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Guest Editorial: Why Has the Computer Failed in Schools and Universities?

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INTRODUCTION

Although the title of this paper is negative, and there are certainly some negative aspects in it, I do not intend this paper to be entirely negative. I hope that pointing out problems with technology and education will lead us to use technology more effectively than we have so far. Technology can lead to major improvements in education nationally.

The title does not refer to education, but it is education with which I am primarily concerned. It does refer to schools and universities, where education is the fundamental activity, but it could be broader than schools and universities because computers have also failed in informal life-long education up to now. This failure is not an intrinsic flaw in the technology. Evidence suggests that interactive technology has tremendous potential for assisting learning at all levels, but, as with any new approach, there is a period of experimental trial of the technology, a period where there is trial of different possibilities. We are still in this period for technology in learning.

WHY FAILURE?

I do not intend to argue in detail in this paper the evidence for failure. The major consideration is the status of education. Failure is amply shown by the fact that education in the United States, and other counties, continues to have major problems. Although computers have been used in education now for over 30 years, there is little sign that the major problems of education are getting any better. It is in terms of the overall quality of education nationally and internationally that we must judge whether the computer has made a positive or negative contribution. On this basis the computer is clearly a failure.

There are many other places where one can see a litany of the failures. Perhaps an unexpected recent article is one printed in *MacWorld,* in September 1992, by Gerry Borrell, called "America's Shame; How We've Abandoned Our Children's Future." Other articles in this same issue pick up this same theme. Here is a quote from Borrell's article: "...We will spend hundreds of millions (perhaps billions in the near future) on computers and technology in education without effectively addressing problems that were first identified more than a decade ago."

This is not to say that there are not, in trivial terminology, "points of light." There are places where the computer does contribute effectively to learning, but these have, judged in the country as a whole, a practically negligible effect. Furthermore, for reasons that will perhaps become apparent later in this paper, the usages in these "good" situations, give us almost no clue of how to help the country as a whole.

The reader will note that there have been many other nontechnology attempts to solve the problems of education. Nothing has helped, judged on a national basis. However, my concern is with interactive technology. Its use, I believe, has great potential for major improvements in education, but we are not realizing this potential.

REASONS FOR FAILURE

Now I come to the heart of this paper. I will enumerate a series of reasons I regard as causes of the failure of technology in learning. Through un-

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derstanding failure we hope to move forward, to improve education with interactive technology. These items are not of equal importance, but I will make no attempt to rate them. They are all important in understanding what has happened with computers in education.

Hardware Emphasis

When one looks at the literature about computers in education, one finds tremendous emphasis on how many computers are in schools, the types and other hardware information. The statistics are often misleading, because they seldom take into account the junk heaps of unused computers, or the computers used in marginal ways, such as only for playing games. Acquiring hardware is a major unfortunate emphasis in most institutions. The emphasis on a hardware is naturally stimulated, to some extent, by the computer vendors. Particularly in the early days of computing this was a problem. Now the vendors have a more realistic view, but many people still view the choice and acquisition of hardware as the important issue for using technology in education. Thus hardware emphasis continues to be a major problem.

We see a new phase of this stress on hardware in current discussions of networks and multimedia systems. Again, it is hardware that is discussed primarily. Schools proudly tell you that they have laser disc players, even if class use is minimal and teachers do not understand the technology. Almost as soon as the hardware arrives, no matter what hardware, there is a realization that more than the equipment is needed, but often it is too late at that point for much else to happen; the money may already have been spent, or little good software is available.

We need to make it clear to educators and parents all over the world that simply having computers in schools and universities does not improve learning; it may have the opposite effect, and often does.

Little Focus on Learning

It is a corollary of the emphasis on hardware that computers often appear with little or no previous consideration of the role they are going to play in the learning environment of the school or university. There is a vague belief in the magic of the technology by parents, administrators, and teachers. Learning is not just a question of having one particular set of hardware available. Planning for learning should precede *any* hardware purchase.

Little Focus on Students

A related consideration is that the emphasis on hardware generally occurs in situations where the students are ignored. The students become the last things to be considered after the hardware is purchased. Again, the affairs of the school or other learning institution are being conducted backwards. This is not confined to technology.

