that's been around for years.] I was told that the system can show the teacher each student's response to every question. OK, I responded, but can a busy teacher see a summary of that data so that s/he can see trends and identify widespread class misunderstandings? The representative didn't know. He said something about computing an average, but he was not familiar with the terms "item analysis," "difficulty index," "discrimination index," and "standard deviation." (Sigh.)

Today's computers are of course much more capable than the machines of Pressey's, Skinner's, and Crowder's days, yet many systems don't even store all the response data needed to do a complete item analysis, much less use this data to adapt the program to students' individual backgrounds and abilities in real time. None lead developers through the implementation of sound instructional strategies anywhere near as sophisticated as those implemented by Crowder with film readers over 40 years ago. Microsoft PowerPoint provides an "autocontent wizard" that asks me for the *type* of presentation I want to create ("employee orientation," "project overview," etc.), the *style* I wish for that presentation, and what *options* I desire. I have yet to see a test item banking program that enforces even the most basic, long-established rules of good test construction.

It's as if the companies that develop these products simply hire programmers and tell them to start coding, without ever exploring the huge, existing body of knowledge on what's been tried before, much less look for solid theoretical ground on which to base their instructional designs. No wonder so many teachers choose to "do their own thing" when they try out these products and so quickly uncover their limitations and shortcomings.

Of course, it's easy to criticize. It's easy to sit here before my word processor and espouse the need for more sophistication in vendors' instructional products. But as Pressey wrote at the conclusion of his 1932 paper, "The writer has found from bitter experience that one person alone can accomplish very little." Product commercialization is needed to have any real impact on our vast, amorphous educational system, and the cost of developing *and marketing* commercial products today is so huge that they must often cater to the lowest common denominator in an effort to appeal to the widest possible audience. Economic pressure drives many technological advances, and the sorry state of educational financing makes it extremely difficult to find funding for efforts that only address the needs (or desires) of a few sophisticated teachers and/or students.

Therefore, we need to work with commercial vendors to show them how to expand their products' capabilities to provide creative instructional strategies based on solid theory and proven practices. One approach is to adopt the "plug-in" strategy used in so many products today, from Web browsers to Microsoft Excel to computer program development environments. Only such extensibility provides hope that we will one day see a computer-based testing subsystem that implements algorithms such as Ferguson's 1971 Bayesian decision analysis model (based on work done by Wald in 1947) to quantify the probability that a student has mastered a given body of knowledge (see also Emrick, 1971; Ferguson and Novick, 1973; and Millman, 1974). Given such a system, a teacher could adjust those probabilities to ensure that important tests such as final exams have a small probability of false positive errors (saying a student *has* learned something when s/he *hasn't*) while perhaps allowing a slightly higher probability of false negative errors (saying a student *hasn't* learned something when s/he *has*) (Heines, 1979).

Regardless of the sophistication one manages to implement, however, educational technology will never fully supplant caring, dedicated teachers. The magic of human interaction simply cannot be duplicated, just as film has not succeeded in supplanting the thrill of live theater, and even crystal clear digital CD sound can never evoke the emotion of a live concert. Technology is most effective when used *in partnership* with personal tutoring. Yes, that's true "blended learning." The catchword may have been dreamed up by some advertising firm, but the concept was first expressed by Edward L. Thorndike in 1912 when he wrote, "The best teacher uses books and appliances *as well as his own insight, sympathy, and magnetism*."

Note

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