INTRODUCTION

It is now obvious to those working in the fastest growing segments of the increasingly global economy that work at the beginning of the 21st century is radically different. Today's successful businesses require more of all employees and rely on continuous innovation and employee involvement and knowledge at all levels. In high performance workplaces individuals have to do far more critical thinking — analyzing problems, proposing solutions creatively, trouble-shooting, communicating with others, and managing their own time. Added to this economic shift, democracies face a potentially dangerous paradox of how to balance tolerance without sliding into a world where all issues are seen as being relative. The 21st century will be, even more than the 20th century, the century of paradoxes, and to deal with it effectively young people will have to be thoughtful and discerning.

Contrast the needs above with the complaint of teachers on both sides of the Atlantic that many of today's young adults have Nintendo-era attention spans - they want the answers, they want them now, and they do not want to spend a lot of time working them out.

The need to develop higher order thinking skills among all young people has never been greater. Higher order thinking skills refer to reasoning, argument, problem-solving, collaboration and so on. The Director of the Learning Research and Development Center at the University of Pittsburgh, Lauren Resnick, urges "that thinking should not be seen as an esoteric add-on to good solid knowledge and routine skills. On the contrary, the most basic and seemingly elementary performances require active strategic thinking. If students do not learn to think with the knowledge they are stockpiling, they might as well not have it."

Yet, it is critical to point out, current models of formal education in North America, Europe and other established democracies were not, and never have been, designed for creating the disciplined mind necessary for higher order thinking. As the American cognitive scientist John Bruer observed in 1993: "No educational system has ever tried to educate all its students to be higher-order thinkers. Improving our schools to educate everyone to this level, not just the select few, may not be possible if all we do is reaffirm past standards, raise graduation requirements, and apply existing methods and practices more rigorously." The tension Bruer was picking up on, and which is still very much with us almost a decade later, is that education systems have been given radically different purposes.

Despite fundamental changes in how people work, live and find meaning in their lives education systems at the beginning of the 21st century would be familiar to anyone who attended school before the Second World War. While the modern office works at the speed of the latest electronic technologies, the school curriculum still moves at the speed of handwriting with teachers still
controlling the pace of learning. This paradox will be a recurring theme throughout this paper, and it is one that educational researchers and reformers have been grappling with for the better part of two decades. The U.S. Office of Technology, for example, observed more than a decade ago that “Today’s classrooms typically resemble their ancestors of 50 years ago more closely than operating rooms or business offices resemble their 1938 versions. But new technologies are making possible imaginative approaches to teaching traditional subjects and are motivating teachers and children to try new ways of information gathering and learning.” Despite 12 years of dramatic technological advances (including a massive growth in the use of the Internet) and great investment in technologies such “imaginative approaches” to the uses of information communication technologies (ICTs) in education are still largely in the minority. ICTs are still primarily used to facilitate the traditional classroom practices of teachers and school timetables.

To understand the reasons for this inertia, despite billions of dollars in investments in information communication technologies, it is important to understand a little bit about the politics of educational reform. But first, in fairness, it must be noted that businesses have also struggled in determining how best to utilize the new technologies. Many businesses spent much of the 1980s and 1990s investing in ICTs before they ever received any corollary increase in productivity. In fact economists called this disconnect between increased investment in ICTs and stagnant growth in productivity “the Solow Paradox.” By the mid-1990s, however, successful businesses were receiving a return on their investment.

The lesson, it is not enough to invest in technology alone, to receive benefits the technology must be allowed to change the way the organization and employees operate. Successful use of ICTs means empowering the users. To be successful organizations have had to move from a system of operating procedures and direct control to organizational principles of trust and personal responsibility. This issue was raised in a recent international report on the impact of ICTs in business when the authors wrote, “Reaping the full benefits of ICT use will, in many cases, require profound reorganizations of firms, industries and markets. Activities that are currently carried out with hierarchical structures may take place through market transactions and, in the process, change the boundaries of firms and test the ability of existing structures to adjust.”

Consider these insights from the business world when looking at the current political efforts to reform education systems. Has the billions invested in new technologies led to an equally significant increase in student learning and achievement? If not, does the rigidity of the system prevent teachers and

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* By ICTs we mean computers and related pieces of equipment which are networked through the Internet and the World Wide Web. Yet, it should be noted that we recognize the value of books, videos and old fashioned radio in facilitating student learning.
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students from developing truly new ways of utilizing the power of information communication technologies? Can education systems adjust to meet new opportunities?

Politicians, responding to economic shifts and technological opportunities, since the late 1970s have found it to their advantage to jump into the educational debate, and thus education has increasingly been directed by political imperatives. This political interest has led to an increase in educational funding at almost all levels, and this has meant increasing pressures to show accountability – education has become a high stakes business for politicians, educators and students alike. Accountability is the driving theme behind educational reform and the tools used for making education systems accountable are the setting of high standards and uniform tests.

Despite the best efforts of the scientific community – including the publication of a number of reports and books over the past 20 years - these political efforts have largely been uninformed by research into the nature of human learning and reasoning. The reason for this lies largely in the fact that as more money has gone into education, education systems have become intensely focused on showing immediate accountability, and this has meant less space for innovation and experimentation.

This paper will review how educators, within the constraints and opportunities of the current economic, social and political environment, are using all this technology. Much of the evidence comes from the United States, but we believe it is insightful for educators and policy makers in other countries who find themselves facing many of the same questions, doubts and hopes. The ultimate purpose here is not to provide definitive answers, but rather to help you ask questions and see pathways that can lead to better program arrangements for the young people under your care.

The perspective of the 21st Century Learning Initiative on this issue is largely informed by current findings from cognitive science, the brain sciences, the evolutionary sciences and best practices in business and education. From this depth of understanding we have examined the evidence to determine how ICTs can be utilized by educators to help students develop as self-organizing, self-assessing learners.