Software-Based Failure

The next reasons for failure of computers in schools are related primarily to the types of learning software developed up to now. Much of this software is inadequate for the best learning environments.

Elitist Programs

Much of the software available, in spite of protestations to the contrary, is software that can only be described as elitist. That is, it is software that may work with very good students, or with extremely skilled teachers, but given the problems of the country and the world as a whole in education, it is useless. Some programs work only with the developer present.

Teachers in schools and universities feel particularly rewarded by their good students. Although the good students might well be learning entirely without teachers, they nevertheless see this as a great phenomenon. Often these students do not need teachers, so it is an illusion that great things are happening because of the teachers or the software. Teachers may inherently want to work with the best students and may feel unsatisfied with students weak in some sense. Thus, they tend to work in software of this elitist kind, working well only with a few students. Equity issues are ignored.

Weak Interaction

Although the term interaction is widely used with computer and multimedia materials, it has a

variable meaning. Many materials that describe themselves as interactive represent only weak interaction, while what we need in software for effective learning is a high level of interaction.

Interaction is important for at least three reasons. First, and perhaps most important, is that it enables us to customize the learning experience to each student, to individualize it to student needs. If we are interacting frequently with a student, we can determine what the student needs further help with. Interaction also leads to active learning, a better form of learning than passive listening to lectures or reading books. Students can create their own knowledge in an interactive environment. Thirdly, interaction itself has strong motivational effects, so an interactive lesson is likely to be more interesting to the student.

We can see many examples of poor interaction in existing learning materials. One terrible example is multiple choice; it should never be used in technology-based learning material. Another example of poor interaction is a program that depends only on pointing, with a mouse or in other ways. We have a marvelous tool for interaction, our natural languages. It is only through natural languages that we can hope to attain highly interactive material. This is feasible today and should be done much more than it is. Interaction is critical in enabling a child to construct his or her own knowledge and, thus, to own the knowledge.

Programs that Ignore What the Student is Doing

Elitist programs tend to pay little or no attention to the student. The student is given tasks to do, provided with tool-like facilities—perhaps elegant—but the program does not know whether the student is using the tool-like facilities in reasonable ways or accomplishing the tasks. The program probably does not know *anything* about what the student is doing! Some students may use the facility reasonably, others may never even get started, because for that student there is no adequate instruction available. No attention may be given to what the student's weaknesses may be. Some students learn, but many do not.

Everyone gives lip service to the notion that "students are different," but much software pays little attention to this. If the student has conceptual difficulties, the program often does not know this and can offer no individualized help. It cannot suggest that something be repeated, check on what has been learned, or offer another learning strategy. Most programs know nothing about the student.

A particular example of this lack of individualization is in much of the material for using the microcomputer-based laboratory. The difficulties of setting up the equipment are often considerable, but only print is available for either the teacher or the student in most cases. Furthermore, after the student does an experiment and obtains graphs on the screen, the question is, are these graphs reasonable? Where there errors involved in the measurement process? This could usually be determined by the program, but seldom is. Then there is the critical question of whether the student understands the results, even if the results are reasonable. Can they draw any conclusions? What is learned?

I do not mean to complain particularly about microcomputer-based laboratories. I simply use that as an illustration. One can find the same situation in many different types of software, often highly admired, prize-winning software. Programs of this type ignore what the student is doing.

If one raises this objection with the developers of the software, there is a standard reply. The teachers are supposed to come in and provide the assistance. Yet the teachers are already very busy in current environments. That they will be able to provide large amounts of individualized assistance is often beyond possibility, even with skilled teachers. Technology should make life simpler for the teacher, not more complicated. Thus, the software of the type that ignores the student is likely to be elitist, even though it starts out being used with a wider range of students with special teachers.

The Idea of the Moment

"Idea of the moment" applies to both hardware and software. The use of computers in education has been plagued, to use a mild word, with one new concept after another, either new hardware, new software, or new ideas. Seldom do we exploit what we already have. We do a little bit with it, not enough to effect most students, and rush on to something else. The list of topics of this kind is long—it includes such things as Basic, Logo, drill and practice, artificial intelligence, hypertext, virtual reality, tools, video discs, and CD-ROMs; one could go on almost forever with this list. Each of these ideas of the moment tends to generate a collection

of true believers. Often these "cults" go on afterwards, with strong believers, even when the evidence is negative. There is usually little positive evidence for the beliefs of the cult, but as with religious cults, that does not discourage the believers.

