Knowledge and communication in the computer age

Proceedings from Nov 2-3, 1987 Linköping, Sweden

Edited by Claire Forchheimer
PROCEEDINGS
from
KNOWLEDGE AND COMMUNICATION
IN THE
COMPUTER AGE

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Knowledge and Communication in the Computer Age

Introduction

Concepts like “the information society”, “the computer age” or “the microelectronic revolution” might be looked upon as catchwords successfully coined by more or less visible interest groups, in order to promote and symbolize their own goals or strategies.

However, the successful marketing of these words reflects the undeniable fact that noteworthy and considerable changes in the condition of human beings in society are taking place due to the new microelectronics.

It seems necessary to study and observe these changing conditions, but the starting points for such a study are as many as the number of symposia arranged in the field. Without claiming that the starting point of this particular symposium has any superiority to any other it could nevertheless be presented in the following way.

The impacts of microelectronics may be regarded as problematic and sometimes controversial. The impacts occur within most sectors e.g., education, health care, judicial systems, working life, family life and not least, in the mere context of the human being herself. Human knowledge and human communication are affected and values, responsibilities, judgement and common sense may be in jeopardy.

Sectorial research programs and projects are looking at existing and expected problems, as well as possibilities, within some of these sectors. Much more would, however, be gained if some crucial themes were given more attention and some starting points were more explicitly defined. The reasons for this are that:

a) most of the problems appearing within the different sectors have many more roots in common than are usually observed. They concern to a great extent the concepts of human knowledge and communication.

b) historical and cultural perspectives are rarely used within sectorial studies. The exclusive connections to a “here and now” are striking. This circumstance is neither satisfactory nor adapted to the true purpose of the studies.

c) the truly humanistic starting point is often vague. Sometimes we are justified in asking whether it is a question of adapting man to technology rather than the other way round. The fact that human sciences like psychology are used within various computer sciences is not seldom misinterpreted as the presence of a humanistic perspective.

Study and systematic reflection on the role of knowledge and communication in the computer age, done from a humanistic standpoint and with the wider perspective that history and culture can provide, should be the natural task and responsibility of universities with their tradition of basic research and long-range work. Everybody will gain in the long run if research and educational efforts within such fields could be strengthened.

The organizers of the symposium are very honoured and grateful that so many distinguished scientists and scholars have accepted our invitation to contribute to this symposium. We are convinced that much light will be shed on various parts of the problems of this symposium. We would also like to thank the chairpersons and the discussants for their willingness to be at our disposal. Finally, we are very happy that there has been so much interest in this symposium and we very heartily welcome the audience. It is our sincere hope that this symposium will contribute to a better understanding of some of the problems revealed by its title.

Ingemar Lind
Dean, Institute of Tema Research
The Subjective Computer

Understanding the psychological impact of the computer demands a way of thinking that takes the emphasis off product - no matter how extraordinary - and puts it on process. To play with MacLulian: we need to focus on the evocative power of the medium rather than the messages that we create by using it. And so, I begin with a distinction between the instrumental computer, all the things the computer does for us - word-processing, spreadsheets, graphics - and the subjective computer. This second is not what the computer does for us, but what it does to us, what it does to our view of ourselves, how we experience our strengths, weaknesses, styles of thought, how we sense our areas of creativity and experience our blocks.

I first found it necessary to make this distinction when in 1976, I began to interview the first generation of personal computer owners in the United States. At that time, computers had just appeared as objects that could find their way into people's homes and a small community of users had done just that. Known to most as computer "hobbyists", they had a clear public discourse which characterized what was most important about the new machines. It was a discourse of instrumental use. In their magazines and mailings, that first generation of hobbyists said that the computers in everyday life were important and exciting because of what they could do: dim the lights, control the thermostat, cross index the recipes.

But when I interviewed these same computer owners, something very different emerged. Hobbyists typically began by talking about instrumental uses as a way to justify their purchase of a machine. But as the conversation continued, they described a point at which their sense of engagement with the technology had undergone a radical shift. It was a shift to the subjective. They spoke of computers as "cognitive play" and "puzzle solving" and about "the beauty of understanding a system at many levels of complexity". They described what they did with their computers with phrases such as "building another room in mind". Once they actually had a computer in their home, the most interesting thing about it became the computer itself, not for what it could do, but for how it made them feel. For example, hobbyists spoke of the satisfaction of seeing themselves as people who could do a "scientific-type thing", the satisfaction of working within the "safe world of the computer" where they had "control of the whole process - not like things at work where you only get to do bits and pieces", and the reassurance that with the computer, "unlike the rest of life", "things didn't change unless you wanted them to". In sum, people bought an instrumental computer, but got involved with a intimate machine the computer as an element in a self-expressive and self-reflective process.

