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Children in an Information Age (Overview of the Issues)

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INTRODUCTION

The process of education is as old as the human race. All through history this process has become increasingly formalized and socialized (one milestone being, for example, the introduction of compulsory education). These steps made the responsibility of education for the future of the whole society (a nation) more explicit. In spite of the fact that this responsibility has not been questioned for centuries, there are many very recent documents monitoring the disquieting state of the educational process (A Nation at Risk, 1983) and contemplating elaborate measures for its improvement (Pravda, January 4, 1984) to meet the challenges of the future or use the possibilities offered by new technology (Masuda 1972, 1980). These problems seem to be so important that the whole concept of the future in education has be analyzed (Toffler 1974).

Because of all this, education is an inherent part of development strategies in most countries, industrially developed or developing. Individual institutions (ministries) are designing policies aiming to influence the behavior of individual actors in education in the desired direction. The efficiency of individual measures taken in achieving the selected objectives is difficult to predict, because processes studied by several different disciplines are interacting. Here the systems approach seems to be a well suited methodology. This fact also makes the problem of children and computers an attractive potential topic for study at IIASA.

However, a closer look at the issues is necessary before more concrete suggestions can be prepared.

SOME SEMANTICS

Wide interest evoked by the intricacies of computer-based education has brought many disciplines to the scene. Because these disciplines have their own semantics and definitions, there is a somewhat polluted terminology. For further exploration, it may be useful to structure the issue in the following way (Valcke 1982):

Computer Aided Education (CAE) concerns:

- learning *about* the computer, e.g., computer literacy, data processing, computer science;
- learning *through* the computer, e.g., drill and practice, diagnostic testing, tutorial programs;
- learning *with* the computer, e.g., simulations and games, problem solving, creative activities.

These activities will soon be significantly enhanced by the results of artificial intelligence research and should lead to the creation of Intelligent Computer-Aided Education (ICAE). One expects, from the use of ICAE systems that the student could use natural language and voice commands and with the results of research in cognitive psychology (directed at modeling human thought and problem solving behavior) these systems may adjust to different learning styles and to a student's prior knowledge (Douglass 1983).

In the literature, Computer *Managed* Education is also distinguished, which refers to applications when a computer:

- makes and analyzes a test for diagnostic or examination purposes;
- routes the student on the basis of former test result;
- stores, interprets, and updates classroom data;
- reports on progress to the persons concerned.

These education computer systems are implemented on different technical bases. We can distinguish:

- time-shared central computers;
- local minicomputers;
- networks of mini/microcomputers;
- independent personal computers, including programmable calculators.

A significant role in the efficiency of the computer systems is played by the necessary accompanying software. Software for use in educational systems has to meet some specific requirements dictated by pedagogical and psychological issues.

SOURCES OF INCREASED INTEREST IN CBE

One long-term source of growing interest in CBE is created by increasing scientific and technical development. It is often argued that more than 90% of all the scientists who ever lived on this earth are still alive! Similar forecasts are expressed for the future; for example, it has been pointed out (David, Williams 1979) that for a child born in 1979, therefore celebrating his 50th birthday in 2029, 97% of all man's acquired knowledge will have been discovered in his or her lifetime. The consequences of this fact for education-acquired knowledge are said to be that most of this acquired knowledge will be useless, some worthless and some even incorrect. The logical response to this challenge, which would exist even without the emergence of computers in education, is to change the character of education from the focus on knowledge content to a focus on the process of learning. The question is how to incorporate technology into the educational process in order to enhance the capability of an individual's mind to remain fertile, productive, and creative as long as possible without hitting the barrier presented by the psychologically and physiologically sustainable load.

Pursuing responses to this basic challenge has caused scientists and educators to branch into several spheres of interest to decision makers and policy designers.

POLITICAL AND SOCIAL INFLUENCES

The necessity of educating an ever-increasing population opens up the question of efficiency, costs, and overall policy for educational processes. Conflicts between these issues can easily emerge. Disparities in views, interests, and needs of teachers, parents, administrators, politicians, and technicians, not to mention the interests of students themselves, are already recognized.

The individual levels of policy majing generate different signals toward education. Educational requirements deduced from the long-term strategy of development of a particular country could be included in this category of influences. One of the most specific is the "Information Society" strategy of Japan described elsewhere (Masuda 1972, 1980) containing experimental projects in education.

