Powerful Ideas

To really learn from computers, says Seymour Papert, children must become programmers.

CINDY TURSMAN

Even small children can learn to program computers, according to Seymour Papert, the inventor of the computer language LOGO.

As a mathematician and educator who worked with the Swiss developmental psychologist Jean Piaget, Papert emphasizes that students must learn to control and order the learning process by teaching computers what to do. "In many schools today, the phrase 'computer-aided instruction' means making the computer teach the child," Papert claims. "In my vision, the child programs the computer and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, mathematics, and the art of intellectual model building."

Since programming, according to Papert, means solving problems or "debugging" programs, learners have to "think about thinking" and break down problems into discrete steps. "In inventing a video game, for example, children do a lot of geometric and arithmetic thinking about the speeds at which objects move on the screen," Papert says. "When children teach the computer what to do, they must think through what they want it to do and thereby develop a deeper understanding of the material."

Like Piaget, Papert feels children learn a great deal without being taught, by drawing on elements and experiences in their environment: "For example, when programming a turtle—a cybernetic animal that moves around on the computer screen—the child uses his or her knowledge of body geometry to draw a shape. All children know how to move around in space and then can use this knowledge in a very personal way. Similarly, by drawing on the ability to communicate, children can tell the computer what to do."

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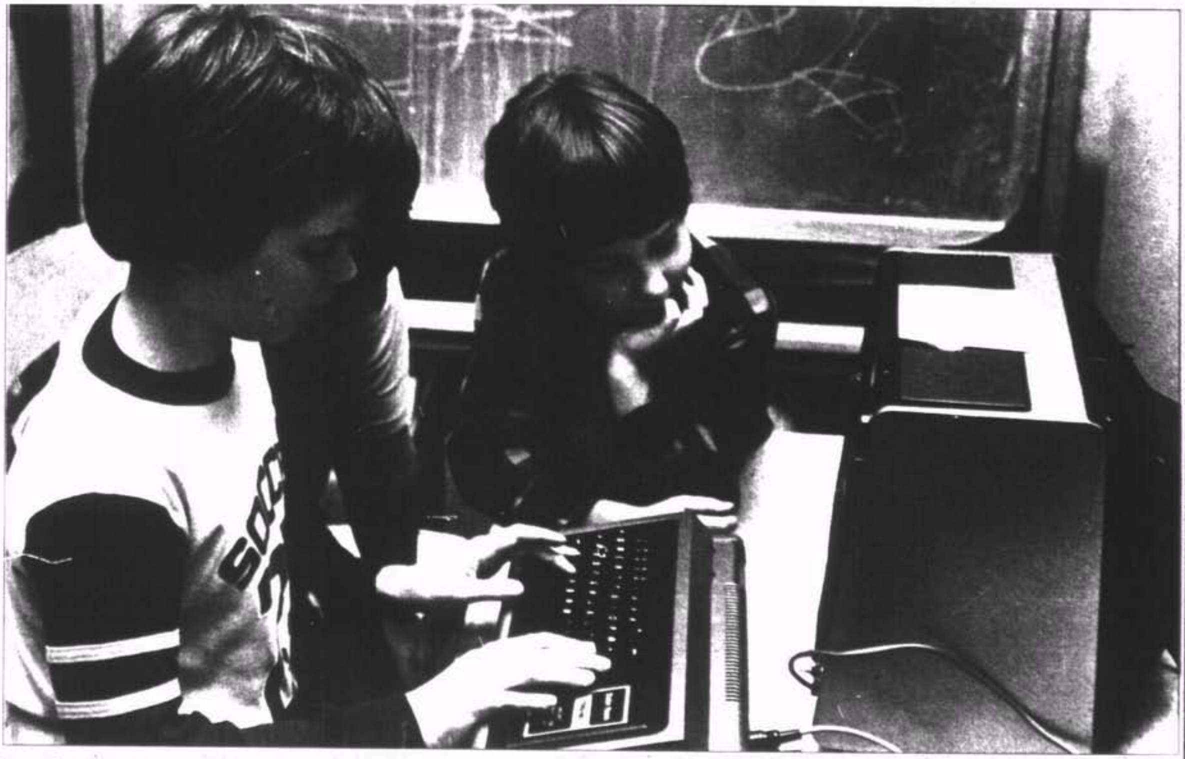
Learning From Prior Knowledge

Papert's work with children at MIT and at a LOGO nursery school in Dallas demonstrates how children can use their knowledge of the noncomputer culture, adapt it to a computer setting, and learn something new, such as formal geometry, computer programming, or grammar. Papert and his colleagues have found that children as young as three can learn to program the computer and master the keyboard by imitating one another and drawing on body movement cues.

