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The Myth of the Educational Computer

To dispel the delusion that the computer by itself can educate, computer professionals need to press for reforms that properly exploit digital technology in the classroom.

ome time ago I was at a forum attended by many teachers who were concerned about the shamefully high level of youth unemployment in Tasmania. There had just been an election, and the new State government had announced that it would slow down a project that was putting large numbers of PCs into schools. Attendees at the forum were unanimously dismayed. Not a single one doubted that putting lots of computers in the schools would automatically bring benefits.

This unquestioning trust in the good to be brought by computers reminded me of the Melanesian cargo cults. In the first half of this century, ignorant of technology, natives of Papua New Guinea and nearby islands fervently believed that ships and planes would bring them cargo from their ancestors, and no one could tell them otherwise. The Myth of the Educational Computer has been so widely accepted that there was about as much point in disagreeing with the forum attendees as there would have been in trying to argue with the natives.

The current computer-as-educator delusion is extremely harmful and yet seems to go largely unquestioned, even by computing professionals. I don't mean to say that computing professionals aren't doing very good work technically in developing courseware and so on. What seems to be missing, though, is a full appreciation of the relationship between technology and education. The literature suggests that much of the work done by computing professionals is isolated from what goes on in schools generally. Our profession's focus seems to be on how to find smart ways to use computers in the classroom, not on how to solve the really important problems deplored in the educational literature.

If, on the other hand, we were doing all our educational computing work in close partnership with professional educators, more of us computing professionals would be pressing for the reforms needed to exploit digital technology properly. The lack of such reforms and the rise of this delusion—that the computer by itself can educate—have already led to a sad waste of resources and enthusiasm.[1]

EXPLODING THE MYTH

High hopes and modest fears about the use of computers in the classroom were voiced more than 30 years ago.[2] The hopes have proved much too high, and the fears much too low. Although in many instances,

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computers are very well used in education, the vast potential benefits of computers in schools are not being realized. Nor can they be in the present political climate and under the prevailing social conditions.

I have three general arguments about computers and education:

- *Computers alone cannot educate anyone.* Training and support of professional educators must both precede, and take priority over, placing computers in schools. This training and support must extend teachers' capabilities, not merely reorient them. If properly done, it will cost much more than the computers themselves.
- *Computing professionals must become active in support of reforms that aid the teaching profession.* Only then can digital technology become of general benefit to our children and young people, and thus to our society.
- *There are grave, worldwide social problems, arguably caused in part by the misuse of digital technology.* We must solve these before we can improve the generally failing educational processes.

To understand these problems and to evaluate the prospects for computers in education, it helps to put the issues in the context of just what education is expected to achieve.

The second edition of *The Oxford English Dictionary* gives two relevant meanings of education: "To bring up (young persons) from childhood, so as to form (their) habits, manners, intellectual and physical aptitudes" and "To train (any person) so as to develop the intellectual and moral powers generally." What these definitions lack is any statement of just what habits, manners, aptitudes, and powers education should aim to develop in the pupil, and why it should choose to develop those particular qualities. This is what education theories attempt to answer.

EDUCATION IN THEORY

Writers with Western European or North American backgrounds typically describe three theories of education: social, liberal, and progressive. Can computers help realize any of these idealistic theories?

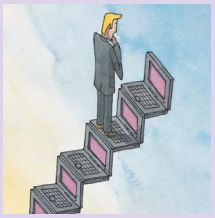
Social education

Before there were schools, education was oral and the responsibility of the family and the community. Carried out as ritual and role play during daily life, its purpose was to sustain the community.

School systems are political entities that are larger than the oral communities. Setting up a school system is always at least partly a political act, intended to support and perpetuate the social entity that provides the system. In stable, affluent societies, children are educated in formal schools, where they are intended to be made literate.

In a typical school system, the rituals and activities within the school are patterned after those the conforming adult is expected to submit to. Teachers are primarily social workers, who aim to fit their pupils into society.

Role of computers. Can computers be used to help inculcate social norms? Those who look to computers to contribute in this way have a dual problem: Not only is the idea of a society poorly defined,[3] but also the nature of society is rapidly changing.