Additionally, we will observe how ICTs are often underutilized and even misused. A central premise behind all the work of the 21st Century Learning Initiative is that if very young children are provided with close social bonds to caring adults and other children in the first seven or eight years of life they will be well on their way to becoming highly-motivated responsible life-long learners. As children develop the skills to learn how to learn, we believe, they then can increasingly use ICTs to take responsibility for their own learning. As students mature and develop the skills to take responsibility for their own learning technologies must be integrated into the life of the school, the curriculum, and in the lives of the young people using it - if not they become an expensive waste of money.

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Building on more than 20 years of research into the effective use of computer technologies in learning, researchers from the US West Foundation observed in the late 1990s that “the successful integration of classroom technology implies changes of huge magnitude in educational philosophy, classroom management and curricular goals.” “The common belief” state the authors “is that if one simply teaches teachers how to use computers and telecommunications and provides the necessary equipment, classroom teaching and learning will improve automatically. Nothing could be further from the truth.

For the technologies to be used optimally, teachers must be comfortable with a constructivist or project-based, problem-solving approach to learning; they must be willing to tolerate student’s progressing independently and at widely varying paces; they must trust students to sometimes know more than they do and to take on the role of expert teacher…and they must be flexible enough to change directions when technical glitches occur.” We would add that not only must teachers be more trusting, thoughtful and flexible in how they work, but the systems in which educators operate must be as well.

“EVERY TECHNOLOGY IS BOTH A BURDEN AND A BLESSING; NOT EITHER-OR, BUT THIS-AND-THAT”

The social philosopher Neil Postman makes it clear in his various commentaries on education that technology is a double-edged sword, and that those of us involved in working with children need to wield it wisely. Education, he warns, is far more important than simply giving children the skills they need to be economically successful in a technologically advanced society. Postman captures the true significance of education when he reasons that, “Perhaps the most important contribution schools can make to the education of our youth is to give them a sense of coherence in their studies, a sense of purpose and interconnectedness in what they learn.” We must ask ourselves what the purpose of education is, and when we have done so then we can best decide how information communication technologies should be used to achieve the goals we seek.

In working out a purpose for education it is useful to look to history for useful examples and cautionary tales for, as the philosopher Santayana observed, “Progress, far from consisting in change, depends on retentiveness. Those who cannot remember the past are condemned to repeat it.”

Traditionally the purpose of education has fluctuated somewhere between two visions. The first, which dominated educational practice throughout the 20th century, sees education as being about shaping the minds of young people to fit the political needs of the nation-state and the economy. Proponents of this view act as if children’s minds are empty vessels waiting to be stuffed with the
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knowledge and skills society values. The teacher plays the role of specialist whose job it is to fill children up with the academic content they need to function as good citizens and productive workers. In this view, external motivation is central to student learning, and appropriate testing and rewards are of the utmost importance. Therefore, the curriculum is designed around the testing regime in which it is answerable, and a successful teacher is one who adequately prepares all her students to excel at answering tests on a standardized multiple choice exam. It is a classic input-output model of learning that would resonate with a behaviorist view of learning. For students, being able to recall information is central to the educational process. Rote learning is at the forefront, and this encourages a teacher-centered model of learning. Knowledge is seen as passing smoothly and evenly from the teacher to all learners.

The alternative vision, albeit still in the minority, sees the purpose of education as helping allow the natural inclinations of the human individual to unfold and endure through personal discovery and experience. Within cognitive science this type of learning is called constructivist learning. Constructivists argue that process is more important than content. Inherent to such thinking about the nature of human uniqueness is the acceptance of children being born with differing traits and predispositions. Constructivist theories of learning are predicated on the progressive construction and deepening of meaning. The emphasis is on understanding as a process that is considerably more involved than transferred information, or even knowledge. A person who is truly passive is incapable of learning. From this perspective, children’s learning is as personal as their fingerprints and this fact calls for teaching that focuses on the individual strengths and weaknesses of each child. With a constructivist form of learning, each child structures his or her own knowledge of the world into a unique pattern, connecting each new fact, experience or understanding in a subjective way that binds the child into rational and meaningful relationships to the wider world.

In this debate over differing views of education information communication technology is neutral. It can be used to support either vision. “Alan Lesgold, a professor of psychology and the associate director of the Learning Research and Development Center at the University of Pittsburgh, calls the computer an ‘amplifier,’ because it encourages both enlightened study practices and thoughtless ones. There’s a real risk, though, that the thoughtless practices will dominate, slowly dumbing down huge numbers of tomorrow’s adults.” As Sherry Turkle, a professor of the sociology of science at the Massachusetts Institute of Technology and a longtime observer of children’s use of computers observed, “The possibilities of using this thing poorly so outweigh the chance of using it well, it makes people like us, who are fundamentally optimistic about computers, very reticent.”

What all these experts on ICTs agree on is that effective uses of the technologies require far more than just access. It requires an appreciation that younger children’s learning needs are different to
those of older children, and that when used appropriately the technologies require a change in pedagogy.

AGE APPROPRIATENESS AND THE USE OF ICTS

The issue of age is an important one. As the leading child psychologist of the 20th century, Jean Piaget, made clear in his writings about children, what may be right for a 14-year old may not be right – and may be outright damaging – for a four-year old. There is a considerable amount of research to show that hands-on learning is much better than keyboard learning in the early years of life. Children, as The Independent newspaper noted, “Need to have developed fine motor skills, and hand-eye coordination, so that the brain is accustomed to working in conjunction with the muscles of the hand. That means lots of different activities that use the hand in different ways and demand precision: cutting, sticking, building and completing jigsaws, as well as clay-modeling and using paint, chalk and crayon. Simple tasks such as putting things down quietly help to teach hands, as did fastening buttons and tying shoelaces in the old days before virtually every children’s garment and shoe was done up with Velcro.”

Physical activity is crucial in building the mind and the nervous system of young children. This is not surprising when one takes into consideration the fact that children are predisposed to playing and interacting with other children. Children find out about themselves by measuring themselves against the standard of their group mates. The community of practice in which they construct knowledge is largely made up of their family, friends and classmates, and for young children this is where they should spend most of their time learning - in personal contact with other human beings.

