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Information technology - a tool and an obstacle in the education of the future

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Abstract

Information technology will cause continuous rapid changes in our technological environment. The general impression is that the digital age will improve our lives and our society. Huge national strategies and programs are underpinned by this belief. They do not properly take into account the human dimension. The information society started principally when writing was invented, but the past technological inventions have not driven major changes in education. Challenges to the education of the future arise when the issues of cognition and human information processing are combined with the future technology. This offers an environment for rapid communication and search for information but especially the means to deepen thinking and understanding. This will set new objectives for education. Permanent skills such as learning to learn in changing environments are more important than rapidly deteriorating content. Visual literacy should be promoted in the future. The educational management must be flexible, react quickly and be able to anticipate change. A proper management information system is needed.

Keywords

Educational management, visions, creativity, literacy, human/social sciences

1 MOTTO

Richard Hamming: *"The purpose of computing is insight, not numbers."*

Hamming's idea is often neglected. Technology is an end in itself. I have been engaged in computers and university teaching since 1961 and have experienced the tremendous development during the past 35 years. Is it possible to learn something from the past progress? Even though we are not able to foresee the future from our experience, we

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may learn something from the history and the present trends. If so, we might better steer computer uses in education at present, and perhaps prepare ourselves to compete in the 21st century. I will consider casual histories that are important.

2 ACCELERATED CHANGE IN INFORMATION TECHNOLOGY

When the first commercially made computer, an IBM-650, was started in 1958 in Finland, experts in the country thought that it was sufficient for all future computing needed in the country. The situation has changed dramatically. Finland is now one of the little countries around the world whose development of, and uses for, IT are out of proportion to their sizes and natural resource endowments (Dedrick et al., 1995). It has become one of the major IT producers and sophisticated users. Historically, Finland has been among the poorest of the Nordic countries, but now has one of the highest per-capita consumption of IT in the world. It has its own multibillion IT manufacturer in Nokia, which is second to Motorola as a world supplier of mobile phones. The rapid development will continue producing increasingly complex and sophisticated working environments. Computers will soon be in every home, too.
Your personal computer has replaced your typewriter, it connects you to other computers, to other people all around the world. It gives you access to libraries and data banks. It allows you to draw pictures, make animations, compile multimedia, design hypermedia documents and deliver them in the Internet. All this is available only if you are willing to learn repeatedly new computer equipment, new programs and operating systems, new peripherical devices, new types of applications. New skills are required every day in an ever changing environment. It is necessary to enhance worker productivity. Technology has become such an integral part of our life that we have to learn to integrate it into our nature.

The new technology has obvious benefits. It will also cause a growing mental burden of lifelong learning required by the continuous changes inherent in a working life based on computers and world wide networks. The educational authorities and organizations must promote networking of the educational system and create open learning environments to support the development from "once-and-for-all" training towards lifelong learning. Individual study opportunities must be improved at all levels of education, and study methods, teaching material, as well as the required information services need to be developed. New types of "information products" for lifelong learning purposes must be developed.

The principle of lifelong learning is not possible if people are not willing to learn. It is not sufficient that we have professionally skilled teachers. They know how to manage and to communicate information in their own fields and moreover to teach methods of obtaining and using information to enable learners to work independently. They also can use media necessary for open and flexible learning and be able to modify and develop material for the electronic media. The most crucial point is to develop the learning environment and the materials and contents so that learners are motivated to learn, can do it efficiently and not repeating the same things every second year. Learning to learn is the future key issue. Those who will master this in the rapidly changing world will survive.

The key component of most product designs is the human being. This idea must be taken most seriously in any information product serving education. There are parallels to the design of any good computer application and its user interface. Difficult user interfaces are no longer tolerable. Everything must start with the requirements definition for the product. We may learn from the experiences in general customer oriented product planning (Holzblatt et al., 1995). The problem is to know enough about ourselves, our brains, our learning psychology, our ability to learn continuously new things.