Computers alone cannot educate anyone.

In any case, it is difficult for teachers to build socialization when their pupils lack even the rudimentary inter- and intrapersonal skills necessary for a traditional classroom to function. Committed parents used to provide this preschool socialization, but they are disappearing as are the skills themselves.[4] It is also pointless to model progression through public life when the gap between rich and poor is widening at an accelerating rate, and many long-standing social institutions and values are fading. These social problems have been repeatedly documented by the UN Development Program, which makes its annual reports available (http://www.undp.org).

Nevertheless, if it is essential to foster basic social skills—and I believe it is—computing technology can effectively support teachers in planning and controlling social interaction by inducing the very basic skills underlying the use of language and numbers (see the sidebar, "Drill and Practice").

Liberal education

Liberal education, usually traced back to Plato's *The Republic*, aims to deliver a curriculum of elevating subject matter presented in a logical sequence to make it easy to learn.

Liberal education is elitist in principle. In many English-speaking countries, the traditional higher school subjects are English and French, history and geography, mathematics and science—choices clearly not based on social utility. Although few would master these subjects and few would really need them in later life, they were deemed to be "good for the mind"—and the mind was liberal education's target. Teachers are primarily subject matter experts, who seek to impart knowledge and understanding to their pupils.

Role of computers. The liberal educators have been at the same time the most involved, the most optimistic, and the most threatened of all educators since computers have been adopted for school use. There can be no doubt that modern digital technology could deliver, and in many cases does already deliver, liberal and vocational instruction satisfactorily (that is, reliably and cheaply).

Drill and Practice

The primary school classroom of a half-century ago was dominated by drill and training. The marks in my 1939 Grade 1 report were for reading, spelling, writing and transcription, written arithmetic, practical arithmetic, mental arithmetic, art, and handwork—all of which suggest drill or training. In my memory, this was no bad thing.

Nowadays, training is considered authoritarian and therefore harmful. It is also associated with very narrow forms of vocational preparation. But fluent reading, writing, and arithmetic can only be built on training in basic skills, which is precisely where automatic machinery excels. Skills must be speedy and automatic, noncontemplative and unquestioning, otherwise true literacy and numeracy are unattainable.

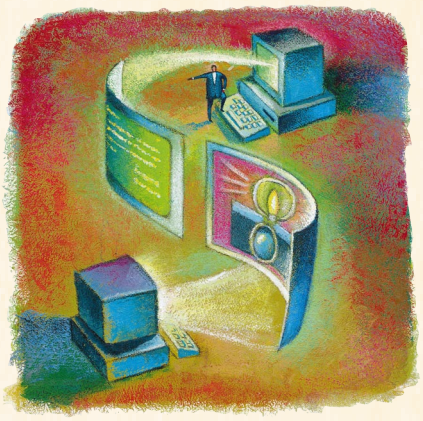
Machine-administered drill should not be confused with computer-assisted instruction (CAI). Instruction is much broader than training. A general-purpose computer is of course a powerful instructional medium, but not only would it be wasted on mere drill, it would be less effective than a machine designed specifically for that purpose.

The ideal machine

An ideal drill machine would be exact and exacting, adaptive and consistent, impersonal and unthreatening. Such a machine would give swift and clear presentation and immediate and reliable feedback. It would be simple and cheap, rugged and small. Because the skills it seeks to induce are general and uniform, such a machine could be made in millions and sold for a few dollars, so that all children could have one when starting primary school.

For basic numeric and arithmetic skills, one drill machine design might be usable in most of the world. For basic language skills, one machine design might do for each writing system, though it would need to be adaptable for different languages.

Such drill machines would not be internally simple—their cheapness would spring from the huge quantity needed. They would also need to be very carefully designed, though they could be steadily improved. As vehicles for attaining basic skills, they would draw on the experiences and techniques of interactive gaming to make the training interesting and absorbing, and they would aim to provide feedback and competition for the user to improve speed and accuracy.



