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INTRODUCTION

The process of education is as old as the human race. All through human 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 which may not fulfill this responsibility. These signals are coming even from countries which devote considerable resources to education.

Because of its importance, education is an inherent part of development strategies in most countries, industrially developed or developing. Appropriate institutions (ministries) are designing policies aiming to influence the behavior of individual actors in education processes in the desired direction. The efficiency of individual measures taken in achieving the selected objectives is difficult to predict because the educational process at large is a complex social phenomenon where several disciplines are involved. The resulting semantic and methodological differences make it sometimes difficult to achieve a fruitful communication through interdisciplinary barriers. Because cultural factors are also involved cross-national, cross-cultural and comparative studies might bring a specific insight into the process. This by no means proves that one could easily transfer experience from one country to another.

SOURCES OF INCREASED INTEREST IN EDUCATION

One long-term source of growing interest in modern education is created by even faster scientific and technological development. With an increased amount of information circulating in the national economy and in modern products as proponents of "information society" point out the knowledge to handle the information by computers is considered particularly important.

More generally speaking the importance of an educated labor force has been known for centuries, but more exact explorations made by Denison (1962) concluded for the USA using methods which became known as "growth accounting" that:

> Increased education is not only one of the largest sources of past and prospective economic growth. It also is among the elements most subject to conscious social decision.

Five years later the study was repeated for Europe and reached a similar conclusion (Denison 1967):

> The increase in education has been a principal source of growth in the United States and it is important to know that European countries have not been achieving more rapid growth by raising the education of the la-

bor force more rapidly.

More recently Drs. Millendorfer and Hussain (1985) tried to correlate the labor force qualification by means of neoclassical production function and as they claim (see Figure 1) received a reasonable correlation between the economic growth (in GDP/capita) and qualification of the labor index (including developing countries), even if we neglect the time lag between the causal factors. Recent economic decline only increased this challenge. I am inclined to call these a "pull" factors.

There are valid even more for modern technologies. After serious studies Soete and Freeman (1984) expressed important views that education and training in a high technology environment are sometimes a more important ("intangible") investment than the physical capital investment and should not be considered as consumption or current cost.

Out of curiosity I cannot avoid a quote from the early work of K. Marx made around 1857 when he wrote referring to the increase of the free time of the society: "The savings of work-time is equal to increase in free-time, i.e. time for full development of an individual, who acts back on the productivity of labor as the greatest productive force. He can be considered from the point of view of immediate production process as production of *capital fixe;* this capital is the man himself." (Translation and italics are mine).

Among "push" factors one can include influences of the fact that resources devoted to education are large and in some national institutions managing public funds are predominant. Higher expenses then for general education are recorded for vocational training. Authorities responsible for education often strive to decrease those resources and yet to meet the increasing requirements. This is another factor pushing innovation into the education process.

Educational policies have to deal with intricate economic, political, managerial, and technical problems where the introduction of computers is only one issue among many others. To illustrate it I would like to mention a most recent interesting study of educational policies of seven countries (Hough, J.R., 1984) where no one explicitly mentions the introduction of computers.