As the developmental psychologist Jane Healy noted in 1998, “computer learning for young children is far less brain-building than even such simple activities as spontaneous play or playing board games with an adult or other child. ‘Connecting’ alone has yet to demonstrate academic value, and some of the most popular ‘educational’ software may even be damaging to creativity, attention and motivation.” A group of U.S. educators and psychologists warned in the summer of 2000 that early exposure to computers stunts children's development and that such technologies should only be introduced after elementary school. They argue, “children need stronger personal bonds with caring adults. Yet powerful technologies are distracting children and adults from each other. Children need time for active, physical play; hands-on lessons of all kinds, especially in the arts; and direct experience of the natural world. Research shows these are not frills but are essential for healthy child development. Yet many schools have cut already minimal offerings in these areas to shift time and money to expensive, unproven technology.”
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Some parents, teachers and policymakers counter that all good jobs in the future will demand computer skills so it is good to teach children keyboard skills at a very young age. Young workers will need, and in fact already do need, computer skills to be successful. But that does not mean that parents or the teachers of young children need to panic and start throwing all this technology at the very youngest children. Joseph Weizenbaum, a professor emeritus of computer science at MIT, told the San Jose Mercury News that even at his technological-heavy institution new students can learn all the computer skills they need 'in a summer.' Additionally, the technology used by schools today will be obsolete long before five and six-year olds will leave high school. Creativity and imagination are the prerequisites for innovative thinking, which will never be obsolete.

The 21st Century Learning Initiative accepts the position that "in the early grades, children need live lessons that engage their hands, hearts, bodies and minds – not computer simulations." It is for this very reason that we advocate providing increased opportunities for parents to spend time with their children and radically smaller class sizes in the early years of primary school. If we get the early years right then we can develop a pedagogy that would enable older students to take increasing responsibility for their own learning. Responsible learners can and do use information communication technologies to create new knowledge and creative solutions to old problems.

Pause and Consider the following questions
1) Do you accept the view that, "If students do not learn to think with the knowledge they are stockpiling, they might as well not have it?" If you accept this point how can ICTs be used to help children convert information into useable knowledge?
2) Has technology changed the way your school views learning and the relationship between teachers and pupils? If so, how?
3) Are ICTs in the learning process nothing more than hype and hyperbole?
4) From your professional experience do you think it is useful for very young children to use ICTs in the classroom? If so, how are they useful? If not, what would you tell a teacher of four or five-year olds about using ICTs with children on a regular basis?

Additional Readings
ICTS AS INSTRUMENTS OF “DRILL AND KILL”

Used appropriately and at the right ages, information communication technologies go far beyond just providing the basic keyboarding skills necessary for success in a modern workplace. ICTs can create environments in which students learn by doing, receive feedback, work collaboratively and continually refine their understanding and build new knowledge. We know this from research into best practice.

For example, “In an inner-city high school physics class in Chicago, students are examining computer images captured by automated telescopes. To identify the types of galaxies represented in these images, pairs of students use software tools to enhance the images on their computer screens so that patterns are easier to detect. They change the colors and brightness of the images, zoom in to look at specific features, and zoom out to get an impression of overall shape; they rotate an image to see it from multiple perspectives. These student activities are part of a technology-supported project called Hands-On Universe. Automated telescopes now capture many more images from outer space than professional astronomers have time to analyze...In the course of these activities, students learn basic concepts and skills of research astronomy and help search for super novas and asteroids. (Two Hands-On Universe student groups have in fact discovered previously unknown super novas and had their work published in scientific journals). Hands-On Universe enables students to use the same kinds of software tools that scientists use (albeit with more user-friendly interfaces) to examine and classify the downloaded images.”13

Despite examples of best practice far too many schools in America still use computers for highly structured, drill-and-practice type activities that focus on the development of basic skills. This use, known as Computer Assisted Instruction (CAI), has been employed since the 1960s for individual instruction in isolated basic skills. “Drill and practice programs give intensive work on specific academic skills. Because most are based on a behaviorist theory of learning that emphasizes stimulus, response, and reward, they tend to give the student a certain number of problems (sometimes after a pretest), offer direct feedback on whether the answer is right or wrong, and dispense a reward for correct performance. Rewards range from a verbal prompt (‘Great Job’) to a game which may occupy the student for longer than the actual drill.”14

A 1998 Educational Testing Service study of 13,373 fourth and eighth graders showed that drilling with computers actually led to lower test scores.15 Critics also note that it is an expensive way of getting the basics across that can better be accomplished by motivated teachers. CAI simply shifts the onus of the expert from the teacher to the computer. Cognitive scientists point out that building basic skills in this isolated fashion misses out on the importance of developing skills in a context that matters to the learner. Howard Gardner warns that, “Far too many students do not see the three Rs
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being used productively at home, nor do they witness their utility in school; and too few students are presented with problems, challenges, projects, and opportunities that draw in a natural and productive way on these skills. Such Effective learning means making connections between ideas and facts, not simply accumulating facts. Technologies that are used to build connections extend learning opportunities.

Another popular way, yet highly ineffective, of using information communication technology is to treat it as a separate course and to have a specialized teacher teach "computers" to students. This usually entails students having access to computers during one class period a day in which they learn how to use word-processing and some basic computer programming. The students are then tested and graded on what they have learned during their time in the computer course. There is little effort to integrate the technology across the school’s entire curriculum, although there is often times an effort to let students access information off of the Internet for special projects.

Jane Healy gives an apt description of this teacher-centered form of computer instruction in her book Failure to Connect. Healy writes:

“Mr. Smith’s classroom carries the faint scent of computer dust mingling with adolescent angst. Twenty-two computers are arranged around the periphery, with chairs facing the center of the room. As we await the arrival of students, he explains that I am to see a seventh-grade class starting an eight-week cycle of ‘computer literacy,’ including technical information and word processing. This is their second class; in the first they watched a video explaining how a computer works. Mr. Smith, a former industrial arts teacher, sees 125 students a day and also oversees all technology planning and support for the building. We are in a suburban school district noted for its forward-thinking philosophy and strong history of educational excellence...