Of course, a lot of things have changed since the late 1970s. Today, the computers that we bring into our homes are extremely powerful. They are designed to be black boxes that allow unsophisticated users to run sophisticated software. They are not easy to tinker with. So not surprisingly, the instrumental discourse about computers is stronger than ever. But how much has really changed? Even in this day of "turnkey" computers and practical software, is there still the subjective story behind the instrumental machine? My current research on children and adults using computers in education, recreation, and business, shows that there is and that its importance is greater than ever. The subjective computer is behind the technology's impact on children as they grow up and behind its compelling quality for adults as well as children. Computer "holding power" depends on the machine's potential for radical personalization: different people make the computer their own in their own way.

Developmental Impacts

Computers enter the lives of children in three stages. The first stage is metaphysical. Children between three and eight-years-old ask themselves such questions as: "What is motion? What is number?" "What is alive and not alive?" On this last question, the computer provokes children to do some new and hard thinking. For the child's eye, the computer, reactive and interactive, is an object on the boundary of life. When in the 1920s, the Swiss psychologist Jean Piaget investigated the question of what children think is alive in the world of "traditional", that is, non-computational objects, he discovered that children sort the alive from the not alive by gradually refining their ideas about motion. For the youngest children, everything that moves can be alive. But as children get older, the quality of aliveness is reserved for objects that can get from A to B without an outside push or pull. Finally, this idea of motion from within is refined to an idea of "life motion", breathing and metabolism.

But children do not find this way of approaching the question comfortable when it comes to computational objects. For example, electronic toys and games which speak, do math problems, or play tic tac toe, do not physically move, but seem to the child to be more alive than many things that really are alive. Faced with these objects, children use new criteria for aliveness. These are psychological: do the machines have intentions, consciousness, feelings? and even, do they cheat? This shift from a physical to a psychological discourse for talking about aliveness is one
important way that the computer enters into psychological development.

At around the age of eight, children's preoccupations in the presence of computers turn from philosophizing to winning. Children want to beat the computer. They want to be its master. At around twelve or thirteen, this mastery stage ends and the computer provokes a return to reflection. But this time, it is not reflection about the nature of the computer, but about the self. In the first, metaphysical stage the child ponders where the computer fits in the world of what is alive and not alive. In this later stage, the computer is used as a way to think about one's own identity.

Other powerful technologies enter the developmental process as children move from metaphysics through mastery and identity stages. The computer is special because of its betwixt and between nature; as a mind that is not quite a mind it provokes questions about mind itself. And it is special because as a medium to master it can so easily become personalized and projective. I now turn to another set of issues that make the computer special in terms of its psychological impact. Among technologies, computers are unusually compelling. Their holding power has many roots. Here I isolate three, concentrating on the machine's ability to be different things for different people.

Computer Holding Power

The mirror in the machine

For some people, what is most powerful about the computer is that it can serve as a kind of psychological mirror. Deborah, a young woman of thirteen described the holding power of the computer for her by saying that "when you program a computer you put a little piece of your mind into the computer's mind and you come to see yourself differently". The externalization of mind in program is a heady experience; Deborah saw herself and learned about herself in the mirror of the machine.

Behind the power of this mirror relationship is the sense of a mind-to-mind connection with the computer. Although Deborah was talking about her experience programming, this dynamic is not limited to programming. Consider what many of us think of as a banal use of computer power, the video game. The master game player does not respond to discrete game cues. Rather, success comes from "psyching out" the rules, discovering the program behind the behavior of the objects on the screen. In other words, the holding power of a video game is built on the fantasy of achieving a meeting of the minds with the program or rather, with the programmer behind the game.

Perfectionism

A second root of computer holding power involves another kind of mirroring. It touches on my case. I am something of a perfectionist. And this perfectionism comes out in my own writing. Before I wrote on computer word processors I would type out my papers, blacken this first draft with corrections, and give it to my secretary to retype. And then I would blacken it once again. Finally, after many iterations, there would be a "final draft" whose small errors would be corrected with white out and pencil.

