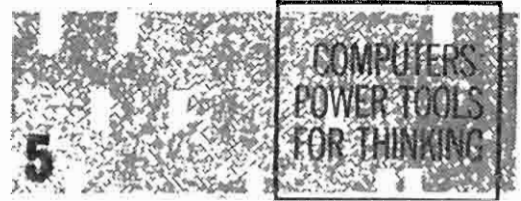


# THE CHRISTIAN SCIENCE MONITOR

*Second Section*

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## The teaching machine

Computers offer an unprecedented opportunity to give pupils individualized instruction. The following article outlines some of the capabilities and problems uncovered in attempting to adapt the electronic teacher aids to the classroom.



*Professor Suppes*

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*Written for The Christian Science Monitor*

**I**MAGINE THAT YOU HAVE A 10- OR 11-year-old child and the funds to hire a private tutor to educate this child. What sort of instructions would you give the tutor?

All of us can give at least a partial answer. We would want the tutor to give instruction in reading and other aspects of English, mathematics, elementary science, and history or some other aspect of the usual curriculum in social studies.

Let us also imagine that this tutor, although highly intelligent, is not at all familiar with the curriculum in American schools or even with the basic facts and traditions of American culture. So he nods affirmatively to your instructions. But he says that he needs to know a great many more details

about how you want each of these subjects taught.

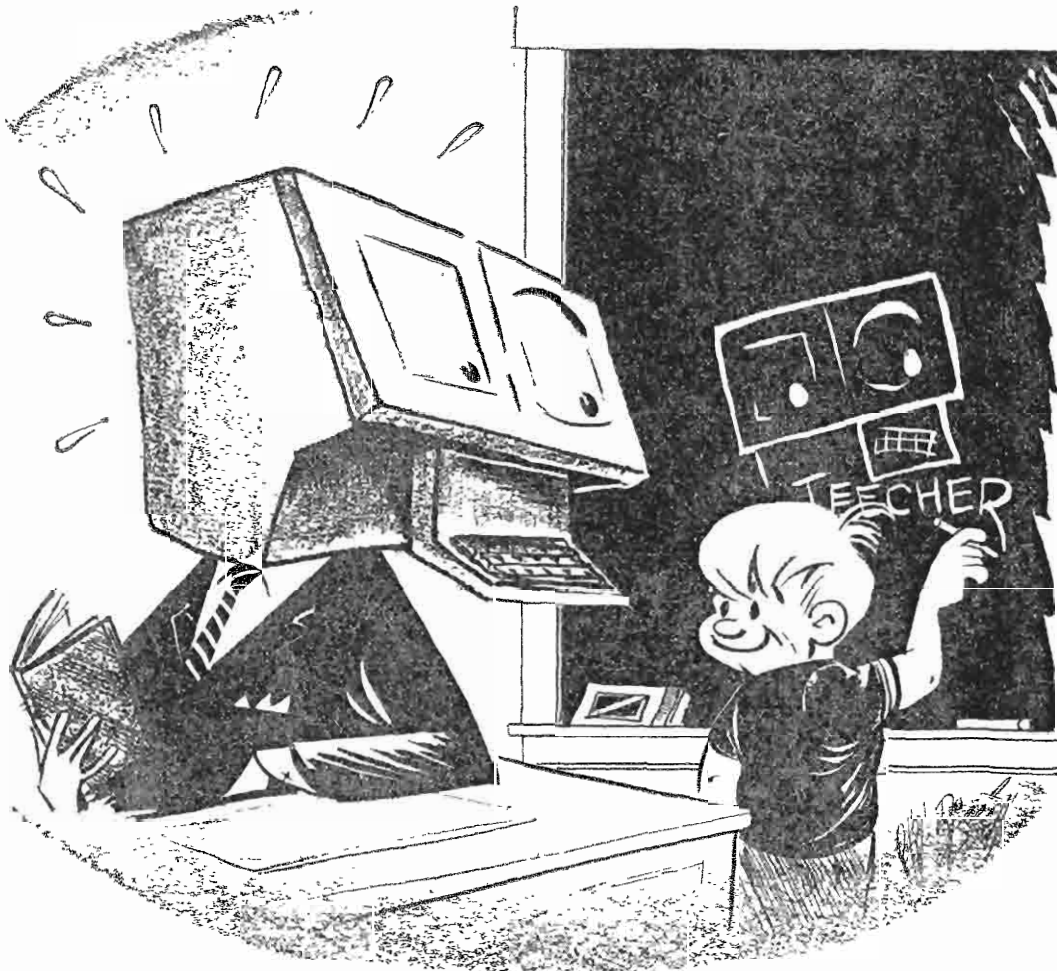
This is much like the situation we face in programing computers to offer individualized instruction to our students. The computer has the basic capacity to be highly responsive and intelligent in presenting curriculum and in handling the learning difficulties of students. But the computer does not have a long intellectual and social tradition of teaching. The computer has not been to school itself. It has not been trained to teach.

### **Tutor capability described**

On the other hand, the power of the present technology to offer highly individualized tutorial instruction to students should not be underestimated. It is my own judgment that at the present time technology is more powerful than our understanding of how to use it effectively and efficiently.

Let me try to describe the present capabilities of our computer as tutor and some of the problems we encounter in programing the computer to help in the teaching process.

Suppose that a classroom of 25 youngsters



contains consoles that look like either typewriters or television screens with keyboards, and which are under computer control. Suppose that these consoles can be used to provide individual work in arithmetic according to the classroom teacher's requirements.

