Learning for the 21st Century

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A look ahead at the future of ICT in education – the American experience[1]

Abstract

Over the last years, the new Information and Communication Technologies (ICT) have become essential to the American educational system and policy decision-makers come to realize that it is more worthwhile to invest in this field than in repairs on educational facilities. Yet the strong development of infrastructure for ICT is slowed down by the lack of curricular innovations so that the revolutionary cultural impact of these new digital technologies is still subject to criticism with regard to the compilation and transmission of knowledge. But there is no doubt that our traditional culture based on printing media, making research and education accessible only to given groups at given places and times, will be replaced by a culture based on digital media conveying knowledge to everyone at any place and time. This development will challenge our traditional educational institutions to such an extent that their position within the global social context must be redefined. The consequence for schools will be both the removal of access limitation to knowledge and the development of new forms of inner-school and out-of-school communication as well as of analysis, synthesis and simulation for the learning process.

Introduction

To present some reflections on the current state of Information and Communications Technologies (ICT) in American education is more than a challenge, for describing the state of American education is difficult. The American experience with ICT is extremely diverse. Above all, this diversity is in rapid movement. In describing something, one too easily concentrates on particulars, presenting a still life, a genre the old Dutch masters practiced so well. We cannot catch the American experience with ICT, however, by presenting some characteristic vignettes, stopped in mid-gesture. To convey the American experience, we must convey a sense of its movement, a feel for the wave-like

[1] These reflections have been presented at the Information and Communication Technology Conference – November 8, 1997 in Lunteren, The Netherlands.

rhythms in a choppy sea, which characterize technological innovation in American education.

To give a sense of the movement, I will depict three trajectories of activity. First, I will survey the main features of current changes that are redirecting and heightening efforts to use ICT in schools. Then I will describe what is likely to be a significant resistance to these developments, a resistance, which is now evident but not influential, but that will probably become significant in a few years. Third, I will indicate what activities will effectively resist the resistance, however strong it may be for a time. By concentrating on these hardy uses of ICT, we can ensure that adverse influences will not have a decisive effect in stopping the restructuring of education with information and communications technologies.

Current trends with ICT in the United States

Currently, American educators are shifting their practice with technology. We continue to situate computers in special places set aside for teaching about computers, but we are concentrating much more actively on bringing technology into ordinary classrooms to enable students to learn with it regularly. In the first wave of innovation with computers, which began early in the 1980's and continued into the early 1990's, the main effort was to build well-equipped labs. In these labs, students would learn to use computers, which usually meant in practice that the academically talented would master the essentials of computer science while all students learned to use standard software applications. Such efforts to promote computer literacy are, of course, not disappearing. Nevertheless, the goal of computer literacy is not sufficient to justify first-rate technology installations, especially ones that bring ICT into the classroom. Furthermore, we increasingly believe that advanced telecommunications should facilitate learning in all subjects, quite possibly at all grades and levels of sophistication. In short, computers belong in classrooms, all networked well to each other and to the world, so that small groups can use them throughout their education to assist their collaborative learning through a problem-solving pedagogy.

This more ambitious model of good practice has taken hold strongly in a remarkably short time. Very few schools, if any, have reached the goal, but a remarkable number of schools and schools systems are trying to move towards it, all seemingly sure that it models the conditions for major educational advance. Each classroom in a school should have multiple workstations in it, at a ratio of about one to five students. All workstations should be linked together in a school-wide local-area network, and the school LAN should link to the Internet by a broadband, leased line – at least a T1 (roughly the American equivalent of X.25), or soon a cable modem, ATM, or whatever proves to be the dominant high-speed hook-up, LAN-to-WAN, enabling multimedia at a distance. This infrastructure, we seem convinced, will enable the rapid transformation of educational practice. As a result, a teacher-centered, didactic in-

structional system will become a student-centered, inquiry-based, problem-solving educational process in which all students meet expectations reserved in the past for only the very brightest. It is an exciting set of aspirations and a rather exhilarating rush of effort to fulfill them.

A variegated consensus is in fact mobilizing substantial resources to support the widespread implementation of this model. A lot of people have concluded, I think, that ICT offers the last, best hope to reform a system of education that does not work well as it stands. Americans have been somewhat favorably surprised by the resurgent strength of our economy is recent years, but the same cannot be said for our educational system. The year 2000 is getting close to hand, yet Goals 2000 – our ambitious effort to achieve world leadership in elementary and secondary educational attainments – seems likely to fall far short of its stated goals. Few believe that the potential results of programs aiming at the incremental improvement of different aspects of the current system can aggregate into the substantial improvement of the whole educational enterprise. To do that, policy makers and practitioners need to find a significant new source of educational effects to deploy throughout the system. There seems to be a spectrum of feasibility, running from poor schools to excellent ones. We need less to move schools on that spectrum towards the pole of excellence. Rather we need an educational force that will change the entire spectrum of feasibility markedly for the better. Information and communications technologies are by far the most likely candidate to serve as that significant new source of educational effects. Moreover, if they take hold with respect to routine practice in every classroom, they will make by far the most improvements in the spectrum of feasibility.