Class begins. Half the students take notes and the rest gaze at the floor as Mr. Smith lectures and questions them. He expects precise answers. Students who have parents in the computer business seem to be the only ones who know the material, and I find much that is unfamiliar to me as I try to follow a technical discussion of differences between Macintosh and IBM engineering and fine points of MIPS (millions of instructions per second). Five out of the 22 students participate in the discussion; Mr. Smith airs his expertise while the rest avert their eyes and glance at the clock...

Before they can turn their chairs around and touch the keys, each student will have to pass a test on the content of Mr. Smith’s lectures.”

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A large number of educational administrators and teachers support Mr. Smith's use of technology simply because it fits in the traditional way of doing things. It does not require a change in how classrooms are managed, and in fact requires little more than finding space and money for the equipment, and a slot in the curriculum. In America, the use of ICTs as a tool to extend the values of the teacher-centered classroom predominates, especially in state-run schools that serve inner-city communities and rural areas. There is little evidence however that such usage of ICTs correlates with higher academic achievement, and in fact some research studies suggest that if the goal of education is to develop higher order thinking skills it may be outright damaging. It would also appear to be an extremely expensive diversion.

The educational historians David Tyack and Larry Cuban have noted that the history of technology in the classroom is largely one of teachers using the possibilities of technology to build on what they have always done. There are few examples of classroom technology resulting in what the researchers from the US West Foundation believe necessary - "changes of huge magnitude in educational philosophy, classroom management and curricular goals." Tyack and Cuban claim, "Perhaps the most fundamental block to transforming schooling through machines has been the nature of the classroom as a work setting and the ways in which teachers define their tasks. We have suggested that the regularities of institutional structure and of teacher-centered pedagogy and discipline are the results of generations of teachers' experience in responding to the imperatives of their occupation: maintaining order and seeing that students learn the standard curriculum. Teachers have been willing, even eager, to adopt innovations such as chalkboards or overhead projectors that help them do their regular work more efficiently and that are simple, durable, flexible, and responsive to the way they define their tasks. But they have often regarded teaching by machines as extraneous to their mission."

It is important to understand, however, that many educationalists are hopeful that ICTs will have a far more lasting and significant impact than earlier learning technologies such as filmstrips and television. Optimists point out that computers and information networks are significantly different from earlier learning technologies in that they are transforming workplaces as diverse as offices, airlines, steel manufacturing, ship building, oil exploration, hospitals, the military, and even the home. In fact there is increasing evidence that ICTs are changing the structure and rules of modern economies in ways as significant as the industrial revolution changed agricultural societies.

The evidence from discussions with parents seems to support the view of optimists. "When asked to rate the importance of computers for learning, 87 percent of parents in the study gave computers a strong rating. The perception that computers are very important in education does not vary much by occupation, income or education, though fully 91 percent of [the] African American [parents in the study] think that computers will make a difference in the quality of [their children's] education."
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Tyack and Cuban note that historically, "No public urgency compelled such attention to the media previously used in schools."22

THUS FAR, AN OPPORTUNITY MISSED

Proponents of ICTs go even further and contend that confining these technologies to the teacher-centered model of education is akin to putting a rocket engine on the back of a cart. Advocates point out that the real power of ICTs lies in their ability to offer multi-sensory, reflective, and collaborative learning environments unconstrained by time, place and formal structures. The power of ICTs, supporters note, lie in their ability to empower individual learners and groups, while breaking down barriers to learning. For example, Britain’s Open University has over 160,000 students using a variety of information communication technologies to take distance learning courses. China’s TV University System already has over 580,000 students in degree programs.23

Most teachers, we believe, are not Luddites who feel technology is threatening or useless, and in fact many are advocates of learner-centered models of education that help students construct their own understandings. In the long run these learner-centered advocates of ICTs are optimistic and hopeful about the future, but they are waiting for the appropriate support from their leaders to move forward. The immediate problems facing teachers are lack of training, support, and a clear vision as to where politicians want education to go. Teachers understand and live daily with the following educational paradox - constructivist models of education, which best facilitate the effective use of ICTs, are in political disfavor in many parts of North America and Europe. Consequently, despite the need and opportunity, there are few immediate incentives to work hard at developing a constructivist pedagogy for the effective use of ICTs. In fact there are a number of disincentives.

Despite various well-publicized examples of individual schools doing wonderful things with information communication technologies the fact is few teachers have been adequately prepared to help students use technologies effectively. Nor is there, except in a very few places, sufficient technology to provide access on demand for both teachers and students. In the U.S., for example, despite the large sums of money being invested in computer information technologies there has been no similar push to train teachers in technology use. A US Department of Education survey in 1999 found that only a third of public school teachers consider themselves prepared to use computers and the Internet.24 "In the United States," according to the OECD, "it is remarkable that expenditures on technology training for instructional staff increased only slightly from 4 percent of the technology budget in 1994-95 to 5 percent in 1998-99, given the high political priority of the use of ICT in education and the fact that many teachers lack ICT skills."25

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Henry J. Becker analyzed data from one of the most comprehensive surveys of teacher technology use, the International Association for the Evaluation of Educational Achievement survey, and found that of 1000 teachers surveyed only one of six teachers used computers regularly in the classroom, and of these, a majority used them mostly for drill and practice, avoiding more complicated applications. Becker found that teachers using computers effectively were more likely to work in schools offering high levels of teacher development on computers and having technology coordinators available to assist teachers with ongoing problems.26 Drill and practice programs can benefit some children with certain learning disabilities, but for the majority they are little more than a distraction.