Now, with an effectively unlimited amount of computer power at my disposal, things take a different form. I find myself asking myself many questions such as: What font will best express my thought in this paragraph? What combination of roman and italicized print, what size type, what configuration on the page? I am not alone. Over the past several years, I have watched my academic colleagues in the humanities become involved with word processing and have seen a group of finely trained intellectual professionals become dedicated graphic designers. Their behavior and mine illustrates a second root of computer holding power: the machine offers the promise of perfection. This is the promise that if you do it right, it will do it right and right away. In this psychological environment, a typographical error is like a Scarlet A, or as one of my colleagues said, "a sign that you are such a lazy writer that you couldn't take the one or two seconds to make a correction". The computer promises that it can make your product, your extension of self, "perfect". Again, like the promise of mirroring, this is heady stuff. And for some people, this promise is what is most seductive about the machine.

Personal appropriation

Technologies other than the computer - the motorbike, the car, the stereo - each have their holding power, each have their special ways of mobilizing powerful feelings. Different technologies make different people different kinds of offers they cannot refuse. What is special about the computer is the range of different kinds offers it makes to different kinds of people. This is a third root of computer holding power: the enormous opportunity for a personal appropriation of the machine. Different people make the computer their own in their own way.

Let me try to capture this diversity with an analogy. I have gone to school in two cultures: the United States and France. In France, I was
tormented by a class for foreigners called "French Composition Class" where we were taught to write like good French men and women. There was a format; Every composition had to be in three parts and each of the three parts had to have three parts. And there had to be an outline. Our assignments were to write compositions. We had one week to submit the outline, and two more weeks to write the final draft.

But I cannot write with an outline. I need to let my association build. I take my ideas and lay them out, I move them around, and the patterns emerge. It is a process more like tinkering than planning. I "grow" my papers. I do not fill in their outlines. How did I handle the French composition class? I wrote the composition my way. I began by writing my ideas on small pieces of paper, spreading them out, moving them around, associating new ideas to the once that I had, "sculpting" my final composition. Only then, paper complete, did I write my outline. Of course, I had to do all of this in the first week. Then I turned in my outline, put my completed composition in my desk drawer, and explored Paris for the next two weeks while the "good students" were doing it "right".

I was able to use this technique to succeed in composition class because I was highly motivated and have a capacity for quick work. But I was going through an educational system that was designed to keep people like me, people with my relationship with words, out of the culture of writing. My strategy had a cost. I developed a sense of myself as not a good writer because my kind of writing was "cheating". That is certainly how my teacher would have seen it.

The analogy with the computer is direct. For some people what is exciting about working with computers is that you work within a rule-driven system that you can master in a top-down, divide-and-conquer way. These "planners" tend to talk of computer use in terms of the imposition of their will over the machine. Indeed, what they like best is the precision of thought and the sense of domination and premeditated control that the computer allows them. Others use computational media much more in the way that I relate to writing. Theirs is less a style of planning than of negotiation. It is more associative and interactive. They try one thing, then another, stop back, and reconsider. The process looks more like a conversation than a monologue.

These two styles of mastery, these two ways of making the computer one's own do not determine the level or quality of the final product. A program written by a "tinkerer" can end up just as structured as one written by a planner. My associative style results in my writing books and papers that tend to be divided into three parts with each of the parts further divided into three parts. A style of mastery determines process not product.

Planning versus tinkering is only one dimension in the highly personalized styles of mastery the computer allows. There are others. For example, risk versus reassurance. An architect who uses a computer assisted design program talked about the pleasures of using a system where there was nothing more to the rules than what he could see and control. But other people, indeed his own colleagues using the same system talked not about reassurance but about risk. For them, the best thing about the design system was the excitement that came from its complexity. They liked it because things could get so complicated that they were almost out of control before you needed to face the challenge of pulling them back.

Hackers, the virtuoso programmers who work on some of the largest and most advanced computer systems in the world, often talk about the pleasure of computing as the pleasure of being on the edge between "winning and losing", of "walking the edge of a cliff", or feeling "like the magician before he pulls the rabbit out of the hat". The people who experience risk and the people who experience reassurance are all using the computer to play with issues of control, but they are doing it in very different ways.

