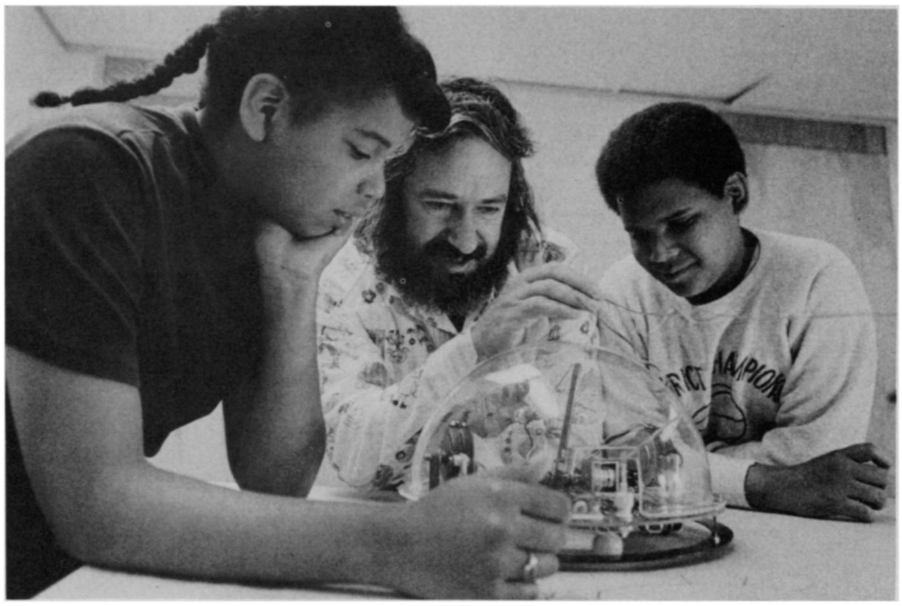
Robots make intelligent teachers

Teaching machines to think teaches people to think

by Robert J. Trotter



Susan Pogany/MIT

Papert and local students examine the insides of a computerized turtle.

Robots, iron men, mechanical monsters. . . . These automatons lumbered around between the covers of science fiction novels for years before computers, television, transistors and other technological advances made it possible for them to clunk their way onto the pages of scientific journals. Even when they did, in the 1950's and 1960's, the optimistic proposals and vivid imaginations of their controllers sometimes brought skeptical frowns from the more staid members of the scientific establishment. Machine translation was one such proposal. But an advisory committee of the National Academy of Sciences investigated and reported in 1966 that high-quality translation from machines was unlikely and probably not worth devoting a lot of time or money to.

Even so, such projects continued. They usually come under the heading of artificial intelligence (AI). During the past few years, advances in AI have been steady. Mathematicians and engineers at the Massachusetts Institute of Technology Artificial Intelligence laboratory have combined a computer, a television camera and a mechanical arm into a system with enough artificial intelligence to recognize blocks of various sizes, colors and shapes, and to assemble them into structures without step-by-step instructions from an operator. For more complex tasks, an advanced arm has been developed. It has eight movable joints and can reach around obstacles. A similar mechanical arm at Stanford University has been programmed to pick up the pieces of a water pump, assemble them and screw them together. Binocular vision and touch sensors are being developed to make these arms even more useful. A mini-robot at MIT's AI laboratory will eventually perform mechanical tasks too minute or delicate for human hands.

A computer at the Bell Laboratories in Murray Hill, N.J., has a vocabulary of 1,600 words. It can read stories and then speak them aloud. Checker- and chess-playing computers have the ability to learn from their mistakes. One at MIT has been rated as a better-than-average chess player in tournament competition. And the previously frowned upon translation projects are well under way. The U.S. Air Force is currently funding machine translation of German to English, Chinese to English and Russian to English. As a part of the recent Vietnamization policy, a computer was programmed to translate English to Vietnamese. Programming the computer took 18 months but now it can translate an average U.S. Army Manual into Vietnamese in less than two hours.

