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Interactive Learning: Twenty Years Later

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It is always interesting to read what one has written many years ago. In this case the paper was initially given as an invited lecture to the American Association of Physics Teachers, the Millikan lecture. Then it was reprinted with several other papers of mine in Robert Taylor's book, (*The Computer in School: Tutor, Tool, Tutee*, 1980) in the section that discusses the use of the computer as a tutor.

So I welcome the chance to show my current views, and I hope the future perspective. The organization is as follows. I will first review what I regard as the current state of learning in schools today. Then I will consider the role and effectiveness of computers in schools now. My third consideration will be the bad prediction I made at the beginning of the article. Finally, I will discuss what I see as the future of learning and the role computers play. Given my constraints, this discussion will be brief, but I will also give recent additional references that expand these views in much more detail.

EDUCATION TODAY

I cannot convince myself that schools in United States are any better today than they were 20 years ago. Probably they are worse, with teacher shortages. There is a high level of complaint about learning today, as one sees quickly by reading the newspaper or listening to current political campaigns.

So the perception widely held in our society, is that schools are not adequate. International comparisons also show that our schools are weak as compared to those in other developed countries.

The central problem with our present learning strategies is that many students do not learn, or learn poorly, in our schools. The same thing is true in universities, although they receive far less criticism. Our own grading systems demonstrate this, with many making poor grades. I argue that the problem is partially with schools, but mainly with the learning material available for use. It is quite possible for everyone to learn, as Benjamin Bloom demonstrated 20 years ago.

Along with this general level of complaint, many remedies are proposed. Many of these have little empirical basis. Some involve the expenditure of far more money than is currently available, which is unlikely to happen. Some remedies, such as vouchers, are often veiled attempts to weaken or destroy the public schools or to promote some ideology. Some, such as the widespread use of standards and testing, very much alter the structure of classes and often cause the teacher to focus on less important ideas. I do not see that any these ideas are likely to be useful, except in small ways. Some are possibly harmful.

So our problems in schools are still formidable, 20 years later.

COMPUTERS IN SCHOOLS TODAY

There is no question that schools in the United States have far more computer equipment than they had 20 years ago, as a whole. This equipment is also much more powerful than the computers of 20 years ago. Given the steady advance of computer hardware in recent years, computers have become much more powerful for the same cost. This equipment is not evenly distributed, with disadvantaged students less likely to have such equipment

Another new feature of schools is the widespread availability of the Internet. Great pressure has been exerted to make this economically feasible for schools. Again, this access is not uniform across all schools, with poor students suffering. The pressure now is to move from slow connections, such as those available through ordinary telephone lines, to higher speed

access of the Internet (broadband). As with the hardware, much of this is not done with any clear educational goals in mind. Far too much of the thinking about computers in schools involves hardware rather than learning. For example, I can see no educational case for broadband.

How are these computers used today? Rather interestingly, the dominant use in schools is not any of the ones mentioned in Bob Taylor's book. Some of the proposed uses are hardly seen today. One does not, for example, see many classes learning Basic or Logo. Rather, the use of the Internet that dominates school use, with both students and teachers, is through websites that claim to help them. These sites are often ill related to what is happening in the class. There is relatively little carefully designed learning material on the Internet, in the sense I will discuss later. Furthermore, what learning material there is tends to neglect the needs of learning that will be discussed later in this article.

It is worth noting that schools have not, overall, improved with this large investment in hardware and networks. Some argue that computers are the problem, not the solution. I do not agree with this, but I think we are not making the best use of computers so far.

MY INCORRECT PREDICTION

My 20-year-old article starts with the prediction that computers will be the dominant mode of learning by now. So I was not a very good prophet. I still think that the prediction will be accurate, but it has taken a longer time to happen than I expected. My suspicion is that we will need another quarter of a century. I still think that computers will eventually dominate in learning, at all ages.

Why was my prediction wrong? I can see a number of reasons. One, already mentioned, is a tremendous fascination with the Internet, in spite of the fact that there is little empirical evidence to show it is effective in helping learning. Another is the rise of the mouse as a computer device. People had the peculiar idea that one could deal with the world of learning purely by pointing. An even more important factor is the lack of research in learning with computers, effective research professionally done with very large numbers of students.

A factor that I did not take sufficiently into account is the increasing numbers of students who need to learn. This point is critical in understanding the current problems of learning, in both schools and universities. The population numbers are important not just in this country but even more globally. We now have a world with 6 billion people in it, 9 billion in another 50 years.

Our current educational strategies cannot cope with such numbers. Schools were developed at a time when there were far fewer people than there are now. If one looks at the evolution from the "little red schoolhouse" to present schools one sees a constant attempt to try to meet the needs of the increasing numbers of students. The notion that we will solve learning problems by building schools and training teachers does not work even in this country and is even less likely to work in the undeveloped parts of the world. The numbers are all important.