Various research efforts have shown the primary reason teachers were afraid to use technologies in ways that developed higher order thinking skills was a lack of experience using computers and associated technologies. Far too often there is simply a lack of appropriate support for teacher development, or a real appreciation that ICTs demand a more student-centered pedagogy than most teachers are confident with using. In high schools that are utilizing ICTs most effectively “the most adept teachers do less lecturing, and change from classroom know-it-all to learning coach who guides students to what they need to know.”27

The inappropriate use of technology and its correlation to a lack of a changed pedagogy and appropriate training for teachers is not just an American phenomenon. A large international review of this issue in 1998 found that in many countries, “Successful deployment and use of ICTs in the classroom still largely depends on highly motivated, pioneering principals and teachers. Although the lack of appropriate teacher training and experience was identified at the beginning of the (1990s) as a major problem for effective use of IT in education, most policy discussions and technology initiatives in the area of IT and education have tended to focus on hardware and software acquisition and students’ access to technology (...) Computer literacy is still generally low among educators: the majority lack the necessary training, some lack an appreciation of ICTs and their classroom potential.”28 In light of such limited teacher support and training it is not surprising that “a 1996 survey of English secondary school heads of subject departments found that, in most subjects, very few believed that ICTs was exercising a ‘substantial’ impact on teaching and learning in their schools and departments (although about half thought that it had ‘some’ impact).”29

In the summer of 2000 during an international conference in Tel-Aviv entitled “Education in the Age of the Information Revolution: Opportunities and Challenges” the following comments were shared about the difficulties faced by Israeli education in trying to release the power of information communication technologies. They are observations that resonate in many lands:

“After two decades of growing investments we have recently become aware that:
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5) schools are still not ‘ICT-friendly’ – most schools have still not really integrated within the emerging cyber-culture stemming from ICT;

6) in the majority of cases, ICT in schools has not brought about (what has been desired and expected since the mid-eighties) changes in learning/teaching methods towards more research oriented methods;

7) on balance, ICT in education has not led to meaningful increases in students’ achievements.

8) On the other hand we are much more aware today then we were 10 or 15 years ago that we cannot and should not ignore ICT in education. ICT is here to stay, and it is a defining technology (i.e., a technology that is changing the environment and the organizations in which it is being used, and hence its users). It is having an enormous impact on all aspects of our lives. What has been created in the past decade is not just a series of new tools, but a whole new virtual living environment that wraps up all the technological developments of IT (Information Technology) and CT (Communications Technology) revolutions of the past 150 years. In a few years time this is going to be the environment in which we will live, communicate, work, consume, do business, and spend large parts of our social lives. It is obvious now that education systems cannot and should not isolate themselves from the ICT-based environment. By doing this they will doom themselves to rapid marginalization.³⁰

Pause and Consider the following questions

1) Do you see ICTs being used in your school to “Drill and Kill?” If yes, should you continue to do so? If not, what are some of the innovative ways that you use ICTs?

2) Are teachers and students in your school generally excited about the use of technology or frustrated?

3) Does your school have appropriate funds for the ongoing training of teachers to use ICTs creatively? Are most of the teachers in your school comfortable with using ICTs?

4) How does the experience of Israel compare with your experience of using ICTs in education?

Additional Readings


MAKING CONNECTIONS ACROSS THE WHOLE LEARNING ENVIRONMENT OF YOUNG PEOPLE

In charting a course for the future, it is encouraging, to look in a little detail at one pioneering effort to use information technologies (this was before the wide-spread use of the Internet) in a way that actually sought to change the culture of the school, the community, and the way in which teachers taught and students learned. In England in 1980 the head of Alleyne’s Comprehensive School, John Abbott, sought to integrate computers across the school’s curriculum in a way that would replace the paper and pencil technology of the classroom. Abbott argued it was not simply a question of teacher training or providing massive levels of technology. At the most fundamental levels the technologies had a potential which simply did not fit into the parameters of the curriculum.

He pointed out that young people who were proficient in using word-processors for drafting and redrafting essays no longer related to lessons that were dictated by a paper and pencil technology. “When I am writing an essay, I only draft out the opening paragraphs. I spend most of my time expanding my argument in the middle of the essay, and even more in setting out my conclusion. Only then do I go back and concentrate on the opening paragraphs. I am good at doing that,” said Abbott’s most confident students. His students also pointed out that “even though I write three times faster using a word-processor I am not allowed to use them in my exams. There I have to write by hand and think about my writing in a very different sort of way – there is no room for drafting and redrafting. However good I am at using the technology it does not influence my exam results...It’s all pretty stupid really.”

There, from an anecdote almost 20 years old, is the essential problem. Information technologies, and now information communication technologies, challenge the conventional model of education and how they are assessed. Examinations tend to be about first drafts, not redrafting, and certainly not about collaborative learning.

Despite the many inconsistencies his students pointed out, Abbott’s efforts at Alleyne’s were so successful that they attracted the attention of educational and business leaders from around the United Kingdom. In developing his scheme for information technology at Alleyne’s Abbott built on a pedagogy we’d now call constructivist and integrative. He also constantly sought out examples of best practice in other places. He found an exceptional example of what he was looking for at Princeton High School in Princeton, New Jersey. Abbott discovered that the first step towards successfully implementing the use of computers across the curriculum, and indeed across the learning environment of children, is to get the community involved in the process. After two years of intense debate and struggle Princeton came up with a community statement that provided the basis of
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authority and purpose for what both the school and the larger community were responsible for in terms of children’s learning.

“Our teachers understand that, first and foremost, they’re educators,” said the principal John Sekala, “they’re seeking to build up the confidence of young people so that they can become free-standing. They teach these skills within and across particular subjects because the skills we’re seeking to develop have universal application; the subjects are interdependent.”

John Sekala drew attention to three critical factors.

“First of all, the process of building a mission statement is with us – that first two-year period got us to think, talk and work together. It means no one in town any longer expects the school to do everything; we – that is, the town – understood that the work in the school is complemented by what children experience in their lives outside of the school. School and community pace each other.”