Drill machines could provide very powerful feedback in early education.

Although a drill machine for number skills would double as a calculator, it would be a great mistake to base its design on that of present-day calculators. For one thing, their ergonomic design is wretched, and their arithmetic is badly flawed. For another, they just don't have enough of the functions needed for elementary numeracy, such as functions to return the higher or lower of two numbers.

A drill machine for basic language skills should be able to combine training in reading, writing (and perhaps even keying), spelling, vocabulary, and grammar. Combined training, made practical with such machinery, should be much more effective than separate training in each skill. With the advance of technology, such machines might even be able to recognize and produce speech. They could provide very powerful feedback in early education. Imagine letting preschoolers see words immediately after they speak them.

Drill machines need not be confined to training for basic number and language skills. Equally simple drill machines could be imagined for musical and spatial skills, and somewhat more expensive drill machines already exist for some basic kinesthetic skills.

Warning

Literacy is not merely skill with words, just as numeracy is not merely skill with numbers, though in each case the former is completely dependent on the latter. This was well realized even 150 years ago, when a correspondent wrote in the *Launceston Examiner*: "The notion that education for the general people is comprised in the faculty of tumbling over words letter by letter, and syllable by syllable, . . . has surely had its day by this time, and a long day too." Possibly it is the fear of making this mistake that has deterred use of computers for drill and practice.

Literacy is a hierarchy of reading skills that successively takes in coding, semantic, pragmatic, and critical competencies.[1] Drill and practice is ideally suited to attaining the first competency, and of great help in attaining the second, but the third and fourth correspond roughly to intrapersonal and interpersonal skills which come from practice in social interaction, not from interaction with machines.

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Liberal education is likely to be well served by digital technology, whether in the form of electronic page turning or of highly interactive and realistic simulations, providing it remains under the control and direction of liberal educators. The very real threat is that political influence or commercial greed will force out the liberal educator, leaving the education system to crystallize and allowing machines to regiment our youth.

Progressive education

Progressive theories of education seek to help the pupil develop into a complete person in a "natural" way. These theories are often traced back to Jean-Jacques Rousseau, whose ideas were extended in America by John Dewey and in Europe by Jean Piaget.

The aim is to provide each pupil with experiences and opportunities that change as the pupil develops. Ideally, the experiences and opportunities depend on how the pupil develops, so each pupil's individual potential is fully realized. In progressive education, teachers are primarily mentors and facilitators, who aim to promote individual learning and development.

Role of computers. Preventing regimentation in education should be the role of progressive educators, who focus on developing the individual. Their position in relation to computers is precarious. One of the strong themes of the liberal educators who extol computer-administered lessons is individualized instruction. The very inhumanity of programs administering instruction allows the programs, with the appearance of infinite patience, to adapt what they do in response to any pattern of input a pupil might present. But this is still regimentation, with the difference that the students can be regimented at the most effective pace for each one.

When it is suggested that computer-administered instruction might regiment rather than educate, the usual response is that artificial intelligence will sooner or later surmount all such difficulties. The reprise of the progressive educator would be this: There is a machine on one side of the interaction and a human on the other. The more the program adapts to its student user, the more effective its brainwashing, and the more subtly the student is steered to the required responses.

Progressive educators seek to help individual students develop themselves by providing them with an appropriate sequence and variety of experiences. They could well give priority to interpersonal interaction, using technology as a support and tool, but not relinquishing control to it. One appropriate technique is academic gaming, which goes way beyond simulation (see the "Academic Gaming" sidebar).

EDUCATION IN PRACTICE

Education in practice, perhaps better described as schooling, is not the same as education in theory. When we refer to a person's "education," we really mean their schooling, and level of education is commonly equated to level of schooling attained.

Schooling is determined more by political forces than by educational ideals. In some cases, the effect of political influence is to modify the application of educational theory; more often it is to ignore if not negate educational theory. Three major styles of institutional education are evident: *custodial* schooling, which goes through the motions scholastically but is primarily protective; *vocational* schooling, which aims to equip pupils for the workforce; and *economical* schooling, which seeks to spend as little as possible on education (in the poverty-stricken majority of the world, this boils down to no schooling at all).

