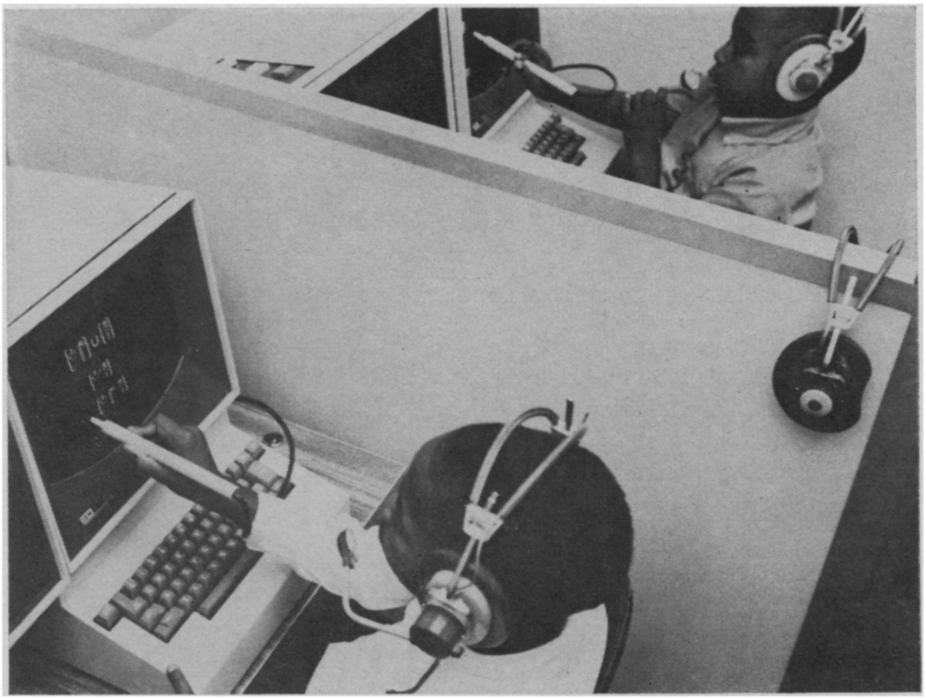


Leigh Wiener

. . . The computer will have to learn as much about the student.

Formulas for Learning

Computers in the classroom promise understanding more precise than psychologists have yet developed.

When Newton discovered gravity, he discovered something that could be quantified, tested, applied, reworked and reapplied by anyone who followed.

But scientists looking into human behavior have had no such certainty. They may reach great insights into human processes, but rarely can they be sure. Because the insight usually lacks the precision of physics, it can be neither measured nor tested for universality.

Such has generally been the fate of learning theory. Descriptions of intuitive and cognitive learning processes abound. They may be valid, but at their present stage of development, they are virtually useless, not only for such things as programming a computer to teach first grade arithmetic, but for establishing guidelines for teaching at all. And that is the problem.

A revolution in education called computer-assisted instruction is surely coming. Congressmen favor it, corporations are backing it and the U.S. Office of Education is spending several million dollars for its development.

But there is a gap between learning theories and their practical application. It must be narrowed if computers are to be a boon to education—the greatest thing since printed textbooks—and not just overpaid drill masters.

Despite the lack of a solid theoretical base, the field of computer-assisted instruction (CAI) appears to be moving rapidly, with some justification.

Though three-fourths of the programs so far developed in CAI are little more than computerized versions of present classroom practices, they do offer the student more individualized material than he now receives in most classrooms. They offer to relieve teachers of tedious drilling tasks, and they promise better education to slum children.

Perhaps even more important, the computers may themselves help fill the theory gap. In the long run, computers in the classroom should build an unprecedented research base for learning about learning, as the data from thousands of students pours in. It is from this expectation that much of the enthusiasm for CAI stems. As Dr. Louis Bright, director of research at the Office of Education, put it, "CAI is the most valuable instrument ever devised for the study and testing of learning theory."

But he says a learning theory is not essential now. Computerized teaching programs can be devised without it. Through a process of trial and error, they will eventually produce deeper understanding of the learning process, says Dr. Bright. And with the exception of one theoretically oriented project at Stanford, all the universities working with CAI—some seven or eight—are proceeding on that assumption.

Theory or no theory, computer-assisted education is in the throes of a classic struggle at the moment—how to get program development out of the hands of technicians and into the hands of educators.

Dr. Francis Keppel, onetime Commissioner of Education, solved the problem for his corporation earlier this year by firing 60 employes. In so doing, he rechanneled the energies of General Learning Corporation, a subsidiary of General Electric, from computer technology to education.

It is an aim shared by Congress. Last year, after several days of testimony on technology in education, the Joint Economic Committee noted that engineers, not educators, were writing most of the programs.

"It appears that the vital function of programming—preparation of the content of education—is falling too frequently to the 'hardware' manufacturers when it should be handled by educational experts." The report went on to note "insufficient coordination" between industrial manufacturers who are creating and selling the programs and the educators.