Federal efforts towards such ends are having large-scale effects on the educational uses of ICT. In fact, I would argue that these efforts are clearly becoming one of the most significant instances of federal influence on educational practice in American history, perhaps by far the most significant instance. Historically, the Federal role in American education has been weak. Many contest the legitimacy of it. The Federal government has controlled a very small percentage of what the nation spends on education. Those resources it controls have sufficed primarily to support programs that modestly diminish the gap in educational opportunity setting the urban and rural poor apart from the rest of American society. The Federal role in promoting the educational uses of technology is becoming uncharacteristically stronger. Federal policy combines both broad, advisory planning with funding programs that support prototyping to practices in schools and the spread of a good ICT infrastructure. While the lead agency is the Department of Education, a strength of the whole effort results from the way several other agencies and the White House are all key components as well, both in the inception of policies and in their execution. It is an effort characterizing Federal domestic policy, not simply a program within a single agency.

Broad, advisory planning is taking the form of a series of reports and recommendations that have synthesized much of the experience with ICT over the

past fifteen years. These have advanced recommendations for integrating technology into classroom practice that are simultaneously simple and comprehensive. The basic planning guidelines set forth by the U.S. Department of Education are in *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge – A Report to the Nation on Technology and Education* (`http://www.ed.gov/Technology/Plan/NatTechPlan/`) (1996).

The plan advances four essential goals:

- All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway;
- All teachers and students will have modern multimedia computers in their classrooms;
- Every classroom will be connected to the information superhighway; and
- Effective software and on-line learning resources will be an integral part of every school's curriculum.

Several other reports reinforce these guidelines as well, for instance the *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States* (`http://www.whitehouse.gov/WH/EOP/OSTP/NSTC/PCAST/k-12ed.html`) by the President's Committee of Advisors on Science and Technology, Panel on Educational Technology (March 1997).

These recommendations largely inform three major funding efforts by the federal government to provide resources to seed the prototyping of a new educational infrastructure. These are

- The U.S. Technology Innovation Challenge Grants. Starting in 1995, this program is annually funding about 20 innovative projects proposed by consortia of schools, community organizations, academic institutions, philanthropies, and corporations. Each project lasts five years and receives, on average about $5 million from Federal funds, amplified with one to three times those amounts in matching effort. The awards are highly competitive, with over 500 full applications per year. Full information on the program is available at `http://www.ed.gov/Technology/challenge/`, including pointers to web sites for the projects initiated in 1995 and 1996.
- The Technology Literacy Challenge Fund. This Fund will disburse $2 billion to the states over 5 years between 1997 and 2001 according to a formula, provide the state wants its share and has a long-term technology plan for education in place. Each state must disburse its share competitively to consortia that will advance fulfillment of the state technology plan at the local level through innovative applications. A full description of the Fund will be found at `http://www.ed.gov/Technology/TLCF/`, and various state plans and the like at `http://www.ed.gov/Technology/sta_tech.html`.
- The Federal Communications Commission e-rate. In the 1996, the American congress revised the basic legislation governing telecommunications in United States, the Telecommunications Act of 1934. That act had estab-

lished the principle of Universal Service, which has made basic phone service affordable to nearly everyone in the United State. The 1996 revision continues to guarantee low-cost, basic telephone service to all and extends the concept of Universal Service to include basic Internet access, applying it not only to individual subscribers, but to schools and libraries as well. To implement this extension to schools and libraries, it prescribes surcharges that will generate a fund of $2.25 billion annually to discount the costs of broadband connections to the National Information Infrastructure for schools and libraries very substantially. A great deal of information on the e-rate will be found at http://www.ed.gov/Technology/, including the „Report to the Federal Communications Commission (FCC) by The E-Rate 1 Implementation Working Group (Working Group), http://www.ed.gov/Technology/eraterpt.html.

If carried through as planned to 2001, these three programs will provide about $15 billion in Federal funds for ICT in schools. Additionally, they will deploy incentives and matching requirements that will double or triple the actual spending for an advanced educational infrastructure. To these three programs, one might add several others, for instance the Telecommunications and Information Infrastructure Assistance Program sponsored by the Department of Commerce (http://www.ntia.doc.gov/otiahome/tiiap/index.html) or the STAR Schools Program, which derive from earlier efforts to promote the use of educational technology (http://www.ed.gov/prog_info/StarSchools/index.html).

Beyond direct funding programs, several more indirect developments on the national level will reinforce the spread of ICT into the schools. Simply put, two major components of the military-industrial complex, so influential throughout the Cold War, are reorienting their activities to support a technologically advanced educational effort.