SOME POLICY RESPONSES

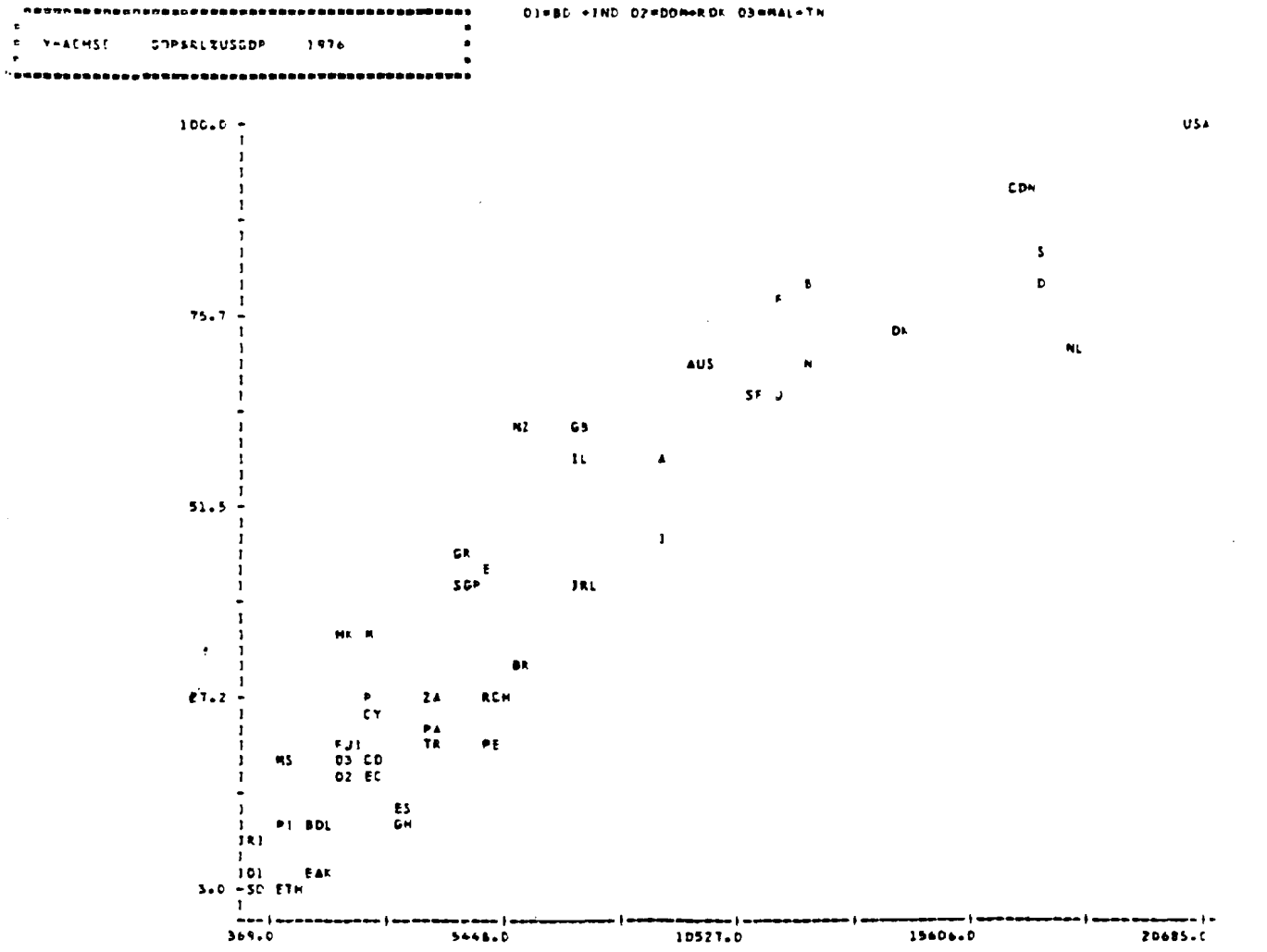
A fragmented overview of some policy responses of different countries is outlined in the following paragraphs.

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 idiosyncrasies and cause teachers to select only those problems which can be comfortably taught by computers.

In 1984 it was estimated that the number of microcomputers in American schools was over 630,000 which could be taken as an indication that virtually every school in the USA had a microcomputer (in the USA there are 83,334 public and 21,749 private schools, and 3,453 colleges). A more recent estimate (Clark 1985)



Diagr.1: Qualification of labour index against real GDP per capita

Figure 1. (Source: Millendorfer and Hussain, 1985)

showed that these computers were allocated to approximately 75 percent of school buildings. 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, a 25 percent tax write-off is available for equipment supplied to colleges).

The distribution of computers depends on individual states as the state is responsible for education. For example, in Minnesota there was one computer for every 50 children (in 1983). There are states where only 50 percent of the schools have computers. On the other hand, for example, in California because of the possibility for tax deductions, producers donated 13,000 microcomputers to schools (in 1983). 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 USA find more home support for microcomputers than in many other countries.

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

CANADA

As education is the responsibility of provincial governments the policy may differ from province to province. In 1984 an interesting experiment was started in Manitoba Province. Several departments jointly established the Manitoba Educational Technology Program (ETP). This program has three aims (Prokopanko 1985):

- to ensure access to new information technology,
- to support curriculum and professional development,
- to stimulate the development of courseware for the use and needs of the national and international markets.

An Educational Technology Resource Center was established to coordinate:

- centralized hardware purchasing,
- responsibility for promotional courseware licensing,
- network distribution for Manitoba schools.

To fulfill its functions the center is equipped with the most up to date hardware, courseware, and support staff. It also acts as a preview center.

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 conducting computer-oriented education in preschool, 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 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 of 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 12 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 education to 7 percent of the population.