Much programming of teaching devices was described as poor, the Committee observed. One witness labeled the result "a shallow penetration by the technologists into education." On the other hand, educators themselves "show little extensive long-range planning," said the Committee.

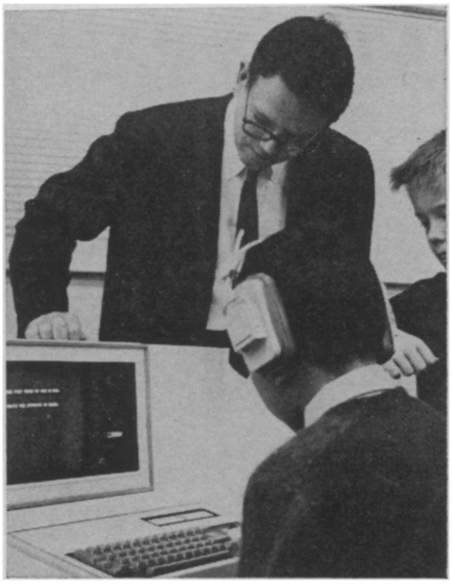
The report also called for more research "not only in the application of technological devices, but on the learning process itself."

Such research is underway at Stanford University. There at the Institute for Mathematical Studies in the Social Sciences, Dr. Patrick Suppes and his colleagues are combining theory, intuition, computers and children in a $2 million project to break ground on a mathematical understanding of human learning.

It is a step by step process. The Stanford group has begun with a simple, conditioning theory—that humans learn basic concepts and facts in an all-or-none fashion. That is, the learner directly associates a right answer with a specific question. But before that association takes place, there is no evidence of learning whatsoever. Very simply, "either you've got it, or you don't," and if you don't, your odds of hitting the right answer are at chance level.

An alternative theory, which the Stanford group has considered, represents the exact opposite. Here learning supposedly increases in a smooth upward line, by increments. Each time a problem appears, the learner has a better chance of answering it correctly, even though he has not yet done so.

But both concepts, however, still suggest some kind of unexplained process—intuition for want of a better term. And intuition, in Dr. Suppes' opinion, is a suspicious word. "It should be a signal to the behavioral psychologist," he says, "that unexplained and ill-understood learning behavior is about to be mentioned, and unfortunately, often described as if it were understood."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Dr. Suppes seeks new theory.

In his experiments on the way students learn elementary concepts in mathematics or foreign languages, Dr. Suppes has, in fact, not found a smooth upward curve. But he has found all-or-none learning, in addition to a kind of half-breed—slight incremental increase and then a sudden learning leap.

Psychologists occupied with describing the total range of human intellect view the all-or-none theory with some disdain.

"It's a simplistic kind of notion," says Dr. Jerome Bruner, learning theorist at Harvard University. "I can't believe the nervous system has evolved through the ages to this."

Such criticism misses the point, answers Dr. Suppes. "I don't want to claim I have an overriding theory," he says. It is a "first approximation only," but one that can be used and hopefully shaped into more sophisticated levels of understanding.

Actually, whether or not all-or-none adequately describes complex learning processes is irrelevant to the Stanford work. The concept is a tool, a framework for organizing lessons in a computer and a means of computing the probabilities that a student has learned something. After that comes the arduous task of revising programs on the basis of returned data.

Dr. Suppes, who is both director of the Institute and chairman of the department of philosophy, has developed drill and practice programs in mathematics and foreign languages since he began working with Palo Alto children and computerized instruction four years ago.

The programs are not meant to teach, only to drill; consequently they require no particular theoretical basis.

Now, however, Dr. Suppes is working toward a more elegant program in mathematics. "If it works, it will be a very pretty thing indeed," he says. Rather than lumping problems into blocks of difficulty and then giving a student one or another block according to his ability—as CAI programs now do—the new computer program ranks each and every problem. A student would receive a sequence of problems unlike the sequence of any other student. As he gets better, the problems get harder, but since they do not follow an obvious pattern, the student cannot find tricky shortcuts to the answers.

Given, say, 2,000 problems and a hundred students, such a program represents highly complex computer strategy and a startling degree of adaptability to individual differences.

The total effect is to turn learning theory on its head and make computers learn about students, says Dr. Suppes.

In addition, he wants the machine to adapt to the speed of the response, as well as its correctness. There is evidence, he points out, that speed is a more sensitive index to learning than correctness—at least for the skill subjects.

While Dr. Suppes has concentrated on mathematics and logic, his colleague, Dr. Richard Atkinson, has attacked the problem of teaching children to read.

Still experimental, the project should give some basis for evaluating different reading theories, says Dr. Atkinson. But first, he must find ways of mathematically describing and spanning the diversity of concepts and skills that children bring to elementary reading.

Eventually, Dr. Atkinson hopes to reach a "rich and highly structured theory of learning."

That is, in fact, the promise computers hold out to psychology—that for the first time a workable, measurable principle of learning will be found—one as mathematically rigorous and elegant as the law of gravity.