“Secondly, the cross-disciplinary approach makes teachers far more managers of a learning process and counselors to the students, and far less instructors within separate disciplines. The use of computers is important – one to every three students. Every essay ever written, every report ever produced, across all subjects, is done on a word processor. This approach was embedded in the process,” Sekala explained. “We do this not to create fluent keyboard operators, but to exploit the technology to support the learning process. Once an essay is written the teacher will comment on it, often at length. Not until the student feels the draft is the best she can produce does she ask for a mark, a mark that reflects not just the quality of the finished text, but the improvement made on her first effort. The staff doesn’t set anything like as many essays and time is now spent developing verbal and audio skills. And, remember, these youngsters’ academic results are outstanding.”

“Thirdly, at the heart of our experience,” continued Sekala, “is our staff development policy. Because our pupils work more independently we don’t need to put them into classes so frequently. With a staff of 81 we never timetable more than 70 with about 15 percent of our teachers on a retraining program at any one time. Most work with a local employer, or professional group to develop new programs. The community is our resource. We can’t conceive how we could run such a school without continuous, locally devised, teacher development. That’s what gives our school its vitality. If pupils are to be continuous learners, it is essential that teachers are learners as well.”

This story of educational excellence picks up on the central themes that researchers on learning now urge policy makers and educators to understand fully before trying to use computers and information networks to improve the learning performance of children. To reiterate, professional development of teachers is a key factor in the effective use of ICTs, and it is essential to find money
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to support and encourage it. According to the Educational Testing Service in the United States, a group that in 1998 conducted the largest study ever on ICTs in America, "Professional development and higher-order thinking are both positively related to academic achievement: Students with teachers who have had such professional development show higher levels of achievement, as do those who are taught higher-order skills with computers. Professional development is also associated with academic achievement indirectly; it increases the likelihood of teachers using computers to convey higher-order skills, thereby increasing academic achievement in that way. Finally, using computers for drill and practice, the lower order skills, is negatively related to academic achievement."

There is a paradox here that needs to be better understood. It is a fact that very little of what takes place in initial teacher training relates directly to the development of higher order skills. For many, teacher training programs seem to be going in the opposite direction with new teachers being trained more and more in simple outcome learning techniques. This is in contrast to encouraging pupil exploration and open questioning. As a group of English headteachers noted in June 2000, "Initial teacher training appears to be going in the opposite direction – new teachers are less equipped to understand (the science of) learning, and they have little background into the potential implications of all this."

Community participation, and especially working to integrate the home into the learning process, is also a central component in the successful use of information communication technologies. Effective school computer use is positively related to home computer use. Students with access to ICTs at home demonstrate higher levels of academic achievement. Such empowered learners control when and where they learn. Not surprisingly, for eighth-graders professional development, using computers for higher-order thinking skills, and having access to technologies at home were associated with more than a one-third of a grade level increase.

COMMUNITIES OF PRACTICE, CONSTRUCTIVISM, AND THE DEVELOPMENT OF HIGHER-ORDER SKILLS

There are, however, two important themes to look at more closely for those advocating the use of ICTs. The first is that knowledge construction is far more than simply acquiring information. The second is that the construction of knowledge is largely a social activity. John Seely Brown and Paul Duguid demonstrate in The Social Life of Information that, "Information on its own is not enough to produce actionable knowledge...Looking beyond information, as we have tried to do, provides a richer picture of learning. Learning is usually treated as a supply-side matter, thought to follow teaching, training, or information delivery. But learning is much more demand driven. People learn in response to need. When people cannot see the need for what's being taught, they ignore it, reject it.
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or fail to assimilate it in any meaningful way. Conversely, when they have a need, then, if the resources for learning are available, people learn effectively and quickly.\textsuperscript{34}

Seely Brown and Duguid go on to explain that their years of work with the Xerox Palo Alto Research Center (PARC) has demonstrated that for people to effectively distil information into useful knowledge requires a community of practice. They note that learning is a remarkably social process when they write, "Learning needs to be understood in relation to the development of human identity. In learning to be, in becoming a member of a community of practice, an individual is developing a social identity. In turn, the identity they are developing determines what they pay attention to and what they learn. What people learn about, then, is always refracted through who they are and what they are learning to be."\textsuperscript{35}

The social context in which children acquire information is critical to the way in which they construct knowledge and ultimately make sense of their world. If the purpose of providing young people access to information is to help them use it to become collaborative members of a community then this requires learning in partnership with others. Teachers still have a critical role to play in the education of young people. It is simply a different role from that of the "sage on the stage." As the OECD points out, "To facilitate active learning is not the same as handing over professional expertise to hardware and software. Rather than diminishing the role of the teacher, ICTs has the potential to enhance it, making possible a more diverse curriculum and a more demanding repertoire for teacher skills and organization."\textsuperscript{36}

Yet, teachers need to feel the confidence to work in ways that are different to the traditional model of education. John Seely Brown contends that the technologies of information and communication compel a change in the prevailing pedagogy. Before the advent of interactive technologies "pedagogy had to do with optimizing the transmission of information. What we now find is that kids don't want optimized, pre-digested information. They want to learn by doing - where they synthesize their own understanding - usually based on trying things out."\textsuperscript{37} Learning becomes experiential. Seymour Papert has argued that, "The scandal of education is that every time you teach something, you deprive a child of the pleasure and benefit of discovery."\textsuperscript{38}

A 1997 Report to the President on the Use of Technology to Strengthen K-12 Education in the United States observed, "In recent years many have argued that the use of new technologies to improve the efficiency of traditional instructional methods will result in limited progress at best. This view holds that the real promise of technology in education lies in its potential to facilitate fundamental, qualitative changes in the nature of teaching and learning." The report continues, "While the educational research community has by no means reached consensus on the best way to educate our children, a large part of that community has in recent years converged on a core set of
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pedagogic principles that form the basis of the constructivist paradigm. By contrast with the more
traditional view of instruction as a process involving the transmission of facts from an active teacher
to a passive student, constructivists believe that learning occurs through a process in which the student
plays an active role in constructing the set of conceptual structures that constitute his or her own
knowledge base.  