It is not that these ideas are not useful. Many of them are, although not all. My complaint is not in the ideas themselves but that one goes continually on to new stances without making good use educationally of what was already available. Emphasis on new hardware and new technology is greater than the emphasis on learning. Believers in these techniques always seem to believe that it is the new one, the next one, that is going to revolutionize education. Many of these techniques, used alone, could have led to revolutionary directions if used reasonably and fully. We could have rebuilt education with technology many years ago.

Relation between Information and Learning

Another persistent problem that has led to difficulties with technology in schools, and one that is particularly important in considering much of what is being written now about the future role of networks and interactive highways for learning, is that access to information is often confused with learning. We need the highways and the ramps into educational buildings and homes, but we also need much more if all students are to learn.

It should be obvious to any teacher that there is an enormous difference between providing access to information, even in an extremely versatile fashion, and a child learning something from that information. This is often ignored. Much of the literature about networks talks about making vast amounts of worldwide information available to children, but often in completely unstructured ways and with no consideration about how to make use of the information. For many students access to information does *not* lead to learning. If one takes a newborn child and locks it in the Library of Congress, providing the essentials of life in addition, one cannot expect that child to come out as a highly learned individual. Similarly, access to large data bases all over the world will not have that effect either.

Again nothing is intrinsically wrong with providing accesses to data and providing hypermedia documents. It is a question of confusing this with learning, or ignoring learning and simply providing information. The issue was beautifully expressed by Arthur C. Clarke, when he talked, via satellite from Sri Lanka, at the conference Reinventing Schools—The Technology is Now, at the National Academy of Sciences in Washington, in May 1993. Clarke said "information is not knowledge, knowledge is not wisdom, wisdom is not insight." Many of the people who push heavily for superhighways of data, that could play an important role in education, seem to consider that all that is important in education is that students have access to knowledge. This may be true for a few able students but it does not represent a point of view that will lead to large improvements in education in the United States or the world.

Failure of Teacher Education

A major problem in education, independent of the technology, is the great difficulty of effective teacher education. As we have had more and more teachers in the world, and an increased population of students, the problem of teacher education has become more and more critical. The problem is particularly important when one considers new techniques, new curricula, or new ways of doing things in education. This is almost always covered by in-service education, and the typical way of handling it is through giving lectures to the teachers. While a few institute for teachers are good, many are terrible and education for teachers is a major national problem. Technology is particularly resistant to "talking about it" to students. Thus, although vast sums of money in the United States go to teacher education programs on the new technology, few positive results, judged nationally, can be seen from this.

Lack of Empirical Evidence

One of the things that plagues education is that so little is known, on the basis of current careful experimentation, about the learning process and about the effectiveness of different kinds of material. In this situation, with little empirical information, it then becomes possible to philosophize, to express strongly held views. Academics are particularly apt to do this, because argument and debate is part of their training.

This problem has particularly effected the use of computers in classes, but it is not due to technology. In most cases in education we have little empiri-

cal information. We seldom do careful testing of the effectiveness of different curriculum material, with enough students to draw careful conclusions. The net effect is that little information in education is based on fact. Some of the other factors mentioned, such as the "idea of the moment," are so prevalent simply because there is so little empirical data. I find this situation strange. One could imagine a full-scale experiment, for example, that would investigate many alternative strategies for teaching reading to young children, but no such full-scale careful experimenting is done. Rather, the proponents of different points of view continue to argue with each other, gathering their own "empirical" evidence.

Extensibility

Many of the ideas proposed for computers in education work well in their initial settings, often specialized ones, but many of these cannot be applied to the country as a whole. They cannot be scaled up from limited numbers of students to 45 million students. The problems of education are pressing for all students, not just a favored group in a few locations. This is particularly a problem with the model schools, or with schools that are part of "research" with university groups. Often project costs are unrealistic, even for the individual school.

There was an interesting example of this during the Reinventing Schools meeting at the National Academy of Sciences, in May 1993. We saw one sequence on video where two students were looking at a weather map and discussing a "problem." They proceeded to call up a scientist who was sitting at his computer with the same weather map displayed in front of him. While this could be practical with two students, imagine doing it with 45 million students. Even if all the scientists in the country and all the scholars spent all of their lives in front of computer screens, doing no research whatsoever, there would be far too little time for the country as a whole. "Experiments" of this kind should not be done. We should concentrate our funds on activities that have some chance of improving United States education.