Another way to characterize styles of computer mastery is to think of transparency versus opacity. For some people, what is wonderful about the computer is that in principle, you can trace your way back from any "high level" statement in a programming language (such as a command in a word processing system) to the bits and bytes, to the on/off switches, and ultimately to the electrons that lie beneath it all.

For others, what is most exciting an awesome from an altogether different direction, not from the potential transparency of the computer but from its opacity. It is possible to deal with this highly complex machine at a level of abstraction in which you can ignore what is going on inside. You can get involved with computational ideas, with philosophy, with artificial intelligence, without understanding how the computer "works" in any simple sense. You can treat the machine as a black box, closed and complete.

The fact that people have such differences in their styles of mastery suggests the metaphor of computer as Rorschach. As with the psychologist's Rorschach inkblots where what you see in the dots speaks to who you are as a person (in particular to your style of coping, adaptation, and defense), what you make of the
computer speaks to who you are as an individual personality. The computer is a projective screen for other concerns.

Let me make my point about styles of mastery in a somewhat different way. We have all been a part of heated conversations between those who argue the superiority of the Apple Macintosh computer and those who argue the superiority of the IBM PC. The next time you are party to one, use this perspective to achieve some distance. Think of the computer as Rorschach, as projective screen, and of the different roots of computer holding power. Listen with the "third ear", the kind of listening that tries to be attentive to underlying meanings and relationships. And try to understand that when people are fighting about the IBM versus the Macintosh, they are really trying to defend their cognitive styles.

Implications for Action

What are the implications of this perspective that sees the computer as an expressive medium that people will want to and will make their own in their own way? And that sees this projective quality as an enduring element of the computational medium, not as a transient phenomenon that will disappear as soon as we get the technology "right".

The implications extend to people working in many different domains of the computer culture. First, there are implications for education. Too often, computer literacy classes communicate the idea that there is one correct way to "do the computer". And that way tends to be the "planner's style". There is little appreciation of the machine as an expressive medium or for the existence of personal styles. There is a tendency for young people to get their wrists slapped when they begin the experimentation that characterizes the associative style of computer use. The net effect of their computer classes is to alienate them from the computer culture. And unfortunately, with the computer, you often get only one chance. Students decide that they are not "good at the computer" in much the same way that students of an earlier generation decided that they were not "good at science". In both cases, the labelling of self in terms of aptitudes and inaptitudes closes doors that are hard to open again.

Second, an appreciation of styles of mastery has implications for the world of work. For example, office automation systems often take a single kind of "user friendly" as what will be friendly to everyone. But productivity with computation, like productivity in writing, increases with the amount of personal appropriation, with room for developing an authentic style. In the case of the office as in the case of education, when this is not possible, people become fearful. And of course, in today's work environments, to be afraid of computers is to be at risk. Even if one finds a job, there may be a crippling sense of dependency and of being left behind.

Finally, there are implications for computer manufacturers. I alluded to debates between users of the IBM and Macintosh. But within the industry too, these debates tend to be waged in terms of the instrumental or utilitarian. For example, arguing that the Macintosh is a good system because it is so "easy". Arguing that the Macintosh is a good system because it is the computer for the 'rest of us' tends to imply that it is for the rest of us who do not want to be bothered with technical things.

But my research shows that when the Macintosh is experienced as good, it is experienced as good because for some people it feels like a thinking environment that "fits". And that for others, and for very different reasons, the IBM feels like a thinking environment that "fits". The point is not who is right, but to learn more about what kinds of people are creative in what kinds of expressive environments. This point would seem obvious if I were talking about paints. Who would argue that artists who choose oils were using the wrong one? But what we so easily accept for other expressive media we deny for the computer. Talk about the best system, the most efficient system, the most easy to use system, misses the crucial sociological and psychological point. People get comfortable and become creative with an expressive medium because of the pleasures and holding power of the material. What was true of the first generation of computer hobbyists is true of the growing and far more diverse computer culture of today. People may buy the instrumental machine but they become involved and stay involved with the subjective computer because it is a way of being involved not only with their task but with themselves.
Children, Computers and Schools

Myths and Limits

Jacques Hebenstreit

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Abstract

In the late forties, when the first computers were built, nobody thought that these machines had any future outside a few big military laboratories who had the money to buy them and the competence to use them.

Technological progress has brought prices down, performance up and has simplified the use to a level which leads today companies to advertise "personal computers" or "home computers" or "domestic computers" with the hope of selling millions of them.