3 PUBLIC ENTHUSIASM AND INTENSIVE PROGRAMMES

It is a general impression that the digital age will change our lives and our society. Individuals will deal with all aspects of information-based technology. The new digital age focuses on the synthesis and availability of data from a variety of disparate sources. Every day we can see and hear in the media news about the networked information society. A complete Internet strategy is increasingly a requirement for doing business and marketing and tapping its vast information stores as a critical resource, etc. The goal is to learn to manage, manipulate, and effectively utilize information in the next decade. Recently, in most industrialized countries, extensive programmes are being carried out to further accelerate the development and use of information technology and its applications in the different layers and functions of society. Information technology is expected to clear the way for profound improvements in education, health care, communications, telework, and administration. As an example, in January 1995, the Finnish Government decided the principles for the development of Finland as an information society.

According to this decision the Ministry of Education is responsible for achieving a long list of goals in its sector concerning education, research and development, national information resources and culture. For the fulfillment of these goals, the Ministry of Education has published in 1995 a national strategy for education, training and research in the information society. The Finnish goals for education are the following:

- All levels of education and training from comprehensive school upwards must teach the necessary basic skills in information technology (IT), management of information, and communication. Teacher training is a key development area, especially in the adoption of new competencies and skills.

- Training of professionals for information technology and information industries will be developed to reflect the diversity of changing professional roles. Students in vocational and higher education should learn information technology, information management, and communication skills that meet the needs of fast-changing and increasingly networked working life.

- Education and training of the information sectors at universities and vocational education will be increased. Continuing professional education and training will be developed to stay abreast of technological advances and to meet the needs of the information industry.

- Adults will be given opportunities to learn basic information technology skills by expanding the range of training available and by improving library services. Exclusion from the labour market must not occur because of a lack of these basic skills.

- The whole education system will be brought within the reach of information network services, ensuring that educational establishments can use these services. Open and distance learning will be promoted at all levels of education and training.

Many questions arise but they are not popular. Why is an information society so important? Why is all this information needed? Is it really necessary and useful? What is its value? Is it reliable? Can we see the difference between facts and fiction, between natural phenomena and computer simulation models, between real life and virtual reality? Do we really need an exponentially growing amount of information? Do we enjoy the limitless research opportunities the Web offers? What are our long term goals and does information technology offer proper tools to achieve them?

4 INFLUENCE OF PAST TECHNOLOGICAL INVENTIONS

We tend to pretend that the present information revolution is something new and original, but is it? It is advisable to take a look at some earlier inventions and their implications to mankind and education.
Actually the information society started when people invented writing and it was possible to store and manipulate information. At the same time thinking, or at least the results of it, started to have more literal forms. This led to the present linear way of coding our expressions character by character. This kind of result is easy for the computer to process. The whole history has taken thousands of years and the diversity of different developments is astonishing (Haarmann, 1990). Seeing and making pictures was left aside.

So far the inventions like pen, pencil, paper, and printing have had more influence on the mental development of mankind than the computer. These past technological discoveries have not driven major changes in education, however. We observe similarities when we look at mailing letters by post, printing press, microscope, telescope, stereoscopic pictures, electricity, telegraph, photography, movies, telephone, radio, TV, video, etc. Once a new invention has been made it is proposed that it will change radically our views and habits and a great enthusiasm exists for a while. However, the lack of impact of camera, radio or TV in the classroom is clear.

Marshall McLuhan (McLuhan et al., 1967) wrote in 1967 about the role of media: "The medium, or process, of our time - electric technology - is reshaping and restructuring patterns of social independence and every aspect of our personal life. It is forcing us to reconsider and re-evaluate practically every thought, every action, and every institution formerly taken for granted. Everything is changing - your family, your government, your relation to "the others". And they're changing dramatically." It is remarkable that he did not have the computer revolution in his mind. It started to influence the general public much later. Similar opinions can be found in the literature in the middle of the 19th century concerning the stereoscope. Very little has changed. Conservatism is the key issue in the history.

A more recent example is the changing history of computer aided instruction. The behavioristic view of learning was dominant when the computer era started in the sixties. The key idea was to prepare programmed learning material so that the computer can replace teachers. Then gradually the technology was shown to be inefficient. Our views on learning have changed. Now the dominant paradigm is based on cognitive psychology and constructive learning theories neglecting subconscious processes. Computer systems are considered as good learning tools and environments for the active learner. The problem is to make learners active.