The teacher may find that Johnny is weak on basic multiplication facts, that Mary is not able to handle fractions very well, and that Susan needs much more practice in solving word problems. If computer programs for the curriculum have been organized for the teacher in advance, it will be a simple matter for her to send each child to a console. It will be easy for her to request appropriate review and practice material in those areas in which each student is weak.

I think most of us would find it fairly easy to be more specific about how this material should be organized. We would all think in terms of the kind of exercises we learned to solve correctly. If we needed a refresher, we would go to some elementary school textbook in arithmetic for further ideas.

The first problem we would encounter in these textbooks is that they are aimed at the average student and, indeed, even at the average performance of the average student.

If, for example, our student were extremely bright, we would want to accelerate his rate of progress through the curriculum beyond that easily provided for by the textbooks. On the other hand, if our student were below average, we would want to provide additional work and perhaps introductions to concepts easier than those in the standard text.

In other words, we would be considering how to individualize the instructional program. There would be little point in having a tutor if the instruction were not individualized.

### **Little research published**

Next, we might go to the library for help. Unfortunately, we would not find much research of a deep or systematically organized sort. This absence of a tough-minded intellectual tradition of study of how we can best individualize instruction is, in my own judgment, the most serious handicap we have to overcome in using computers as instructional devices.

Consider our drill-and-practice program in elementary arithmetic. It was run with some 900 students during the past academic year and will be run with about 2,000 students during 1967-68. Its purpose is to supplement the teacher's regular instruction in elementary arithmetic.

Ordinary Teletype machines are placed in schools and connected by phone lines to our computer at Stanford. Under computer control, the Teletype types out an exercise. The student responds. The student's answer

is immediately evaluated. If it is wrong he is given a second chance. If he is correct he is immediately given a new problem.

At each grade level the curriculum in arithmetic, or more generally in elementary mathematics, is broken up into approximately 20 concept blocks. Work in each concept block covers seven days.

On the first day the student is given a pretest. On the basis of his pretest score he is placed in one of five levels for five days of training. During the training he moves up and down in the five levels, depending upon his score on each day. At the end of the five days, the student is given a posttest, which is entered into his record for that concept block.

### **Individual review added**

The program just described constitutes about 70 percent of his work at the Teletype console. At the same time that he is working on a given concept block, he is also being individually reviewed on previous concepts on which his work was least satisfactory.

For example, a fifth-grade student who, in February, is on the 10th concept block is reviewed at the same time on that one of the preceding nine concept blocks on which he had his lowest performance. For one student this review block might be addition of fractions; for another, problems of long division; and for another, solution of word problems.

At the end of the block, the student is also given a review test on the review block. His score on the review test is used to update his record of achievement on this past block.

This program goes beyond what can ordinarily be provided by the teacher. Moreover, because of the computer's rapid mode of operation compared to human response time, a single computer can be highly responsive to a large number of students.

In the next round, we hope to organize the entire elementary-school mathematics curriculum into a number of strands extending from grade 1 to 6. Such an organization of the curriculum into strands is already fairly widespread. We can take advantage of work already done in this respect. Typical strands would be those for addition and subtraction, elementary geometry, fractions, measurement and applications, multiplication and division.

### **Difficulties carefully sorted**

We are arranging the exercises within a strand according to level of difficulty. The basic idea is that each student enters a strand at the bottom, where the problems are the easiest. He works his way to the top over the several years of his attendance in elementary school.

Under most analyses there will be some-

where between 10 and 15 strands, in terms of which we will organize the elementary-mathematics curriculum. We must then determine how the work of the student shall be distributed among these strands. Second, we have to determine how he should move up and down in a given strand according to his performance.

We have fairly good techniques for assigning an expected level of difficulty as it is reflected in the expected probability of an error for each exercise in a given strand.

As already stated, a student begins at the bottom of a strand. Whenever he makes a correct response we move him up a small step in the strand. If he continues to make correct responses he can move upward in the strand very rapidly.

Whenever he makes an error we move him down by a small step. If he continues to make errors we move him downward until he encounters problems he is sure to be able to handle.

### A simple program

One simple scheme for distributing time across the strands is the following. At the beginning of each day we give the student one problem from each strand. The remaining time, perhaps enough for another 10 or 12 exercises, is devoted to exercises from the two or three strands on which the student's current position is relatively the lowest in terms of grade placement and scale of difficulty.

Under this scheme, at any given time, we would have available a current and significant record of the student's level of achievement in arithmetic.

For almost the first time, in curriculum instruction, we can make a detailed and objective analysis of student performance. The computer's vast capacities for gathering and analyzing data makes it possible.

Now we can take the fantasy out of curriculum instruction. We can find out in detail what does work and what doesn't work in each section and, indeed, in each subsection and problem of a given curriculum.

I have not yet dealt with one skeptical query about the kind of programs I have been describing. It asks whether individualization actually improves student learning and performance.

The current application of computers is too recent to have built up a decisive case. Yet, what data we have accumulated over the past several years is quite encouraging. In a very short additional period massive objective data will be available for analysis by skeptic and protagonist alike. As an enthusiastic protagonist, I dare to predict that computers will soon play as significant and universal a role in schools as books do today.

Fifth of a series. Next Thursday: Computing the weather.



By Peter F. Knight

*'I hear my computer talking'*