- The first of these is the American research establishment. It is beginning to take domestic social priorities seriously, with educational priorities very high among them. For instance, the National Science Foundation, and other research funding agencies, are including educational values prominently among the criteria for awarding research funds to competing projects. These developments are having significant effect in changing advanced centers of research and scholarship and broad public purposes, particularly education. This shift is pervasive through major Federal funding for research. The new NSF criteria governing merit review, set in March 1997 by the final recommendation of the National Science Board and National Science Foundation Staff Task Force on Merit Review, http://www.nsf.gov/home/nsb/pubs/nsbmr975/nsbmr975.htm, provide a clear statement of it.
- The second component of the military-industrial complex to shift significant attention to education is industry itself. The driving force here is not simply the perception that technologically sophisticated schools might be a lucrative market for technology and media companies. The motivation is

more fundamental. During the Cold War, some defense industries had a direct interest in supplying material and weapons. Beyond that, however, corporate capitalism in general had an even more fundamental interest in maintaining the security and autonomy of the regions of the world in which business did business. So too now, some companies will market to education. Beyond that, however, the corporate world perceives a much more general interest in improving the quality of education, especially in ways that will advance the technological effectiveness of knowledge-based economies. Good education is good for business: hence industry supports educational reform. This support is manifest in a myriad of ways. As an important instance, in 1996 the President requested a group of influential business leaders to create the CEO Forum on Education and Technology „to help ensure that America's schools effectively prepare all students to be contributing citizens and productive workers in the 21st Century." Its first annual assessment of the nation's progress toward integrating technology into American classrooms through the year 2000 was released in October 1997 and is a useful part of the national planning effort (`http://www.CEOForum.org/`).

In ways such as these, Federal policies, for better or for worse, both derive from and serve to advance an establishment consensus, which will very probably prove to be relatively bi-partisan, allowing for a few differences of emphases across traditional cleavages – urban-rural, rich-poor, and management-labor.

In addition to Federal policies, reflecting a national consensus, the States, as the official sovereigns in American education, are also having significant effects. The federal government, particularly through requirements for receiving funding through the Technology Literacy Challenge Fund, is prodding each state to develop a long-term comprehensive plan for integrating technology into schools (a good set of pointers to these is at (`http://www.ed.gov/Technology/sta_tech.html`). A few states can say that they have long since been there and done that. Many others have recently begun to form plans and implementation schedules. All these are likely to have substantial effects in mobilizing through state taxing and borrowing powers substantial resources for ICT in education over the next few years. Even for those cautious politicians, who feel pushed to do something about education although inclined to spend as little as possible in doing it (of whom there are not a few), substantial spending on ICT can appear to be the path of least resistance. The reality is that the physical plant for American schools is generally in serious decay, with an estimated aggregate cost of some $400 billion need to bring it into good repair. Such repairs, however needed, will not have dramatic educational effects. Hence making the repairs is politically very unattractive, requiring very large expenditures with little to celebrate as a result beyond better-appointed settings for children and teachers to work. Estimates for the cost of a quality technological infrastructure for schools range around $40 to $55 billion, and this investment has the promise of bringing with it significant educational effects. As

expensive as investment in school technology may be, relative to investment in school repairs, it seems cheap. Consequently, prudent politicians are likely to calculate that they had best seek to make the schools far more effective than they currently are by investing in technology. Then, when the public begins to take some real pride in its educational effort, the politicians might try to lead an effort to refurbish the school plant as a whole. With such reasoning, along with calculations about state economic competitiveness and the like, the various state governments are likely to increase support for technology in their schools.

If the states are the official sovereigns in education, the localities are the actual sovereigns, and there too ICT is currently faring well. The federal and state efforts are fortuitously combining with rising local investments in technology for education. The Internet has become a very popular cultural phenomenon. Part of that popularity is resulting in great local interest in hooking „our schools" to the World Wide Web. Motivation for these efforts arises largely from local pride, from the urge – often the lust – of keeping up with the Joneses. It would be reassuring if all this local effort were in pursuit of proven educational values, but that is not the way local educational politics ever really works. In this case, all sorts of people are finding the Internet useful in their work and engaging in their daily lives. Others hear the hype, and the faith has spread rapidly that the Internet will help the schools help our kids. Semi-evangelistic efforts like Net Day result in technological installations of dubious value, but they have tremendous effect in building the constituency for expanding the use of ICT in schools. Consequently, local technology budgets are increasing, many bond issues to finance the acquisition of equipment are passing, and local technology planning is improving markedly. Hence, investments in quality infrastructure are going up.

Most of the effort at the federal, state, and local level addresses the task of equipping the schools with an advanced technological infrastructure. There are, however, three other components to the American consensus about ICT. These recognize the importance of curriculum innovation, professional development, and student assessment.