Custodial schooling

Government school systems are often very sensitive to community pressures—parents usually vote. This

Academic Gaming

Computer-mediated instruction and computer-delivered simulation can free the teacher to give more attention to students who need more attention. Also, in computer laboratory work, students give great value to peer interaction. Academic gaming goes beyond simulation to provide for systematic peer interaction, in which the role of the teacher is switched from that of authoritative expert to that of facilitator, or even collaborator.

The most familiar example of academic gaming is a business management game in which participants form teams that interact through some kind of business model. Each team makes periodic business decisions, which are fed into a simulation program, and then acts on the results of the simulation to make the next cycle of decisions. With skilled supervision, participants can not only learn about running a business, but can also acquire skills in teamwork and decision making.

Academic games use simulation *as the basis for cooperation and competition*. They therefore have much more educational potential than simple simulations.

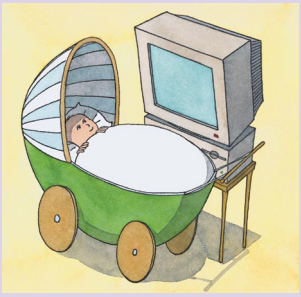
And an academic game can, with some

The most familiar example of academic gaming lets students learn business skills under skilled supervision.

exercise of imagination, be based on almost any model, not just a business market model, and so can be used to foster a great variety of learning, including interpersonal and intrapersonal skills. Belief in the educational value of such techniques led in 1970 to the formation of SAGSET, the Society for the Advancement of Games and Simulations in Education and Training (http://graph.ms.ic.ac.uk/sagset/home.htm) and later to ISAGA, the International Simulation and Gaming Association.

Academic gaming is a very powerful tool, but its competitive aspects can cause great damage if it is not carefully developed and if teachers who use it are not sufficiently trained. This makes it expensive. On the other hand, a large amount of highly educational activity can be based on intermittent use of a single computer.

Academic gaming does not have to be strictly competitive. I remember many years ago reading about a very impressive game based on the fishing industry. It was a fairly conventional game, but the model was of an ocean of fish with a realistically limited capacity to reproduce. While the teams might start by briskly competing, the benefits of cooperation become apparent in later stages.



Custodial responsibility cannot and should not be shunted off to machines.

leads to educational distortions, most notably when the bureaucrats see it as more important that the students come to no harm than that they come to any good. Another motivation for this custodial emphasis is the fear of litigation.

Custodial schooling therefore tends to promote pupils through the classes automatically, either by stipulating that test results be ignored or that students never explicitly be failed. Custodial schooling is an institutional approach to achieving passivity in the schools and to reducing problems for administrators. In custodial schooling, teachers are primarily guardians and supervisors, and the aim is to avoid problems and responsibility.

Role of computers. One of the hopes that seem to lurk behind the political push for computers on every school desk is that they will engross the pupil and thus fulfill the custodial aim. The student surfing the Web or otherwise being driven by a computer can come to no harm and will be too absorbed to bring harm to others.

Unfortunately, computers *can* bring harm to their users. Teachers in schools with computers have long been familiar with the occasional student who becomes obsessed with using computers to the exclusion of other important activities. The Internet has made this kind of addiction more accessible, and not just for school children, as a virtual visit to the Center for On-Line Addiction (http://netaddiction.com) will quickly show. Absorption in the Internet could also lead to harmful behavior—there are reports of school computer use reducing socialization.[5]

The point is that custodial responsibility cannot and should not be shunted off to machines.

Vocational education

While social education seeks to deliver to society recruits that will better the community, vocational education seeks to deliver to industry workers that will better the workforce. In this kind of schooling, teachers are primarily agents of industrial and commercial organizations, and indeed governments nowadays actively promote the support of education by industry. Even universities, once bastions of liberal education, are becoming vocational.

Role of computers. The hope that computers can contribute to vocational education is more overt than the custodial hope: Students should be given experience with computers, the chorus goes, because they will need the skill to use such machines in their jobs. I call this a doubly blind conclusion.