In deference to the political controversy surrounding constructivism, it is seen as being on one side of
the debate, the report to the President goes on to tentatively support a constructivist paradigm for the
effective use of ICTs. The report reads like a cryptogram when it states:

"However compelling we may believe the argument in favor of constructivist practice to be,
and however plausible we may find its theoretical underpinnings, the proposition that
constructivist techniques, as currently understood, will in fact result in more favorable (in some
sense) educational outcomes must still be largely (though not entirely) a collection of exciting
and promising hypotheses that have yet to be rigorously confirmed through extensive, long-
term, large-scale, carefully controlled experimentation involving representative student
populations within actual schools."

At this point in the text a footnote is inserted which reads, "This observation should not, however, be
taken as a rationale for accepting the pedagogic status quo within our nation’s schools, or for halting
the progress of educational reform efforts that seek to employ technology within a constructivist
framework pending the completion of long-term experiments."

The report to the President continues:

"While the Panel is thus unable to make a confident and definitive statement regarding the
superiority of the constructivist approach, it believes there to be a high likelihood (italics is
theirs) that many or all of the essential elements of this approach could play a major role in
improving the quality of our nation’s elementary and secondary schools...In order to
optimally cultivate this ground, schools will need to make changes that extend far beyond the
mere installation of a network of computers. While some benefits may be obtained by using
information technologies to pursue existing curricular objectives or by adding new material to
an existing course, the richest harvest is likely to accrue from a fundamental restructuring — at
least at the level of the individual course, and ideally, across disciplinary boundaries as well.
Such fundamental restructuring, however, is likely to prove complex, difficult, expensive, and
time-consuming, and may encounter resistance from parents, educators, and the general public,
particularly to the extent that such changes conflict with commonly held beliefs about the
nature of knowledge and learning."

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This is the closest the Office of the President in the United States can come to endorsing one view of learning over another without being attacked by conservative members of Congress. It is a political compromise, but one whose significance goes far beyond the United States for what that country does, especially in the development of software and computer systems, influences educational systems worldwide. The important point to remember is that the science of learning supports a learner-centered use of ICTs.

For such models of learning to emerge there must be a partnership among all those involved in the formal sector of education. In light of this fact, the community statement on learning developed by Princeton offers truly valuable insights into how to most effectively integrate ICT into the larger environment in which children learn. All facets of the community must be involved. The fastest way to destroy an educational movement that seeks new ways of doing things is to have it come across as a top-down initiative. In the United States, according to Tyack and Cuban, historically “top-down implementation provoked many teachers to dig in their heels or simply to put technology in the closet.”

THE PARADOX: THE POWER OF ICTS AND CURRENT SYSTEMS OF EDUCATION

The power of ICTs lie in their ability to help students construct their own knowledge, take charge of their own learning, articulate new possibilities across disciplines, and collaborate with peers and teachers in the learning process. The effective use of ICTs enable older learners to take charge of their learning strategies, and ultimately enlarges the learning environment. There are a few problems with this fact. It collides up against the segregated nature of age-based classroom learning, and it collides with the traditional model of teacher-centered education that has struggled to accommodate the varying backgrounds, learning styles, rates, and needs of the slower or more gifted learners.

Let's us deal with the issue of the predominance of classroom based learning set to the age of the learner first. We accept the view of the OECD that, “A lifelong learning approach calls for a sweeping shift in orientation, from institutions, schools and programs to learners and learning.” The 21st Century Learning Initiative believes that the nature of constructivist learning and the power of information communication technologies call for a model of learning that does not draw sharp boundaries around the learning needs of young people.

We argue that the current model of education is upside down in that it provides the most teacher support in the later years of secondary school, and the least in the early years of primary school. We contend that the youngest primary school pupils should receive the most direct teacher support, and the least use of information communication technologies. We advocate a class size of 10 for five-year
olds, a class size of 12 for six-year olds, and so on chronologically. This is only possible if the youngest children are taught in a way that actively helps them learn how to learn. As children get older they should be intentionally weaned of their dependence on direct teacher support, and this weaning process entails helping students move away from teacher directed learning to independent learning through the use of books, library materials and ICTs. This can happen only if funding for education is seen as being flexible and this requires a system that does not start with the premise that education is split up into three distinct parts – primary, secondary and higher education.

Successful early years education empowers adolescents to take increasing control over their own learning, and this includes being able to effectively use ICTs for independent learning. The power of ICTs lie in their ability to help confident learners breakdown traditional repositories of information and to expand their access to knowledgeable people. As Professor James Duderstadt, president emeritus of Science and Engineering at the University of Michigan, points out, “Today’s highly partitioned system of education will blend increasingly into a seamless web, in which primary and secondary education; undergraduate, graduate and professional education; on-the-job training and continuing education; and lifelong enrichment become a continuum.”

The 21st Century Learning Initiative made the case in *The Unfinished Revolution* that, “The education system of the future will need to actively permeate learning opportunities throughout the entire culture. This form of dynamic learning will not be seen as a system, but rather as a way of life. Learning will be something that we all recognize, encourage and actively support through community participation and the power of the connected world of information communication and technology.” Duderstadt adds, “Rather than aspiring to an ‘age of knowledge,’ the nation (the USA) might instead aspire to a ‘society of learning,’ in which people are continually surrounded by, immersed in, and absorbed in learning experiences.” A society of learning will need to be more interdependent and seamless than the currently fragmented levels of education all seeking more money to do more of what they have always done. Despite the resistance of many traditional educationalists we are arguing for a model of learning that actively seeks to work smarter.

The effectiveness of current models of education are largely measured by standardized forms of examinations that focus on low-level skills and fact-based knowledge. Effective use of ICTs elicit thinking, problem-solving and communication skills. Such higher order skills are not measured by multiple-choice bubble-in test sheets that are used to measure how well someone remembers facts. Some in education, however, support such forms of testing because they consider the development of higher order skills a euphemism for moral relativism, and they say that standardized exams should focus on the basics such as spelling, grammar, mathematics and cultural literacy.