- Curriculum Innovation. Infrastructure by itself will accomplish little. To make it work educationally, a thorough redesign of the curriculum will be essential. There is a widespread expectation that such a redesign of the curriculum will somehow happen, making educational experience more student-centered, engaging, and flexible, while raising standards of quality in ways that all can meet. Provisions for actually redesigning the curriculum are, however, haphazard at best. We will return to the curricular problem below.
- Professional Development. With the need for curricular changes, significant changes in pedagogy, and therefore in teacher education, also follow. At its simplest level – one that unfortunately is not simple to execute – teachers need to gain confident mastery of how to use the new technological infrastructure. Beyond that simple level, furthermore, the new infra-

structure carries with it a redefinition of the roles teachers perform. It requires that they abandon the commonsense of current practice and replace it with unproven techniques, ones that often seem very risky according to traditional commonsense. The task for professional development, both pre-service and in-service, is great.

- Student Assessment. Then finally, if educators change the curriculum and the ways teachers and students do their work, they will need also to change the ways they assess the quality of education and the performance of students. Here national policy in favor of national testing may be at odds with itself. The recent drive towards more stringent testing seems designed to enforce policies aiming to improve the performance of the existing system and its curriculum, not to sustain and follow through with efforts to transform current practice. The discordance may not last long, however. To the degree that policies to promote ICT in education seem influential, those promoting national testing seem controversial and divisive. How to evaluate educational performance by and in the high-tech school will remain a significant challenge distinct from the effort to institute national test of student achievement.

Infrastructure building, curricular innovation, professional development, and student assessment: these are the essential elements in a surprising consensus about what should be done. At the very least, considerable effort pursuing an essential part of that consensus is underway.

All is not well, however. In fact, it is very important that educational reformers seeking to use ICT in education should pay close attention to their looming political plight. The expensive, currently popular, and easy part of the process is to create the infrastructure. The current prestige of the Internet is very high. People do not nuance their expectations for its educational potentials. It is highly probable that communities will invest in a great deal of new infrastructure over the next few years while devoting insufficient effort to curriculum innovation, teacher development, and student assessment. If that happens, the public mood will in due course change, and people will start to ask why they spent all these resources on expensive capacities when educators can accomplish so little of interest with them. I have considerable experience with well-financed, leading-edge projects, which are in principle working across the full range of needed activities – infrastructure building, curriculum innovation, professional development, and student assessment. Even with the firm determination to concentrate on the latter three concerns, constructing the infrastructure tends to soak up the available monies and energies. Following through with the rest is not easy. Chances are high that in a few years curriculum innovations will prove disappointing; professional development will be spotty; and students will continue to be assessed by traditional measures, which will magnify the relative performance of traditional programs and minimize the significance of the powerful innovations that in fact take place. Thus, conditions may be ripe three to five years hence for a significant backlash to take place.

We can anticipate the main lines of this backlash, for the key arguments are already being made, although at the present time they are not being heard very widely. *Fortuna* being what it may, the underlying public mood will surely shift. At that point, the public will seem to discover these arguments, which will begin to have significant effect. I will suggest that they will almost certainly slow investment in ICT in education, and such a slowing may actually prove beneficial, providing time for the needed curriculum developments and the like to mature. However, there is a risk that they will completely stop the process of change. I will make, in addition, two additional points. First, I will profess the hope and expectation that this backlash probably will not, in the end, stop the transformation of education through ICT. And second, and with more significance, I will suggest that educators can now adopt strategies of innovation that will strengthen their initiatives against countervailing forces and will help set the pedagogical transformation on a secure and beneficial course.

Consider the countervailing arguments that will gain apparent weight as the public comes increasingly to feel that practice has fallen short of its expectations for technology in education. Current anxieties that the Internet is too hospitable to pornography and child molesters lurking on the net will not be the telling issues. Educators should not take these problems lightly, but the pathologies long pre-date ICT and there are technological means to control the seamier side of the Net. The backlash concerning the educational uses of digital technologies will raise more fundamental questions about the whole effort to transform education using information and communications technologies. The backlash will take up two main arguments, both of which are closely related, one questioning the power of ICT as an agent of change in education, and the other, with the same effect, stressing the vast powers to resist change inherent in the existing system of schooling. Let us call these two arguments „Peter and the Wolf" and „Mr. Marshmallow." Together, they will suggest to the public that it has been spending excessively with unrealistic expectations.