It is claimed that no other nation's children devote so much time to computers as Japanese children. However, it is also claimed that, for example, even if all Upper Secondary Schools in Japan have computers, only 2 percent of these schools have more than 20 computers, e.g. in every classroom (Shiba 1985). 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. Also an ad hoc committee has been established, under the supervision of the Prime Minister, with the task to draw a plan for basic changes in the educational system. First findings indicate a trend into individualization, internationalization, elimination of "gakureki shakai", and a common test scheme, etc. (Japan Times, April 25 1985, p. 3).

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.

FEDERAL REPUBLIC OF GERMANY

As education is not a federal issue its policy is handled by individual states, which allows for regional differences. It is reported that Bavaria has gone furthest toward computer literacy and compulsory informatics in the lower Secondary level. All gymnasiums with mathematical orientation are offering 28 hours of informatics in the 10th class within mathematics. Special programs for teacher education have been initiated for elementary schools (Grund and Hauptschulen), gymnasiums (5-13th school year) and vocational schools. There are (in Bavaria, for example) 3-4 microcomputers in one classroom.

Computerization is relatively slowly finding a foothold in educational policy for several reasons – one reason is that the complicated procedures, generated by the complicated structure, only slowly muddle through the necessary steps (teacher training, curriculum development, etc.). (Gorny 1983).

UNITED KINGDOM

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

A consistent program: "Microelectronic Education Programme 1981-85" (Aston 1985) deals with two areas:

- using computers as a learning and teaching aid for individual children, groups, or whole classes;
- introducing the topics of information technology into the curriculum (new subjects or existing ones).

Secondary schools are the main targets of this programme.

SWITZERLAND

In this confederation decisions on education lies in the hands of 26 sovereign states. Here a coherent policy started in 1975 when Training Center for Swiss Teachers in secondary education set up an informatics coordination group:

- to initiate the introduction of informatics to secondary schools;
- to organize training courses;
- to serve as an information "clearinghouse".

SWEDEN

In Sweden in 1974 the Swedish Board of Education started a project called DIS (Computers in Schools) where three distinct functions were followed:

- general knowledge (what every citizen should know) about computers;
- the computer as a tool for different subjects in secondary schools;
- what hardware and software should be used.

DENMARK

In September 1983 a Committee was set up to work with Informatics in Folkeskole (primary and lower secondary education). Its task was to (Jensen 1985):

- propose aims for teaching informatics
- write guidelines for curriculum and teaching informatics
- propose the integration of informatics elements into other subjects.

As a result a new subject "Dataleare" was introduced in August 1984. The introduction of computers into schools is backed up by interesting research initiatives.

FINLAND

The Government of Finland established a National Data Delegation as an advisory and liaison body for issues regarding information technology. In the scope of this activity the Delegation recommended:

- the introduction of courses for the 9-12 age groups to familiarize them with the use of computers;
- measures to increase the support for information technology in general.

These activities are part of the overall reform of the educational system, which strives, among others, to integrate secondary and vocational education (Raasio 1985).

NORWAY

The Norwegian Government launched an action program which comprises:

- teacher education;
- introduction of experimental technology in selected schools;
- development and testing of software;
- introduction of computer technology in vocational education.

These activities cover the most important issues regarding the introduction of computers into schools (Wibe 1985).

AUSTRIA

Computers in Austria are used predominately in post-compulsory education. At this stage there are three main types of schools which give access to university, and also post-compulsory vocational schools which do not give access to university. The curricula, which is edited by the Ministry of Education and Arts, states that "the aim of the subject is to promote knowledge and the ability to solve different problems with the aid of computers." Computer education for teachers was also instituted. There are also projects, (computer camps) organized by a professional society (The Austrian Computer Society) that strive to teach a more creative use of the computer, beyond numerics, during vacation periods. In the past year much has been done, for example, microcomputers have been given to gymnasiums (3-8 according to size).

SOVIET UNION

Computers were introduced to schools in the USSR very early on, starting at the university level in the early 1950s (first generation computers). Later secondary schools also received computers, generally a microcomputer. At the same time the curriculum was 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 (dialogue) programming languages.

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

Last 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 the Communist Party of the Soviet Union (CPSU). The paper states that the grandiose tasks of the end of the century and at the beginning of the next one will be solved by those who are sitting behind school desks today. Among many recommendations intended to improve the efficiency of education one 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.