A more recent message from the US President's Commission on Excellence in Education is contained in the title of its report "A Nation at Risk". It cites the idea of an analyst (Paul Copperman) that

> "Each generation of America has oustripped its parents in education, in literacy, and in economic attainment. For the first time in the history of our country, the educational skills of one generation will not surpass, will not equal, will not even approach, those of their parents."

They recommend many measures (divided into five groups) to attain excellence in education.

This year (Pravda, January 4, 1984) a major policy paper was presented in the USSR on "Basic reform directions of general and professional schools" initiated by the Central Committee of CPSU. The paper states that the grandoise tasks of the end of the century and at the beginning of the next will be solved by those who are sitting behind school desks today. Among many recommendations intended to improve the efficiency of education we can mention the task to

> "equip the students with the knowledge and habits to use modern computer technology, to secure wide applications of computers in the educational process, to build for this purpose special school and interschool cabinets."

The political and social pressures are often oriented to increase efficiency through cost reduction measures. There are indications that the introduction of computers in education does not always lead to real cost savings (Rushby 1978). The evaluation of computer-based education is not an easy process when one strives to assess the effectiveness and efficiency of acquiring specific skills (Venezky 1983).

The political and social influences have also global dimensions. These influences have led, for example, to the creation of the World Center for Microelectronics and Human Resources based in Paris. This was where one of the most important experiments took place: that of applying computers to education in a developing country -- in this case Dakar (Senegal). The idea behind this experiment was that the time had come when applying computers to various cultures may bring benefits to both donors and acceptors of technology. Numerous critiques and questionings of this idea exist (Dray and Menosky 1983).

ECONOMIC AND TECHNOLOGICAL INFLUENCES

The diffusion of computers into the learning process on all levels of the educational system seems to follow all the problems known from the introduction of computers to other areas; for example, into management organizations. In addition, however it has its own peculiar problems. So one can identify for example:

- both the market pull and technology push effects, the latter still being predominant;
- the problem that designers and manufacturers have in selecting between special custom-made, and the more universal mass-produced, equipment;
- the lag of software development behind the hardware availability. This is valid for high level simple languages (BASIC, COMAL, etc.) or for more sophisticated languages such as LOGO (with graphics) now implemented in truncated form even on microcomputers, but also for special educational programs for teaching several subjects (languages, mathematics, physics, etc.). Not only is the program's efficiency important (as viewed from the point of optimal use of hardware capabilties), but also pedagogical viewpoints should be taken into consideration if learning is to be efficient.

Previously the market-pull was not sufficient to attract enough resources for software development. The situation now seems to be changing. The Creative Strategies International in a recent report (IEEE Spectrum, November 1983, p.126) predicted that the US educational software industry would grow 48% annually between now and 1987. Predictions suggest that classroom computers may be a focus of software development in the future even if present software development represents only 15% of classroom computer use.

Teachers suggest that most of the small systems offered for education have been developed in computer laboratories without adequate input from pedagogs, so the solution is too technology-bound. This is also the equivalent of quite a common situation in other computer applications where the computer attracts the bigger share of attention and money, while future expansion and integration of the system are more often overlooked.

Obviously, there will be a growing specialization of systems from those for the elementary school environment where one should take into account the absence of the children's reading ability (a problem of interaction) to content-centered CBS for the university environment. The optimal representatives of appropriate systems will have to be developed on a multidisciplinary basis and to involve: technicians, teachers, educators, psychologists, and administrators.

EDUCATIONAL PRESSURES

Educational pressures seem to be the least significant, but they may well be the key to the appropriate diffusion of computer-based education. The educational potential of computers has not been fully identified, and much of the focus until now has been on the possible quantitative gains: higher cost-effectiveness of the educational process with computers, more effective use of time, etc. This focus may be the result of economic and technological forces in action.

Important qualitative impacts of computer-based systems can also be identified. Among the most frequently mentioned are:

-- The possibility to "tailor-make" instructional procedures in order to respond to individual learning types. Until now much of this has been achieved by using programmed instruction paradigms based on past responses of the student, but alternatives accommodating individual differences are somewhat rigid. One can expect fundamental improvement when results of artificial intelligence research are applied where knowledge representation, processing, and inference are studied. These results will help in modeling the thought process and the process of learning.

-- Computer-based education is adaptable to the individual student's speed of learning (self-paced learning systems).

-- CBE can provide a direct feedback on the state of the learning process which is important information for the teacher.

Many of these benefits are also challenged in scientific literature. There are prestigious studies indicating that computer use has no overall significant effect on student achievements. There seems to be no valid methodology of research delivering comparable and reproducible results. As a solution a model-based application of CBE systems is suggested (Valcke 1982). This model (theory) should give insight into the education and learning process and should be built by an interdisciplinary team of scientists, teachers, administrators, and policy-makers.