Reference to Peter and the Wolf needs little explanation. We all know the tale of the boy who ran into the village crying out that a wolf was coming, feeling quite full of himself as everyone scurried to safety and the men sallied forth to hunt the threat down. Once, twice, thrice the boy performed his hoax. The fourth time a real wolf chased him and he staggered towards the village, pleading for help, but the villagers ignored his cries, only later to find his gnawed remains. Critics, like the villagers, are saying that would-be reformers have too often sounded the hype about the transformation of education through technology. Thomas Edison made unrealistic claims about the educational significance that one of his great inventions, moving pictures, would have. The early development of radio equally exaggerated expectations of great pedagogical reform. Prophecies of educational transformation as a result of television were even more grandiose, yet the effects of educational TV have proved weak, while most observers hold the educational side effects of entertainment televi-

sion to be highly deleterious. How often do we have to fall for exaggerated claims before we realize that pronouncements about the technological reform of education are a form of crying wolf, perverse ways that a few use to garner an attention that otherwise they would be entirely unable to command. The very disappointments, which in due course will make the public mood receptive to this argument, will then be taken as *prima facie* evidence that indeed „Wolf! Wolf!" has been cried out again. Thus, the public may come to view the claims for ICT in education as empty of merit.

In contrast, my reference to Mr. Marshmallow will need more explanation. Mr. Marshmallow was a soft advertising confection of the 1960's – a cute, puffy persona enticing children to buy a brand of marshmallow candy. A couple decades later, Mr. Marshmallow had a key role in the popular movie *Ghostbusters*, serving in the climactic scene as the greatest of the ghosts that the comic team had to bust. Throughout the film, the ghosts stood for the pathologies of urban bureaucracies and the charm of the film lay in the notion that a combination of naïve good will and high technology could send these ghosts scampering. Towards the end, as all the ghosts came out together, to the surprise of the audience, a huge version of Mr. Marshmallow floated in the lead, coming to occupy a strategic berth atop a building. There Mr. Marshmallow sat, a soft, smiling, amorphous blob, seemingly to absorb every effort to destroy it that the Ghostbusters could mount. The scene, we savvy New Yorkers would say, appeared possibly to have been filmed on and around 110 Livingston Street, the notorious home of the New York City Board of Education, which oversees, with fabled bureaucratic irrationalities, the instruction of the 1,100,000 children in the city's public schools. Mr. Marshmallow, particularly as rendered in *Ghostbusters*, is indeed a perfect symbol for the institutional character of school structures, absorbing every effort at change with a nod here and a dither there, smiling on with an endless supply of spongy inertia. The critics of using ICT throughout education will say, to increasing effect, that efforts to transform education with technology represent a combination of naïve good will and high technology, like the Ghostbusters. They will add, however, that unlike the film's heroes, this combination will not win out in the end, for the educational system is too resistant to change, too adept at absorbing and neutralizing innovation, to ever undergo significant transformation. Better to tinker wherever opportune, steadily improving the system from within.

Should the public mood turn skeptical, and in due course it will, these critiques will gain a significant following. The basic argument is rather fundamental – reformers are greatly exaggerating the power to induce change that they attribute to ICT, while they underestimate severely the power to resist change in the existent system. Consequently, the public is expending very substantial resources expecting very substantial benefits. But in truth, the promised benefits will never materialize and therefore, the expenditures in anticipation of them are a waste that the public should not be making. Better spend the resources on other worthy purposes, more realistic ones albeit less ambi-

tious. Those of us who propound change, proposing to use information and communications technologies to transform education, need to take these arguments seriously and prepare to answer them in practice. It is not sufficient to hope they will disappear. We need to weigh the possibility of truth within them. And we need further to develop strategies that will have staying power despite the potential ascendancy of these critiques in public discourse.

Responding to the critique of ICT

First, let us ask whether we might actually again be crying wolf, proclaiming great educational significance for media largely irrelevant to work inside the schools. Can we identify how information and communications technologies in education differ from prior efforts to use communications innovations with educational effect? Moving pictures, radio, and television are pre-eminently powerful mass media. Sometimes interpreters discuss digital information and communications technologies as if they are yet another form of such mass media, a new broadcast medium. It would seriously misinform people, however, to liken the digital technologies and their cultural effects to the great broadcast innovations earlier in the twentieth century.

If people think they have heard it all before with moving pictures, radio, and TV, they are misunderstanding the cultural imports of the various technologies involved. These earlier developments differ significantly from those occurring with the digital technologies. The former have proven to be powerful mass media, useful for communicating entertainment, advertisements, and news to very large audiences. Few would claim they have had significant effects on the creation of knowledge or the conduct of the major professions. To be sure, some lawyers manipulate the media to the benefit of their clients and some researchers use film and videotape as an essential means of recording data. Nevertheless, it would vastly stretch reality to claim that film, radio, or TV have become routine essentials in the pursuit of knowledge or the conduct of professional practice. The same is not the case with digital information and communications technologies. Across the board, these technologies are becoming essential to research, scholarship, and professional practice. ICT are not mass media in the traditional sense of the word. They are interactive, random access technologies, much more closely related to the book and to the library, than to the movie theater or the TV studio. We must not underestimate the historical significance of these differences.