Pieces vs. Courses

The final problem to be discussed may be the major problem, the dominant reason, although not the only one, why the computer has been such an abysmal failure in assisting learning and solving the major problems of education. Most of what has been produced are short pieces of software. Seldom have the computer and its related technologies been used as the basis for full courses. There have been some courses developed, such as the logic courses at Stanford University, the language courses at Stanford, and the physics course at the University of California, Irvine, but the only recent example of developing a full course making extensive use of the computer is Writing to Read.

This could be contrasted with what happens in other areas. For example, vast amounts of funding have gone into video courses, both from private foundations such as Annenburg CPB, from universities such as Oklahoma State, and from government projects as Star Schools. Hundreds of video-based courses are produced every year, yet no courses fully based on interactive technology are produced.

What is the importance of whole courses? Small pieces of software added to conventional courses do not fundamentally change the course. A lecture/textbook course with some software is about the same as it was before the software was available. Computers should not be adjuncts to traditional modes of running a classroom. Rather they can lead to entirely new ways of running a classroom impossible with the current learning technology. These new ways will prove to be much more effective in assisting students to learn.

To realize the full power of technology in education we must realize that new types of courses are possible with the technology that are not possible without it. New course structures, new roles for teachers, and new patterns for organizing classrooms in schools with the technology, often with very exciting possibilities, cannot be done unless we build whole courses from the beginning using the technology. So far there is not even a single recent experiment in this direction. Attempts to get the National Science Foundation to fund such projects have been unsuccessful.

As one example of this, consider the question of fixed pacing vs. variable pacing. Almost all the non-technology-based schools of today have fixed-pace courses. The one exception to this is probably at the elementary level where there is some presence, although still small, of ungraded schools. Part of the difficulty concerns how the teacher is to handle a class where everyone is going at her or his own

pace. The computer makes this practical, so that we can now insist that all students master the material, even though it will not take the same amount of time for each student to do so.

TECHNOLOGY AND LEARNING

This negative paper has a positive side too. I have tried to suggest that directions that have led to failure are not necessarily ones that we need to follow. Interactive technology, both in developing full courses and playing a major role in teacher education, has the potential to produce order-of-magnitude improvements in our educational system. The negative aspects we have given about the failure of computers in education lead us to positive directions. The following might be considered a start in this direction.

- We need to create full technology-based courses, courses that from the earliest stages assume that the computer will be a very important learning component in the courses. This should happen in both schools and universities.
- The new courses should make full use of modern multimedia capabilities, where these are desirable for pedagogical reasons.
- These courses need to be student centered. That is, it is the student we should be concerned with, not the teachers, faculty, administrators, or other components of education.
- These courses should be very sensitive to the needs of each individual student. Close attention should be paid to student performance, testing frequently as part of the learning material and offering other learning mechanisms when the student is not succeeding.
- The courses should do more than offer facilities and tools for students. They must make certain that all the students are learning all the material. Mastery for all users should be the goal.
- With the new courses, careful records should be kept on student behavior and decisions made in the learning material should be based on how students are learning. These same records will be useful in improving the courses and in research on learning.
- The courses should be highly interactive: they should allow the student frequently to answer meaningful questions and to make meaningful decisions. The mechanism of this interaction should be the English language, just as it is in conversations between two humans. Simplistic interaction, such as multiple choice, should not occur.
- The courses need to have realistic costs and time. It should be assumed from the beginning that any new course is to be delivered nationally, and so strategies that depend on unique situations should not be followed. We want courses that will work for all students, regardless of background, gender, race, or other factors. We need courses that are possible within current financial constraints for education.
- Each of these new courses should be accompanied by a full range of learning materials for teachers. These learning materials should be technology based, usable by the teachers in their own homes and in their own schools. Often these new courses will follow new organizational structures, with new roles for teachers, so nationwide teacher education is essential.
- Little current knowledge is available in producing full-scale technology-based courses. Hence, an experimental period, to gain this knowledge and experiment with marketing the material, is needed.