The computer based labs are recommended as they support "learning by doing" (although in a virtual environment) (Soloway, 1994). Computers should be present in the classroom (Shneiderman et al., 1995). Most of these ideas are in a preliminary and experimental stage and not commonly used because of the lack of knowledge and equipment. I myself have not followed my propositions for computer uses in the university classroom (Mäkelä et al., 1990) although I think they are still valid. The reason is that the technology is too complicated and rapidly changing. It is fairly difficult to invent novel applications as the old tradition is in your mind all the time. It takes time to adapt oneself to the changing world of new ideas and concepts. Learning is a hard job even for the teachers. A good advice is to take only small steps. A few of them are perhaps giant leaps for mankind.

Anyway we must remember what Alfred Bork (1989) has written:

"Unfortunately where technology is involved people often start by asking questions about how to use a particular technology. This seldom leads to the best. . . ";

"No matter whether technology is involved or not, our primary concern should be with learning, and this must be strongly emphasized from the very beginning. . . . ";

"The notion that we start from learning problems has a strong corollary: The people in charge of the development should not be the technologists, but extremely competent teachers and educational researchers in the area involved. I emphasize too that it is not the subject matter experts, and not the educational psychologists that we want, as is often suggested; these people can be very helpful but they should not be in charge. Rather we want people who are experts in helping people to learn the subject matter, different individuals than subject matter experts, or psychologists. There is no substitute for the intuition of a skilled teacher!"

5 CHALLENGES FOR THE FUTURE EDUCATIONAL SYSTEM

We must see education as a whole and combine the technological advantages with the human aspects of computing. They will be central in the future. Educational computer systems must offer contents, tools and environments for rich and efficient personal accomplishment.

Perhaps the most exciting and threatening challenge is the continuous change in our working environment. We must study and learn permanent skills instead of changing facts which will deteriorate. Teaching must be as much as possible independent of the present technology and well suited to the human brains.

How to achieve this? Do we understand computer systems and the media they represent? What are the relevant and lasting features? The ideas and doubts of C. Stoll (Stoll, 1995) are worth studying. Understanding the situation and learning to learn and to adapt oneself without frustration in the rapidly changing environment are the basic goals. More than the basic skills to use computers are needed.

The history of e-mail shows that simple solutions work fine though they may require a fairly long time to be accepted and widely used. More powerful and sophisticated applications will need more time and elaboration before they are used world wide outside the professional circles. A deeper interactivity will be a standard part of modern communications. We can already study interactive multimedia collaborative processes and use complex, global, real-time multipoint collaborative and videoconferencing systems (Ishii et al., 1994).

In these systems it is necessary to understand the partners' ways of thinking and talking immediately. The cultural and semantic problems must be recognized. The technology is not an answer even though one may expect a real time language translation during a telephone call to be reality in the future. Smells, flavours, gestures, touches, feelings and emotions are still nearly impossible to convey electronically.

The vast information stores on electronic media must have a proper structure and assisting tools. They help search for relevant and valuable information so that users do not become lost in the information space. People should learn to know their needs and to understand and evaluate the information available. They should construct their own knowledge from the scattered pieces of information they are receiving all the time. Contents production should be a more important part of the information industry than the

production of hardware and software. Who is responsible for the subject matter and its reliability? What should be the information content of the material?

Multimedia and hypermedia materials will be the usual forms of information. Two types of problems will arise. When deep understanding and learning are required, the information product (e.g. hyperdocument) must intentionally guide readers through an information space, controlling their exploration along the lines of predefined structure (Thüring et al., 1995). The information structure should be tailored for a specified group of readers. So, the readers' reactions and expectations should be known.

Another problem is to convert an expert's knowledge to a readable form. The increased use of pictures and images, instead of words, in everyday life needs consideration by everybody. The producers and users of information should learn to communicate by producing and scrutinizing pictures of our ideas and activities. The second computer revolution is visualization (Friedhoff et al., 1991), not only as a scientific tool but also for nonprofessionals. The ability to produce and read pictures will be vital. A flexible way to generate pictures by the computer, and to visualize abstract objects and difficult structures, are central challenges for technical development and education.