Innovations taking place with digital information and communications technologies are primarily transforming the ways people produce knowledge. The implications of this fact are fundamental for understanding why the use of ICT in education will be different from the use of moving pictures, radio, or TV. The stock of knowledge, and the means for advancing it, determines the content of educational experience. Moving pictures, radio, and TV have had little to do with core educational experience because they had scant effect either on the stock of knowledge or on the means for advancing it. The case is

proving entirely different with digital technologies. What people should hear about digital technologies they have not heard all before. It is not simply that office technology is in widespread use, displacing typewriters and slide rules. It is not simply that a powerful new dissemination tool is at hand. The transformation is much more fundamental. The empirical stuff out of which the sciences and the professions are built is increasingly digital stuff – from innumerable readings telemetered from space or from buoys bobbing at countless places across the oceans of the world; to vast digital collections of legal precedents and rare books and other sources, retrievable by any person from any place at any time; and further to distributed consultations between specialists all examining the same unusual cell section, appearing simultaneously to each. Education deals with the intellectual apparatus of our culture and this apparatus is becoming digital. That is the difference between the current situation and those that came before.

What about the Mr. Marshmallow problem? As it relates closely to the critique of crying wolf, so too the response closely connects to the point just made. Historically, change in the technological basis for intellectual work has been very unusual. The number of such changes in Western history is limited. The last one took place with the introduction of the printing press during the fifteenth and sixteenth centuries. Then, in an extended process of change, the locus of basic education moved from the household workplace into the school. Educators relatively quickly invented the textbook and strategies for making full use of it. They further developed the core strategies – age grouping, subject-matter segmentation, lesson design, promotion by competitive tests, among them – that are still so familiar. Schools, which then took their basic shape in European cities to provide instruction to the sons of the burgher class, have basically been spreading, largely unchanged, around the globe and through all components of society – slowly, steadily becoming the great Mr. Marshmallow of our time.

Let us infer from historical example the following proposition: educational practices, however resistant to change, will undergo transformation when basic changes occur in intellectually significant systems of communication take place. The Mr. Marshmallow problem, therefore, comes down to a very basic question, with respect to which only time will really tell. How fundamental, as a historically significant innovation in the creation and dissemination of knowledge, are the information and communications technologies? Are they like the introduction of printing in our culture, something of sufficient strength to restructure educational institutions thoroughly? Alternatively, will they prove to be something lesser, innovations that may change particular practices within key institutions while leaving their essential structures largely in tact?

It is risky, to say the least, to try to prognosticate the outcome of such questions. On the one hand, elementary and secondary education may possibly be an environment in which the ecological limitations, so to speak, on the transformational power of the new technologies may become evident. On the other, there are characteristics in the digital technologies that seem to me to change

the basic pedagogical situation in ways that may make it, as we say, a whole new ballgame. Here it is best to shift from observer to reformer. While I believe that technological change significantly sets the spectrum of possibilities between which we make determining choices, I am not a technological determinist in the strong sense of the word. Technological change may condition the range of possibilities for human action; it does not foreordain outcomes within the conditioned range. What will happen depends on the courses of action that key groups adopt. Consequently, I want to close by reflecting on the developmental strategies through which ICT can effectively serve as a sound restructuring educational force in a process of change in which the outcome is no means foreordained.

The task before us

Let me recapitulate. My basic argument is that innovations that have little to do with the creation and employment of knowledge have weak effects on all educational practice, including the elementary and secondary levels. When, however, innovations in information and communication technologies transform how the culture creates knowledge and brings it to bear on the conduct of life, then the effects on education are potentially great. We can distinguish between current digital innovations in information and communications technologies and previous developments in the mass media in this way. The latter had little import for people working to create and apply knowledge in historical life, while the former have pervasive significance for that enterprise. Let us build on this distinction and make it the core of a strategy for ICT in education, a strategy that may maximize the beneficial historical effects of ICT. We can state the essential element of the strategy in the following proposition: uses of ICT in schools that derive from and contribute to the power of these technologies to transfigure intellectual work and the advance of knowledge will be the uses with the greatest long-term significance and historical staying power.

Innovators did not create digital information and communications technologies expressly to serve elementary and secondary education. This is a fact obvious to all, and one of great significance for long-term innovation in education. Many innovators and many critics see this fact as a problem and an inconvenience – what has not been made for elementary and secondary education will prove irrelevant to it unless thoroughly reconstructed according to its special needs. This view may be too parochial. The independence of ICT from education may prove precisely to be an essential source of its actual potential as a transformational force in education. Certainly, it will have much to do with ensuring that ICT has staying power in the face of publicly effective criticism. Should critiques of the use of ICT in education become powerful, these will have little effect on the fundamental drive to further innovation in the technology itself. That drive depends largely on the value of ICT for research and professional practice, not for the schools. All the same, with each

development in the technology, the question of how it might apply to the schools will come back to life.