There is also an abundance of papers reporting surprising results which have been achieved on exposing young children to various kinds of computer systems. The main reason for these results is the excellent imagination some computer experiments develop in children. This helps them comprehend difficult issues with ease. How to use this natural "resource" children have for acquiring facts, "computer literacy", and to enhance the whole education process is not entirely known.

SOME POLICY RESPONSES

Education is always resonsible for the ability of the future society and is, therefore, part of overall policy supportng economic and social development. A fragmented overview of some policy responses of different countries (Hammond 1983) is outlined in the following paragraphs.

United States of America

In the USA pioneering efforts in computer applications have been developed and a clear vision of applying computers to education have been pursued. Numerous studies supported by the government (US Office of Education, National Science Foundation) and several foundations (Exxon, Sloan) have tried to make this vision a reality.

At the same time opposing views were voiced arguing that computers are expensive gadgets which do not increase the quality of education. What is more, rigidly programmed machines may lead to idiosyncracies and cause teachers to select only those problems which can be comfortably taught by computers.

There are excellent analytical studies depicting the real impact of computer based education at college level in the USA (Kulik, Kulik, Cohen 1980).

In 1983 it was estimated that the number of microcomputers in American schools was over 100,000, which could be taken as an indication that virtually every school in the USA had a microcomputer (in the US there are 83,334 public and 21,749 private schools, and 3,453 colleges). However the distribution of computers in schools is not uniform all over the country. In spite of this number of computers there is no overall policy of computer applications, though there are some measures taken to enhance the computerization of schools (for example, 25% tax write-off is available for equipment supplied to colleges).

The distribution of computers depends on individual states. For example, in Minnesota there is one computer for every 50 children. There are states where only 50% of the schools have computers. In some cities the schools are equipped by local microcomputer producers. The situation is different for university education, where some universities already require that a student owns a microcomputer and others are to follow soon. Some of these universities expect to interconnect microcomputers into networks (Bereiter 1983). However, in general, affluent children in the US find more home support for microcomputers than in many other countries.

Japan

Applying computers to education is a part of national strategy in Japan, denoted by the term "Information Society" (Masuda 1972). Part of this project was a Computer-Oriented Education in an Experimental School District (cost $266 million). This plan conceived of an experimental school district conducting computer-oriented education in pre-school, kindergarten, primary school, junior and senior high schools, university playing a central role. The plan includes rationalization of school office work, an individual education guidance system, computer-oriented education, and an educational science research center. The project planned to help solve problems concerning future computer-oriented education, measuring the educational effect of the intelligence network, planning a standard education system, and developing a new individual educational system. It was conceived as an educational experiment, permitting objective scientific data collection and analysis of differences between the computer-oriented, private instruction, problem-solving type of educational system and the contemporary group uniform education system.

In the early stages, a computer-aided instruction (CAI) system model classroom has been tested in primary schools under the direction Tsukuba University; training programs in computer operation and programming were begun in public commercial high schools. But Japanese children are already in contact with computers when they attend kindergartens, which they attend until they reach the age of five (in Japan there are 14,893 kindergartens). From five until twelve years of age they attend elementary schools (amounting to 24,945). This is followed by lower secondary schools (10,780) and then by upper secondary schools. Ninety percent of the population continue their education until the age of 18. In Japan the state-run schooling follows a national curriculum and private schools provide educaton to 7% of the population.

It is claimed that no other nation's children devote so much time to computers as Japanese children. However, some critical comments have pointed out that education in Japan has been too application oriented, not fostering creative, logical, and philosophical thinking. To remedy this is one of the tasks of the new, almost legendary, fifth generation computer project in Japan.

France

The French National Experiment in Educational Computing started in October 1970 but initially focused on secondary education. France is also following a national curriculum, which has the advantage of a coordinated approach with related education of teachers. One of the recent schemes assumes 10,000 computers in lycees. The standard of the future is eight computers and a printer in each classroom.

Britain

In Britain a sustained effort began in 1973 with a modest budget of £2 million and with the title National Development Programme in Computer-Assisted Learning. In 1981 a new scheme (£3 million) was started to persuade every secondary school to buy a microcomputer. This scheme seems to have been a success: in the first year 80% of state-run secondary schools bought a microcomputer (with a 50% subsidy from the government). In 1982 a similar scheme (estimated to cost £9 million) was focused on 27,000 primary schools.