First, many young people won't get jobs, whether they use a computer or not. In Australia in September, 1997, 17 percent of young adults (aged 20 to 24 years) were either formally unemployed or employed part-time but not in school. Another 9 percent were neither employed nor in school.[6] The number of youthful unemployed and underemployed has been increasing in many countries over the past decade, and the trend is likely to continue, even with economic growth. Moreover, unemployment statistics are misleadingly optimistic. Nowadays, only those who are actively seeking work are usually counted as unemployed, not those who have given up seeking work, voluntarily or otherwise.

Second, the jobs the young *can* get aren't what they used to be. Many jobs are being "deskilled" by computers so that workers in fact require fewer skills, not more. Grocery store checkout clerks, for example, need no computing skills, not even keyboarding. Their jobs are threatened not by their lack of skill but by self-service technology and by Internet supermarket shops. This deskilling trend is expected to continue, and not just for intermittent and part-time jobs, but even for professional jobs.[7]

So if more and more people are to be without jobs, vocational education becomes less and less relevant. And if more and more of the jobs that are available are unskilled, acquiring skills with computers is not the kind of vocational training that is needed.

Economical education

As part of the political imperative of reducing public spending, governments in many countries are also reducing spending on schools. This, and pressure from the International Monetary Fund on Third World countries, is why economical education is widespread. In this kind of schooling, teachers are lowly paid and insecure, while their administrators are highly paid and may be paid more the less they manage to spend on schools.

Role of computers. To the politician and bureaucrat, probably the most compelling argument for putting networked computers into the education system is the prospect that they will cut costs. Experience so far gives little support to this. Earlier technologies like movies, overhead projectors, and television have each gone through a "cycle of ecstasy, disappointment, and blame."[1] And the Web today is what television was yesterday: the great hope of the educational world—and of the commercial world.

Computers seem cost-efficient because it is easy to overlook the associated costs. Many grand plans do not provide funds for equipment installation, housing, maintenance, and obsolescence; nor for the employment of skilled support staff; nor for the training of teachers; nor for adapting timetables, curriculum, and examinations. Worse, because the need to cut costs is

usually seen as urgent, computers are installed in a hurry. Schools and their staff have no time to adapt their ideas and techniques to the new methods.

The cost-cutting imperative is at its bleakest when employed at the highest levels of education. The virtual university has been described as a university "reduced to an underprivileged provider of information, with no greater identity than an icon on a Web page, and the academics reduced to employed authors of directories of information peddled by an electronic kiosk, serviced by technicians and an occasional graphic artist."[8]

Relatively few virtual universities will be needed, so the competition will be fierce. A recent *Scientific American* article reports a view from Oxford University that five universities will survive worldwide.[9] If the virtual university can be made to "work," virtual schools will not be far behind.

RECOMMENDATIONS

Thus, if we are to realize the enormous potential benefits of digital technology not only in education but throughout society, our society must be dominated by the wisdom and compassion that comes from good education. And good education comes from good teachers, not from machines.

Indeed, I believe that digital technology will eventually be used to make all the world's education systems more beneficial, beyond our present dreams. But benefits have so far come at a snail's pace. If this is to change, the computing profession and its members must be active in making it happen.

The following recommendations—both for general and particular support—put forward activities that will likely lead to the greatest benefit from digital technology for teachers and pupils.

General support

These recommendations, which relate to the social context of education, must be tackled primarily by professional computing societies working with other community bodies. In short, our educational problems are *political* and as such can be overcome only by *political activity*. Computing people should urge their professional societies to be active politically and should personally support such activity.

Show and tell. Computing professionals should realize—and help others to realize—that machinery is not the solution; rather, its misuse is a large part of the problem. Our professional societies are best positioned to point out the opportunities and dangers of digital technology and to influence and support our community leaders in moving communities away from increasing inequity, oppression, and social alienation, and toward a balance of equality, liberty, and community.