On March 28 of this year, the Politbureau of the CPSU and the government approved a decree which proposes to introduce, into all secondary schools, a new subject "Basis of informatics and computer technology," also to use computers extensively for teaching other subjects, and to start courses for training teachers (from September 1985).

Computers should also be used in out-of-school environments, in technical creative activity, youth clubs, centers of culture, etc. It was stressed that the intensive mastering of computers by the younger generation should be an important factor in speeding up scientific and technical progress.

To help this program to materialize, the results from many projects which are now underway in the whole Soviet Union will be used.

OTHER SOCIALIST COUNTRIES

In the other socialist countries the introduction of computers also started in the early 1950s at the university level. Later, secondary schools were equipped with microcomputers. Now with the wide availability of the 8-bit micro-processor, microcomputers are being widely applied to secondary schools. A strong interest is also devoted to vocational training which is being coordinated with secondary school education. In Bulgaria the activities are coordinated by government bodies like the State Committee for Science and Technology, the Academy of Sciences, the Ministry of Education, and also Youth Organizations (for more details, see Vasko 1985). Also important are the activities of professional organizations which, for example, in Czechoslovakia, created 39 regional centers to spread knowledge on the use of computers to the widest audience. Similar activities are being performed in Hungary by the Neumann Janos Society. In Poland a government scheme has been adopted to apply computers in education in the years 1986-90 (Petshak 1985).

TENTATIVE PRELIMINARY CONCLUSIONS

In my paper I could not give an exhaustive report on the state of the introduction of computers into education in individual countries. I rather presented a part of the situation. Nevertheless, some preliminary conclusions can be attempted.

1) As with the general application of computers to the other softer applications, for example, management we could detect several stages of computer diffusions (Nolan 1973; Nolan 1975).

Stage I	initiation	(acquisition)
Stage II	contagion	(intensive system development)
Stage III	control	(proliferation of control measures)
Stage IV	integration	(user/service orientation)

(Similar stages can be detected in innovation diffusion in general (Brown 1981).

Different countries can be in different situations, but also within a country some institutions might be in different stages. For example, in several countries computerization at the university level is in a higher stage than that in the secondary or elementary level. Yet it is important to analyze and identify the present situation system-wise before making any policies for the future. So much for the dynamics of the process.

2) One can detect several directions as far as approaches are concerned. Perhaps the most distinct ones are:

- the computer as a tool and/or aid in teaching and learning;
- informatics as a scientific branch, and the computer as one of its implementations; development of corresponding curricula;

There are also, of course, mixed strategies.

3) On the organizational level strategies for computerization are dependent on the structure of the national educational system and its management. However, the causal relations seem to be fuzzy. They run from fragmented policies (Netherlands, Rushby 1981), to more coherent ones (FRG, UK), to centralized ones (France, USSR, Poland, regions of the FRG, Canada, etc.).

4) Components of the policy are among others:

- Overall educational policy strategy, centrally defined, (Japan, France, USSR, etc.):
  - including – standardized hardware, software, courseware;
  - teachers education;
  - curriculum;
  - guidelines;
- Financial support:
  - special funds, grants, etc. (UK, France, USSR, etc.);
  - tax allowances (USA);

- subsidies (Austria, UK, USA, Norway, etc.);

– Organizational response:
  - the creation of specialized institutions (Canada, Europe-ATEE);
  - funding of R&D in existing organizations (Finland);

– Societal measures:
  - involvement of parents (Austria, Bulgaria);
  - use of leisure-time activity (Austria, USSR);

Useful activities can emerge from new international organizations such as ATEE (Association for Teacher Education in Europe). It prepared a syllabus and courses for teachers, in different areas, on Information Technology and Society, Problem Solving by Algorithmic Means, etc. The syllabus is being implemented, experimentally, in the FRG, Denmark, and the Netherlands (Gorny 1985).

Many new policy measures have been introduced recently. Certainly a most interesting topic for further research could be the efficiency and effectiveness of these measures, as well as the most efficient forms of their implementation. All of these measures have the ability to guide and enhance the known positive impacts of computer use in education.

Education systems seem to be particularly resilient to innovations. Although the computer is very specific, its impact, in spite of wide studies, is not well known. Recently, it has been pointed out that the impact of television is only now becoming apparent after 30 years of use. I would subscribe to the claim of the Armenian Socialist Republic's Minister of Education who said:

> Miracles are not taking place. Especially in education. It takes hard work to teach pupils useful knowledge, but it is clear that the computer can help.

(Achumyan 1984).

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