In addition to keeping the processes of change ever alive, the fact that a great deal of important activity with ICT has little to do with elementary and secondary education provides the opportunity to intertwine the applications of ICT in the schools with all those driving transformations that are happening regardless of what happens in the schools. In this way, innovative educators can build strategic alliances with significant independent agents of change, possibly enabling them to concert levels of historical force far greater than they could mobilize without such an alliance. Such alliances are important in an effort to exert transformational forces on Mr. Marshmallow. Institutions have an agenda, a set of roles and functions that they perform in the mix of institutions that make up a culture and civilization. If the agenda of a major institution remains constant, then its standard operating procedures, once established, will likewise remain largely constant. An alliance of many elements, which fit together in new and useful ways, will most probably have the actual power to change the agenda of institutions such as schools.

Schools have served as the most egalitarian part in a system of intellectual channeling and sorting that has been inherently elitist. By inherently elitist I do not mean that people have chosen to make it such, facing the opportunity to do quite the opposite should they have so chosen. Our intellectual enterprises have been necessarily elitist, open only to limited numbers of well-prepared individuals, because the material character of work in those enterprises required it. A research library is very costly and overuse can easily destroy it as books become lost and randomly shelved. It is simply impossible to invite all the school children of the world into the stacks of the few great research libraries that exist. Likewise, research quality laboratories are often dangerous and filled with equipment that is both expensive and delicate. Access can be open only to those who have passed through a rigorous apprenticeship as a result of which they know what to do and how to do it. In these ways, the means for producing knowledge and applying it to the work of the world have been necessarily specialized and open only to specifically prepared elites. These means have been very scarce, expensive, and easily worn out if subjected to excessive, unskilled use. As part of the cultural effort to produce and disseminate knowledge through these necessarily elitist means, schools have provided the foundation for sorting and matching people with different capacities and interests to all the different specialized activities that make up the complex life of our culture.

In a print-based culture, many of the most powerful intellectual resources will be available to only some people at some places and some times. This condition is inherent in the material character of books and journals and all the other material objects of traditional intellectual culture. The *telos* or goal of the print-based system has been to make selected intellectual resources available to special groups at special places and special times, so that they can conduct the intellectual work of the culture. I believe that the development of digital in-

formation and communications technologies has inherent in it a different *telos* that will result in all intellectual resources becoming available to any person at any time at any place. This change will make an inherently egalitarian culture possible in principle, although we so far have no historical experience of how such an egalitarian culture will work in practice.

We have already moved remarkably far in a short historical time towards the new *telos*. As we approach that condition, the elitism inherent in our intellectual and educational institutions in the past ceases to become an intrinsic, necessary condition of the enterprise. Once research libraries, archives, scientific databases, museum collections, codes and standards, samples, research instruments, and on have been digitized, anyone and everyone can consult and use them as much as they please without harming or degrading the collections and tools. Once classrooms are on line, it is not only feasible to let school children into many intellectual resources from which they were previously prohibited, it will be impossible to keep them out unless educators create explicit controls to do sot. This prohibition on access has been so strict until now that none of us really has thought of it as such, assuming rather that it is part of the necessary, natural order of life. Children would be unable to use these resources, we think – not stopping to think that in a significant sense this is a proposition that has never been put to the test.

Aristotle, and many others of great good will after him, believed that some people were by nature slaves, assuming that the material conditions of slavery were an inevitable necessity of human existence. Under changed conditions of production, such presumptive justifications of slavery seem perverse and inhumane. Who can learn what, why, and when is a question equally subject to the relativities of historical change. Owing to ICT, the intellectual assets that teachers and students can actively employ day by day in schools are changing with astounding rapidity. The intellectual resources of our cultures are all becoming available to any person at any place at any time, including typical pupils and students in everyday classrooms. Will the traditional program and routines of the schools continue to function as the new technologies transform the long-standing constraints on intellectual work under which students and teachers have labored? If any person can access and employ any cultural resource at any time and any place, does it continue to make sense for educational institutions to serve primarily as gatekeepers, matching individuals to one or another specialization, certifying skills and capacities from dropout to high-level professional? Might a different agenda for the schools emerge?

We have astoundingly little experience of how to use the emerging abundance of intellectual resources in elementary and secondary school classrooms. Even on the university level, the classroom, the library, and the laboratory have been physically separate from one another, but they are now rapidly converging and the place of education at all levels will be in the midst of them all. Consequently, we have before us a very interesting task, namely discovering the ways in which we can put these newly accessible resources to good use in education. We need to create a complicated new pedagogy. It will change how we

manage educational time, design educational spaces, teach in the classroom, and organize knowledge for everyday use. As an educator, I have of course some ideas about how these transformations should take place. This is not the appropriate occasion for explaining them, however. One or another of us may find ourselves infused as innovators with a kind of historical grace whereby something that I develop or you develop comes to structure future practice. Who has this grace, we do not know. History will disclose it from the kaleidoscopic efforts to address the challenge. Effective new practice will unfold as a function of innumerable exploratory efforts the world around. I want to close by stating two convictions that might be worthwhile in pursuing such explorations.