Thoughts and images are intimately connected in our brains as about one half of our brain neurons are connected to the human visual system. Visual input is the most efficient way to feed data in, and pictures and images are the natural data formats. The main difficulty lies in the output from the brains. Traditional education does not support picture production and the corresponding output channel is missing. Perhaps computers can help us in this. Education will be both a problem and a solution. A recent issue of Computer Graphics (Special Focus, 1995) paid attention to visual literacy. It should be added to the list of basic skills and seriously promoted and supported at every level of education.

Issues of cognition and human information processing are widely neglected. Interesting are the changing balance between pictures and words in the technological age. (see e.g. Davies et al., 1990), and flexible thinking that uses both the left and right hemispheres of the brain (McKim, 1980). Flexible thinkers have easy access to both subconscious and conscious levels of thinking. They have many vehicles for the representation of thought. Some of them as language rely on logical reasoning using linear operations. The visual vehicle facilitates holistic, spatial, metaphoric and transformational operations providing a vital and creative complement to logical reasoning. Another vehicle is the emotional intelligence.

Computer systems will differ from our physical environments. Virtual reality as a 3-D interactive series of pictures will destroy our ability to see the difference between real life and simulations. Real world circumstances and social norms are not recognized in the computing situations. This will give rise to ethical problems as explained in Conger et al. (1995). Ethical education (Huff et al., 1995) must be integrated to the basic skills not only for tomorrow's professionals but also for nonprofessionals.

Teacher education should be reshaped to match the new demands. The new skills of visual and computer literacy and ethical subjects should be added to the curricula at all levels of education.

Education is one of the key issues in the adaptation to the rapid changes. Blonder (1995) thinks that it is not enough and puts forward another scenario: Computers' capacity will exceed that of human brains' in about hundred years. Machines will be intelligent enough to be independent of human operators. The human genetic development is very slow. Hence, the only possibility to adapt ourselves into the development is the use of genetic manipulations to compete with the computers. As continuous exponential growth is not natural, I expect that Blonder's scenario is not real. The growth will smooth

down as the usual S-curve shape shows in many natural phenomena. This will happen before we are ruled by computers!

6 CHALLENGES FOR EDUCATIONAL MANAGEMENT

Networked computers will be the most important tool in education within the next few years. Computers and networking are available in every school and the schools are integrated with their local environment. There are links between schools and educational establishments at different levels and operating in different fields, and links with community and business life. Information network services are available to all schools and libraries. The educational management will be a part of the networking.
The management of the material resources such as hardware and software including networks and communication systems, and especially their delivery and replacement with new versions, forms a difficult OR-problem. Cost-effectiveness analysis and adjustment of different conflicting goals may use the modern computational decision support systems with fuzzy logic. Another problem is establishing the links between the new partners to increase the level of interaction between the public and the private sectors of society.

Modern concepts of learning emphasize the students' responsibility for their own learning and their active role in seeking and using information. The basic skills to find and manage information and to communicate using the new information technology are central. Teachers are no longer distributors of information but change to be tutors guiding the students and helping them in their work and working together as companions. Schools become learning centers which offer open learning environments for different activities. Distance learning and teaching will be a natural part of the education.

The spatial and time distribution of the equipment and persons involved in the education will be dynamic. New types of scheduling problems will arise. The teachers and the students are working sometimes at different places and in different groups. The working habits and conditions will be different. Buildings must be more flexible. Control and evaluation of the activities will change.

The educational system is faced by continuous challenges in the rapidly changing society. Decision making which affects the educational system must be flexible, must react quickly to changing circumstances, and must be able to anticipate change. The management should understand the modern learning theories and teaching based on them, and should support them to fulfill the central goals of the educational system.

Management by results and evaluations are the essential tools for steering the educational system. A proper management information system is needed. It needs to have an adequate information and data base and telecommunication links necessary to collect and transmit information. It must be flexible and anticipate changes. It should be available for both central and local decisions. It should contain all essential data and knowledge about the educational system.

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8 BIOGRAPHY

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