Other West European Countries

There are schemes for model schools supported by local governments in the FRG.

Denmark developed its own computer and language (COMAL 80) for implementation into school systems.

Ireland donates an 80% subsidy to 834 secondary schools to acquire an Irish-built computer.

Australia and New Zealand

Similar subsidy schemes are in effect in these countries. In Australia there is 50% subsidy (up to the sum of $1,000).

In New Zealand a "computer" war even started among the manufacturers when foreign manufacturers wanted to eliminate domestic competition (the Poly microcomputer) by decreasing the prices. The New Zealand government responded by introducing a customs duty in Apple computers (NZ$880).

Soviet Union and Socialist Countries

Computers were introduced to schools very early on, starting at university level in the early 1950s (first generation computers). Later secondary schools also received computers, generally a minicomputer. At the same time the curriculum has been changed, accommodating several courses of programming and computer science on different levels. New specializations have also been introduced.

In the mid-1970s more elaborate schemes were worked out. To illustrate the point, we can describe the scheme approved by the Ministry of Higher Education of the USSR dated January 12, 1978 -- the so-called "Automated Teaching Systems". The scheme is based on two stages. The first (up to 1982) aims:

- to develop computer systems custom-made for schools;
- to start research and development into the psychological and didactic issues raised by the application of such systems;
- to work out a methodology for developing algorithmic and semantic structures of teaching courses and appropriate monitoring systems. Among the first are some aspects of physics, chemistry, mathematics, and programming languages;
- to develop languages for teaching, user control languages, and interactive (dialog) programming languages.

The second stage counts with interconnecting the individual functional systems into an integrated network.

ROLE OF INTERNATIONAL ORGANIZATIONS

International organizations are also active in exploring the challenge of computer applications to education. Among the most prestigious are the activities of UNESCO through the project "Joint Studies on Education".

Much interest was raised by the World Center for Microelectronics and Human Resources in Paris, with world renowned scientists on the staff (Seymour Papert, Nickolas Negroponte). In spite of the fact that the gentle and important ideas which led to its creation lost nothing of their topicality from recent developments, one has the impression that somehow the Center itself may have reached a point of "diminishing returns" due to local and some specific problems.

SOME THOUGHTS ON IIASA'S POTENTIAL ROLE

From a very preliminary scan of the issues connected with the penetration of computers into the educational process one could conclude that problems are:

- interdisciplinary;
- with a strong social and cultural context; and because of this it seems to be a potential topic for East-West joint studies to be appropriately performed at IIASA;
- embedded in modern technology;
- topical and part of economic and social strategies of national development;
- related to national and regional policies.

One could say that the picture is still unclear at best, with many experiments running, but relatively few producing usable results for consistent policy, especially when longer term perspectives are required.

On the other hand, the volatile and fast-changing situation only extends the spectrum of differing views on the same problem. A recent US National Science Foundation Study "Educating America for the 21st Century" puts education among the national goals and adds that "Almost any statement made today will, therefore, be obsolete in a few years, if not months". But there are also dissenting views of eminent specialists. A study carried out for the Carnegie Endowment for the Advancement of Teaching "High School, A Report on Secondary Education in America" led by E.L. Boyer, former US Commissioner of Education, for example, states that: "Technology revolutions have failed to touch the schools largely because purchases frequently have preceded planning".

These illustrations also show where the present focus in this field lies. The longer term impact studies hardly left the speculative stage.

From the above one can state for further discussion some preliminary goals for an IIASA project:

(1) Prepare interactively with collaborating institutions a state-of-the-art report on computer based education, scanning not only the issues but also the active projects in individual countries and identifying the main actors;

(2) Identify a framework for a study on the long-term implications of computers in education. For this some supporting "sub-studies" may be useful, for example on the development of functional properties of future systems from an educational point of view, on the potential of artificial intelligence research, social and psychological implications, etc.

(3) Policy issues connected with computer-based education with an assessment of past policies and some illustrative case studies.

(4) Modeling efforts made elsewhere and their potential for policy advice.

From present knowledge it seems reasonable to work sequentially on projects 1-4 and eventually define more precisely each step.

It seems futile to elaborate more on this subject now when the interest of potential collaborating institutions and IIASA NMOs are only very superficially known. It is certain that more involvement with them would bring much-needed input and guidance for more detailed planning steps. This could be accomplished at the forthcoming meeting on May 3-4, 1984 in Albena, near Varna, in Bulgaria.

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