But perhaps the major reason is the failure to produce the new learning materials that effect use of the computer demands. This is not just the computer material. I mentioned in the original paper that the physics textbook in universities that dominates has done so for a long time. Ironically, that same textbook still dominates 20 years later.

It goes beyond the purposes of this discussion to indicate why we do not generate much new learning material. But careful studies of the post Sputnik curriculum development, particularly the effect of *Man, a Course of Study*, will, I think, provide clues. There has been little innovative curriculum development in United States for many years. Government is reluctant to fund such development now and is often striving not for what has been shown to work but for something new.

Recently Project 2061, a product of the American Association for the Advancement of Science, studied common textbooks in use in teaching science and mathematics. The results are dismal in almost all areas. For example, they did not find a single good textbook for middle school science. The scramble today is to demonstrate that one's textbook satisfies the standards, making as few changes as possible. This tells us something about the standards.

Let me mention just one issue that has been of great concern to me lately. One of the major failures of learning in the United States is that many

students do not learn to read and write effectively. It is exactly here that the computer could be of greatest value. In spite of the statement otherwise, we are leaving many children behind. I would be happy to discuss this further with my readers. We are working on such a proposal.

A VISION FOR LEARNING

So far much of this article has unfortunately been negative. Now I wish to move on to discuss a much more positive view of where learning can go in the future.

Why do many people not learn in our present institutions? I believe it is fundamentally because of our failure to adapt learning to each individual student. Each student is unique, with individual backgrounds, strengths, and desires. But our current approaches to not take into account this difference. This is related to the problem of increasing numbers, already mentioned. We should be finding and solving learning problems when they first develop.

There have been environments in the past in which everyone learned, and learned well. The learning situation I am thinking of is that involving an excellent tutor with a very small number of students. For those who could afford it, this has a long history of being the preferable way to learn. Thus, the children of the wealthy often have been educated in this way. In such an environment each student is treated as a distinct individual, so learning is highly individualized. A typical way of proceeding is for the tutor to ask questions, as with Socrates.

A critical aspect of such learning was a student's native language. Socrates asked questions in that language and expected answers from the student in the same language. Our languages are the most powerful learning tools we have. Note that there was no pointing and clicking in Socrates!

But the problem with this way of proceeding is the cost. Good tutors are expensive, and not widely available. So only a few individuals could be educated this way. We have now reached the point where the computer can serve as a tutor. Further, the computer can do this, unlike human tutors, at a very reasonable cost. Modern communication methods allow us to reach everyone on earth with such tutorial learning, provided the learning material

is available in the student's language and reflects the student's culture. When the previous paper was written, we had already generated such tutorial material at Irvine, with computer equipment much more primitive than today's computers.

Many aspects of this approach were described in the 20-year-old paper. The modern details are to be found elsewhere. I particularly recommend the book I recently wrote with Sigrun Gunnarsdottir (2001). It examines these issues in much more detail than is possible in this brief article.

Our experience is that the best way to proceed in adaptive computer-based learning units is through the questioning process, just as with human tutors. The computer asks a question at intervals of about 20 seconds. The freeform student answers are analyzed by the computer, following the directions of the designers of the material, and the program decides, again from the designers, what question to ask next, based on the student input and on stored records about past performance. For students speaking English, all this is in English. With such frequent questioning, we can find student problems and keep them interested for long periods of time.

With this procedure, almost all students can master the material. Different students will take different amounts of time, particularly if their backgrounds are very different, but almost all will succeed. Different students may see learning materials also. A very small number will need human tutors.

We find it best for students to work at the display in groups of about four. Peer learning is a valuable component of student success.

We need to consider many factors, such as making the necessary hardware available everywhere. This is further discussed in the book already mentioned.

None of this highly adaptive learning is done using methods of artificial intelligence. Rather it is all the result of the design process. Very good teachers working in groups of about four are the designers. They make all the decisions that have just been mentioned.

The record of all these decisions in a verbal and pictorial strategy we call a *script.* The designers make the material responsive to individual student

needs. This system was fundamentally already in existence when the paper was written 20 years ago. But now it is much better supported with software. The script can be stored and modified online, and much of the program can be written by the computer. A much more complete description of the production system is contained in the book already mentioned and in papers at my web site (http://www.ics.uci.edu/~bork/).

The one new ingredient we would now recommend, not possible 20 years ago, is the use of voice input. This makes a student interaction with the computer much more natural, because our language is our natural way to communicate with the world. It also makes it unnecessary to use the terrible QUERTY keyboard. We can reach students who cannot read and write.

Current speech recognition software is now adequate to this task. We stress that no natural language recognition is needed. As with other aspects mentioned, we need more research on these issues.

Very little of this type of learning material exists so far. We do not even have a careful experimental basis to show that this is how we should proceed, so that is the first task. We need learning material of this kind at all levels, from very young ages to old ages. We need to develop also material that is concerned with our major global problems, such as population and violence.

We have a very exciting time ahead of us in learning.

References

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Author Note

This paper was dictated using Dragon NaturallySpeaking.