Lobby for more funds. Our profession should press for much more to be spent on schooling. We should persistently declare that in the long run good education is a precondition for good use of technology, not the other way around. An important focus is to improve the lot of children everywhere. In 1995, 84 percent of the world's spending on education was by the developed countries, which have only 21 percent of the world's population. Among the rich Western countries that make up the Organization for Economic Cooperation and Development, an average of $4,636 is spent per pupil on primary and secondary education. In the developing world it is $165. One in four adults in the developing world is unable to read or write, and the number is growing.[10]

Good education comes from good teachers, not from machines.

Be active in reforming the school system. Today's school systems are plainly failing in their educational aims. The typical developed-country school system has a century-old structure quite unsuited to modern educational needs. In their early days, such systems provided elementary education for all, a high school education for an elite few, and a university education for even fewer. With expanding educational ambitions resulting from increasing average material wealth, a high school education appropriate to an elite few has gradually become inappropriately universal, and a traditionally academic university education has become completely subverted.

To reform the system, computing people—as designers of systems—should heed the appeal of educational reformers to start compulsory schooling much earlier.[4] Compulsory schooling should also continue longer, and do so outside the traditional university system. Perhaps a good way to do all this would be to move to a structure with three layers of at least five years: a primary school social education, a secondary school progressive education, and a tertiary school vocational education, where the vocational component should engender skills for self-employment as much as for being employed.

Politicians will of course publicly proclaim such ambitions as hopelessly expensive, and privately bewail them as dangerous. A concerted political effort from outside the political party system will be needed to bring in these reforms, and professional societies everywhere should join with the relatively few societies that are conspicuous in promoting public good worldwide. The very strong IEEE Computer Society would do well to support their allied but much weaker IEEE Society on Social Implications of Technology, which has shown

A computer is not the solution to problems; it is a tool for solving them.

that it is at least alert to some of the dangers of technology (http://www4.ncsu.edu/unity/users/ j/jherkert/).

Particular support

These recommendations, which relate to schooling itself, can be taken up by computing professionals individually or in groups.

Teach and learn from educators. Educators are the key professionals in improving the education of our children. Computing professionals should never try to solve educational problems by themselves. A computer is not the solution to any problem, it is a tool for solving problems. If educators seem unable to exploit technology properly, we should take the time to train them and also take their advice about relevant educational objectives and techniques. Many of us do this already, but we need much more help.

Look for varied uses of technology. As systems analysts, computing professionals should look for uses of digital technology beyond the Internet and its World Wide Web, which at present seems to be an educational obsession. Digital technology should be used wherever good uses can be found, not just in fashionable ways. Educational techniques such as drill and practice and academic gaming promise at least as much educational benefit when supported by digital technology as does the Web.

Provide equipment and services. Systems analysts should strive to protect educators from the vicissitudes of computing practice and provide them with the hardware and software they need. Educators need simple, reliable machines and standard, adaptable programs and operating systems. They do not need complex, transiently fashionable, and inherently obsolescent computers.

Programmers should provide software that educators can adjust to their needs, as well as the training they need to best exploit the programs. We should discourage the use of programs that simply drive students unless they are intended to develop basic reflexive skills.

Computer engineers should work to provide schools with equipment that is inexpensive and easy to use, especially for less-developed countries. General-purpose computers should be simple and robust, physically and logically. Special-purpose computers should also be widely usable across different cultures, ages, and skill levels.

Perhaps the best indicator of the health of a civilized society is the way it treats its children and youth. Modern society depends on quality education. Digital technology has enormous potential, yet it is completely neutral. It can be used to create a utopia or a dystopia. Which one we are moving toward at any time depends on those who use the technology, not on the technology itself. By emphasizing dystopia here, I am opposing the popular cargo-cultist view of the computer and its Web as a cornucopia full of blessings available to those who believe. The dangers are but rarely mentioned.[11]

The primary responsibility for what happens in schools must remain with the professional educators. But educators need the support of the computing profession to ensure that they are fully and properly trained and supported in their use of computers. Any suggestion of replacing teachers with teaching machines ought to be promptly and loudly condemned by the computing profession. ❖

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