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In the United States, critics of traditional standardized exams argue, "Large-scale testing programs are generally not useful in improving a student’s immediate learning process, though clearly that is what most parents hope for from assessment. As diagnostic tools, most large-scale tests are blunt, imprecise, and often useless --- but most states claim that diagnosis is a reason for their tests. Because most states do not provide an opportunity for sustained and engaged thinking, they are poor tools for shaping or improving curriculum and instruction --- a goal most states claim for their tests. While these exams can provide some information to the public about what students have learned, most do not provide information about whether students can use in their lives the things they have supposedly learned.

Despite these extreme limitations of state testing programs, the cumulative effect of the multiple uses of these tests is that the exams largely define the purpose and processes of schooling in most states. They affect not only curriculum and instruction, but also the culture of learning, student motivation, and the underlying conceptions of what learning is and how humans learn. Driving school reform with traditional tests will not succeed if the nation really wants all children to gain an education that challenges their minds and spirits, that assumes not only that they can learn some skills but can learn to use their learning as active participants in a democratic society."46

Instead of being a means to an end (helping children take control of their own mental processes); standardized exams have far too often become an end in themselves. Thus, the purpose of education is narrowly defined, and this comes increasingly at the cost of developing higher order thinking skills in young people. This fact results in comments like the following from an English businessman, "based on his exam results and degrees he should be a genius, but in fact he has constantly to be told what to do and when to do it. It’s like his initiative has been educated right out of him."

"What you test is what you get" is a familiar verse within the educational community; as a result, if information communication technologies are to help young people develop higher order thinking skills then it is necessary to develop models of assessment that encourage such thinking. If we accept the constructivist view of learning and the power of information communication technology to move education away from the teacher-centered model of learning then it is necessary to change the way in which learners are evaluated. "Assessment, from a constructivist perspective, is process-oriented. Assess learning as it is occurring, rather than separating assessment from learning, focusing not only on what students have learned (facts), but also the ways students learn. Assessing the strategies and tactics that students use to learn will predict how well they will be able to learn and solve problems in new situations."47

A few states in America are moving beyond the limitations of multiple-choice exams. They are using portfolio assessment and performance-based assessments that rely on short-answers, open-ended
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items, writing samples, performance tasks and similar exercises. These models of assessment provide educators with a more thorough understanding of how well their students are learning not just facts but also the processes of learning how to learn. If the goal of education is to help all children become life-long learners who can use ICTs effectively to continually build knowledge then these alternative forms of assessment most become far more common. It must be noted, however, that ideology is not the only factor preventing the spread of alternative assessment schemes. They cost more. For example, “a recent estimate by the General Accounting Office (of the USA) found that a national multiple-choice achievement test would cost $42 million, while a slightly longer test with short, performance-based questions would cost $209 million. About one-quarter of this total would consist of professional development for teachers and scorers.”

CONCLUSION

This paper has reviewed the opportunities and problems arising from the large-scale introduction of ICTs into education systems. It is clear from the research synthesized here that, for the most part, educators are still largely constrained in their ability to release the potential of ICTs because they do not fit comfortably within systems of education that focus on teacher-centered forms of education. Additionally, the technology is being introduced at all levels of education without an appreciation of their actual impact on the learning of different age groups. Teachers are not receiving training on children’s different learning needs or the integrative nature of ICTs because such training is costly. It also runs counter to the traditional argument of education being teacher-centered and based on teaching lower-order skills. The technology is of strictly limited significance, or even damaging, if it does not change the conventional role of teacher and student. The effective use of ICTs call for a change in pedagogy, a different view of teacher training, and new partnerships between educators and the larger community. As Seymour Papert noted in 1992 in Rethinking the School in the Age of the Computer, “School does not have in its institutional mind that teachers have a creative role, it sees them as technicians doing a technical job, and for this the word training is perfectly appropriate.”

In summary, for most students in the United States and the United Kingdom, current school curricula, and assessment, remain predominantly about facts, not about processes and the development of higher order skills. As such, the power of these technologies within formal education is being constrained to work alongside curricula firmly fixed in the working practices of an earlier age - high levels of memory skills, instruction and paper and pencil dexterity. Yet, there is hope that the experiences of path-breaking communities, and the continued explosion of knowledge about effective practices of learning and the usage of ICTs, will lead to increasing numbers of communities and schools actively seeking to work smarter for all their children.

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Pause and Consider the following questions
On Teacher and Staff Development
1) How can we release the full potential of our teachers?
2) How do we make the move from a teacher controlled pace of learning to release the potential of students to take charge of their own learning?
3) How do we move beyond simply using ICTs to facilitate traditional classroom practices, teaching styles and school timetables?
4) How can we encourage teachers to be more trusting, thoughtful, and flexible?

On Pupils and their Potential
1) How can we help students be thoughtful and discerning in an era of hypermedia?
2) What about the early years and key stage one? Is there a conflict between what children can do, what parents would like to see them do, and what is most appropriate at their age?
3) How and why do we underutilize ICTs?
4) How and why do we misuse ICTs?

Additional Readings
1) President’s Committee of Advisors on Science and Technology. “Report to the President on the Use of Technology to Strengthen K-12 Education in the United States.” 1997.

Endnotes:

6 The OECD observed in 1998 that “in almost all countries expenditures on education increased faster than national wealth,” and the White House noted in late 1997, “as a result of current budgetary pressures along with a persistent historical pattern of significant inflation-adjusted increases in educational expenditures, economic considerations have in fact assumed a position of central importance in ongoing deliberations surrounding the topic of educational reform.”
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12 Todd Oppenheimer, p. 54.
14 Ibid., p. 58.
17 Ibid., p. 38.
22 Tyack and Cuban, p. 125.
23 The Economist. (December 13, 1997).
27 Kenneth J. Cooper.
29 Ibid.
33 Ibid.
36 Centre for Educational Research and Innovation, p. 36.
39 President’s Committee of Advisors on Science and Technology, pp. 33-34.
40 Ibid., pp. 35-36.
41 Tyack and Cuban, p. 125.
42 Centre for Educational Research and Innovation, p. 5.
45 James J. Duderstadt.

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