First, there is a tendency to think of ICT as a means of amplifying the power of the teacher to cause learning in the minds of students. Instead, let us think of digital technologies as investments in the power of students to do their work of education, to study actively. For every teacher, there are twenty-five or more students. They are the crucial source of educational work and the greatest benefits from ICT will arise if we design applications to help them be more efficient and effective in acquiring their educations. We have the opportunity to apply capital investments to provide students with powerful tools of inquiry and study. The way students have worked has remained remarkably constant for the past 500 years. We can begin to change the limits on their activities and in doing so we begin to transform the spectrum of feasible educational achievement.

Second, we have the opportunity to try progressivism in education again. The progressive experiment failed in the first half of the twentieth century because it proved unworkable given the constraints of the school as those then existed. Twenty-five inquisitive children could easily exhaust the stock of knowledge and understanding that even the best teachers possessed. The resources that children could mobilize beyond the teacher were highly limited. Hence, the results of the project method and inquiry-based learning were necessarily superficial and imperfect. These limiting conditions are now changing and from my experience with the effect of the Internet in classrooms, it will conduce towards an intellectually rigorous progressive education accessible to all. To make this renewal of progressivism work, it is important to accomplish four things in the classroom:

- Pose powerful generative questions in cooperative settings;
- End limitations on the intellectual resources available to students;
- Enable teachers and students to communicate beyond the classroom; and
- Provide advanced tools of analysis, synthesis, and simulation.

Where these prevail, all students learn; they learn with depth and rigor; and they take possession of their learning as their own.

Zusammenfassung

In den letzten Jahren sind die neuen Informations- und Kommunikationstechnologien (ICT) zu einem bedeutenden Faktor des amerikanischen Bildungssystems geworden, der politische Entscheidungsträger in zunehmendem Maße zu der Erkenntnis führt, daß Investitionen in diesem Bereich wesentlich besser angelegt sind als in die baulichen Reparaturen von Bildungsinstitutionen. Dem massiven Ausbau der infrastrukturellen Einrichtungen für die ICT's stehen aber noch mangelnde curriculare Innovationen gegenüber, so daß die umwälzenden kulturellen Auswirkungen der neuen digitalen Technologien hinsichtlich der Erarbeitung und Vermittlung von Wissen noch sehr kritikanfällig sind. Es kann jedoch keine Zweifel mehr geben, daß unsere auf Printmedien basierende Kultur der letzten Jahrhunderte, die Forschung und Bildung nur speziellen Gruppen an bestimmten Orten und zu bestimmten Zeiten zur Verfügung stellte, nun durch eine auf Digitalmedien gestützte Kultur abgelöst werden wird, die Wissen jederman/frau an jedem Ort und zu jeder Zeit zugänglich macht. Diese Entwicklung wird unsere traditionellen Bildungsinstitutionen derart in Frage stellen, daß ihre Stellung im gesamten gesellschaftlichen Kontext neu definiert werden muß. Für die Schule wird dies zur Folge haben, daß neben der Öffnung der bestehenden Zugriffsbeschränkungen auf das vorhandene Wissen neue Formen der inner- und außerschulischen Kommunikation sowie neue Analyse-, Synthese- und Simulationsformen für den Lernprozeß entwickelt werden müssen.

Résumé

Au cours de ces dernières années, les nouvelles technologies d'information et de communication sont devenues un facteur essentiel du système éducatif américain, et les décideurs politiques se rendent de plus de en plus compte qu'il vaut beaucoup mieux investir dans ce domaine que dans la remise en état d'installations scolaires. Cependant, le plein développement d'infrastructures pour ces technologies doit faire face au manque d'innovations curriculaires, de sorte que le formidable impact culturel de ces nouvelles technologies digitales est encore très sujet aux critiques en ce qui concerne la compilation et la transmission de connaissances. Mais notre culture traditionnelle reposant sur les médias d'impression et permettant l'accès de la recherche et de l'éducation à certains groupes dans des lieux et temps donnés, sera sans nul doute remplacée par une culture basée sur les médias digitaux qui rendra le savoir accessible à tous, en tout lieu et à tout moment. Cette évolution remettra nos institutions éducatives traditionnelles en question, à tel point que leur statut dans le contexte social global devra être redéfini. Il en résultera pour les écoles une ouverture de l'accès au savoir, ainsi que de nouvelles formes de communication interscolaire et périscolaire, d'analyse, de synthèse, et de simulation pour le processus d'apprentissage.

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