Papert describes the experiences of a first-grader who wanted to program the computer to make objects move on the screen. The child had to specify headings in degrees; for instance, 90 degrees meant east and 180 degrees meant south. Although the child didn't know what degrees were, "he watched an older child doing a similar problem and eventually figured out that numbers are codes for directions; all he had to do was crack the code. The secret code is something very familiar to a six-year-old. The idea that angular measure is like a code is a discovery about the nature of knowledge."

Not only is Papert's approach to computer use and learning linked to personal and emotional experiences, it also allows for trial and error in a nonpunitive way. "In many domains involving a lot of structure," Papert says, "most people don't have an opportunity to precisely plan a project, split the task into its components, reach a first solution, find out what's wrong with it, and then take another shot at it. Usually, if you have a big project like designing a house, you do it once and it's over. But with a computer you can undertake very complex projects where nothing is at stake. If you don't like the results, you can try again."

In his recent book, *Mindstorms*, Papert criticizes the formal, "teacher-driven" math curriculum and the uncreative, restrictive uses of computers for pre-packaged drill and practice exercises that actually prevent certain students from learning. It isn't that certain children lack aptitude for math and science, he claims, but the way these subjects are taught may clash with a child's personality type and problem-solving style. For



the "classifying" personality, attention to detail, precision, charts, line graphs, and other static ways of capturing knowledge may be compatible with personality. But for those who learn through action and movement, dynamic, fluid, and holistic ways of capturing knowledge are needed.

Papert's computer language enables the user to work in either static or dynamic modes. It also accommodates those who learn through different styles of problem solving, ranging from "hard" to "soft." "Hard masters" can break a problem into small parts and use a step-by-step problem-solving method to arrive at solutions, while "soft masters" can work from a general notion and arrive at solutions by experimenting with different techniques. Either way, students learn how to manipulate variables and solve problems, Papert says!

Papert's LOGO language and programming approach also accommodate "nonmathematical" adult beginners who are not trained in FORTRAN or other complicated computer languages. Papert and his colleagues at MIT developed LOGO in order to create a "humanistic mathematics" computer program that would be accessible to everyone, not just engineers with formal training.

Recognizing that "anything is easy if you can assimilate it to your collection of models, and if you can't, anything can be painfully difficult," Papert's approach enables learners to explore and personalize "powerful ideas" like velocity, force, and acceleration by creating models and microworlds based on geometry, differential calculus, and Newtonian physics. These models are easy "to think with" and bridge gaps in formal mathematics training.

His philosophy regarding computer access also stems from a concern for larger issues affecting American productivity, education, and use of technology.

"There are political issues, such as where America stands in terms of its competitive power in relation to other countries," Papert says. "Japan is pushing further [than the United States] in really seeing learning on a social level and helping both children and adults learn new skills and how to adapt to new jobs as technological change makes old outlooks obsolete." Educational policies, access, and how people decide to use technology reflect what a particular society values. "I think the fact that our car industry in Detroit is in such trouble is not independent of our educational policies."

Studying computer cultures, learning, and how technology is used is also the object of an experiment Papert is conducting in Senegal, Africa.

"We will not be asking, 'What kind of personal computer is effective in Africa?' or imposing our science, math, and culture on the Senegalese," Papert says. "Rather, through work groups, the Senegalese can invent their own machines and use the computer in ways that suit their needs and culture." Papert's work is funded by the World Center for Informatics and Human Resources in Paris.

Yet, Papert does not claim to have found "the answer" to America's productivity or technological problems, nor that his LOGO environments will replace traditional classrooms: "They are too primitive, too limited by the technology of the 1970s. The role I hope they will fill is that of a model."

As well they might. Three New York City school districts are using Papert's basic design in experiments with instructional applications and computer environments. The project will integrate computers into the entire curriculum, beginning with several classes of kindergarten and primary level students this fall.

Like Piaget, Papert believes learning is largely a matter of manipulating, controlling, and applying cultural and environmental elements to new situations and problems. If computers are part of that culture, and if computers are accessible to everyone, they can be used to solve complex problems and accomplish tremendous learning gains. Whether or not a society decides to do this, however, may depend on the value society places on education and technology in solving industrial, societal, and social problems.

"It is cost effective to give every child a computer," Papert says. "But some educators say they can only afford one computer for an entire school." Letting everyone use the computer is ineffective and will limit results, Papert says. "Instead, give this one computer to a special education class with the smallest number of children. The results will be so powerful that policymakers will change their minds." **EL**