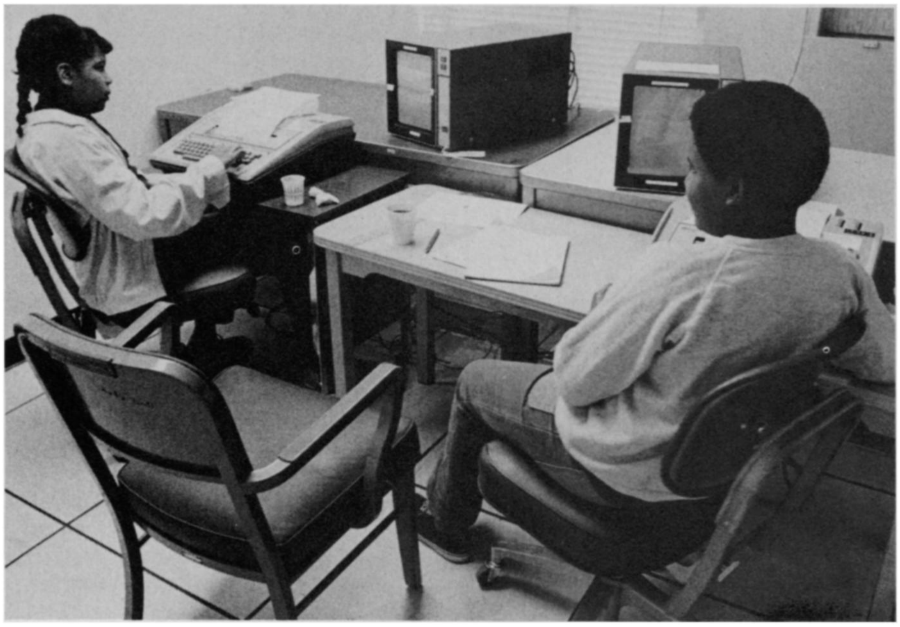
Such advances, however, have not silenced the critics of AI. Sir James Lighthill of Cambridge University surveyed the field for the Science Research Council of Britain. His report suggests that research on AI may be a waste of time. Lighthill discourages work on robots, especially, as intellectually unimportant.

Some of the things robots have been programmed to do may seem frivolous, but AI researchers say robots are only tools for the study of intelligence. Getting a machine to learn English, for instance, demonstrates the problems and methods humans have in learning to speak. Such problems don't always show up in the linguistics laboratory. Seymour Papert, co-director with Marvin Minsky of the AI lab at MIT, compares the study of intelligence to the study of flight. Flight couldn't be analyzed until the principles of aerodynamics were worked out. Human intelligence can't be thoroughly studied until the basic principles of intelligence are formulated. Jean Piaget is studying principles of intelligence by observing the mental development of children. Papert and his co-workers are doing the same thing by finding out how machines learn. The end result, he says, will be theories of intelligence that apply to humans and machines. And this has led Papert to theories of childhood education.

Stanford Univ.

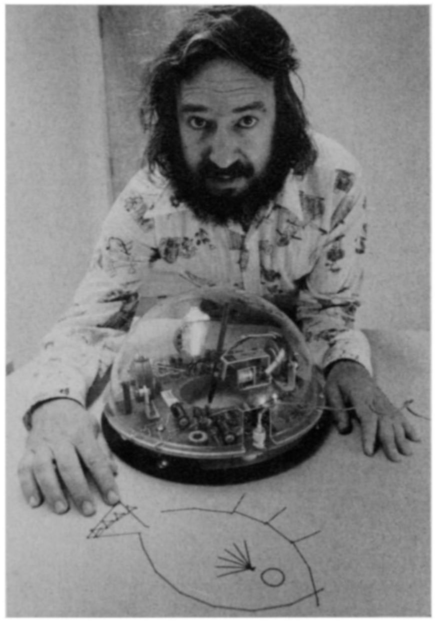
A robot arm for the assembly line.

Papert and Minsky believe that enough is known about machine intelligence to use it as a basis for planning new learning environments for children. An ongoing project at MIT is attempting to provide examples of how AI technology can be used in education. The idea is not to use machines as teachers. Instead, computers are be-



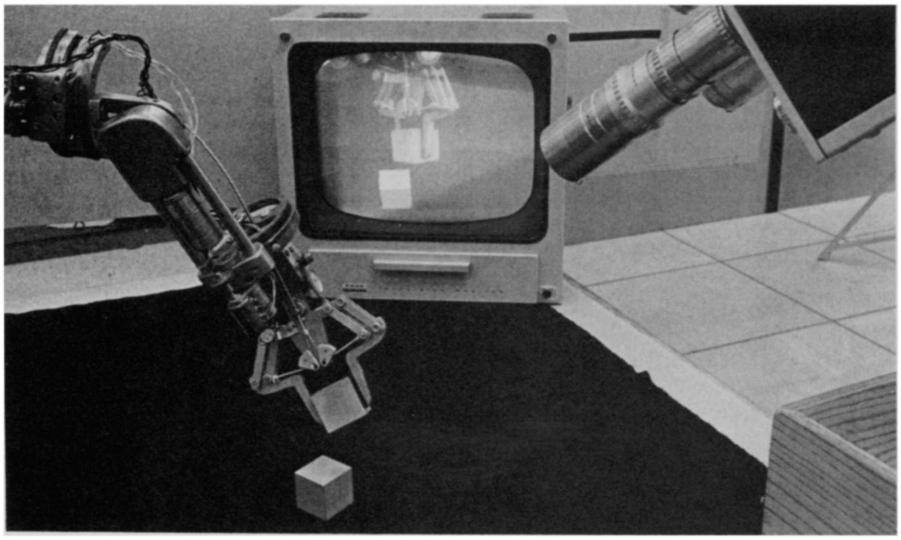
MIT

Computer students compete in manipulating cathode-ray-tube presentations.



MIT

Papert's robot turtle draws a fish.



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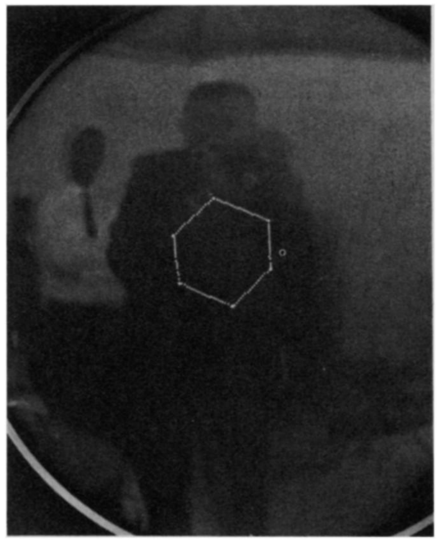
With the aid of television eyes, a robot arm knows which blocks go where.



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Cathode-ray tube displays design.

ing used to give children practice in thinking. To do this, says Papert, it is not sufficient merely to have a computer. It is necessary to develop contexts in which the computer can be used by a child to serve real purposes. Several computer-controlled devices have been designed to do this. One is a music generator that enables a child to produce songs and to experiment in music composition. Another is a graphics system with the ability to produce simple animated cartoons. The computer also has a teletype that can be programmed to compose stories or poems. And there is a cybernetic animal called the turtle that can be programmed to do a number of things including move around a classroom and leave a track or draw a picture on the floor.

By learning to program the computer to generate music, pictures or mechanical processes, the student develops the mental tools to think about temporal, tonal, geometrical and physical matters.

"In many of the projects," the researchers explain, "the child programs the machine to imitate some aspects of his own behavior. To see how to make the turtle move, he looks at his own motion. To make the computer produce grammatical English, he looks at his own sentences. By programming the computer to play games of skill, he acquires a model of the process of improving a mental skill." In this way, the child is learning and using elements of biology, physics, linguistics and heuristic or discoverist thinking.

Much of the work at the MIT lab has been concentrated on developing a science known at Turtle Geometry. By programming the turtle to draw geometric figures, a child begins to learn the basics of geometry. Such work, says Papert, provides a conceptual frame for manipulating geometric objects without a knowledge of algebra. And as Turtle Geometry gives a child a graps of movement in space (that can be used in geometric or physical applications), work with music may lead to a child's being able to think clearly about time as it applies to things other than music.

Mathematics and music are not the only things Papert and the MIT team are working on. Within two years they hope to have fully developed educational modules for such subjects as physics, linguistics, biology and psychology. "Much of science," they believe, "can be reconceptualized to become vastly more accessible." And the final goal of their work will be "a total alternative to the school as it is known today." □