The first tentative to use computers in education go back to the early sixties, but the theme "children and computers" did not really start or become fashionable before the advent of the microcomputer.

Starting in the late seventies an increasingly optimistic wave started flowing: "Children like computers", "Computers amplify the child's intelligence", "Give a child a computer and he will re-invent the world", etc. These slogans were not innocent as those who promoted them had almost always something to sell whether a piece of hardware, a piece of software or a "miracle language".

The net result is that because of these commercial interests research on the theme "children and computers" has been most of the time devoted to "proving" the "advantages" of use of commercial products (which, by definition, have no drawbacks) instead of focusing on fundamental physiological research.

Informatics in the eighties

The history of technology shows with evidence that the form and initial use of a new product is strongly conditioned by the past (the first cars looked like horse carriages and the electric engine first designed to replace steam engines had to wait 50 years before finding its place in vacuum cleaners, washing machines, typewriters and electric shavers).

This general statement is of course true for computers. Since the beginning and up to a few years ago, a company could not afford to buy a computer because of its price except if the machine was to replace a large quantity of manpower which means that the main use of computers was the replacement of people by computers for large application in big companies (printing payrolls, management of orders and invoices, etc) exactly along the line of the first industrial revolution.

To speak of children and computers at that time would have been pure nonsense.

However, for the last 10 years or so, because of the massive decrease of the price of computers due to advent of the microprocessor, the whole philosophy of use of computers has changed drastically. In big companies, analysts are studying today the content of the job of each person from the worker up to the chairman of the board to find out which part or parts of each job can be automated and each person receives a microcomputer or a terminal to assist him by automating such or such a part of his job either to spare time or to allow him to better or to do more in his work.

We are entering the era of computer assisted activities (Computer Aided Design, Computer Aided Manufacturing, Computer Aided Drafting, Computer Aided Management, Computer Aided Medical Diagnosis, Computer Aided Office, etc) which is also called CAX where X stands for any activity.

Ten years ago, computers were used to replace people along the line of taylorism where hundreds of people did punch cards to feed the machine. Today, we are entering a period where computers are becoming personal tools, sitting on the desk of each professional and allowing him not only to save time by asking the computer to take over all the tedious parts of his task, but also allowing him also to do much more and attack more difficult and more complex problems than he could before.

The fast increase in the number of computers used in all professions and at all levels of activities (the production of microcomputers for 1986 is around 9 million units and is going to increase sharply this year) has already a number of consequences.

The first consequence is a lack of professionalism in informatics which are, by definition, those who design and manufacture the hardware and the software which the users of computers will buy and use.

The second consequence is, at least in developed countries, a kind of growing awareness in public opinion of the key role of informatics for the society of tomorrow which has been initiated and strongly supported by all mass media and official speeches. This in turn has led governments in almost all developed countries to proposals or decisions to introduce computers in the whole educational system from kindergarten to university.

Moreover, because of the decreasing price of computers and the way manufacturers and computershops are advertising their products, an increasing number of parents are feeling more and more guilty if they do not buy a computer to their children.

Despite some dissimilarities in scope and methods, all proposals or projects to introduce computers in education, can all be classified in what I shall call three scenarios.

First scenario: computer awareness/computer literacy

In that first scenario, children should be taught about computers, how they work, how they are used, their social impact, the way they
change jobs and, last but not least, children should be taught programming (the British Microelectronics in Education Project included even microelectronics) and all this before the age of 12 or 15.

This scenario looks like a kind of emergency decision to face the massive arrival of micro-computers. It is oversimplified because it does not make much sense to teach the state of the art of informatics to children who will be adults in 10 years from now, given that nobody is able to predict what informatics will look like in 10 years from now (who was able 10 years ago to predict 500 $ computers, computer networks, integrated service networks, electronic mail, extensive databases, multiple windows, pull-down menus, etc).

In my opinion, this scenario is not only useless, it is harmful because the time spent on these topics could be better used to teach much more fundamental subjects like mathematics, sciences or oral and written expression which are more than ever necessary to turn out the highly adaptive people needed by our modern and fast changing society.

In some places, it is suggested to go even further and to teach programming and/or algorithms.

The teaching of programming

Some people argue that it is necessary to be able to program a computer with two kinds of arguments:

a) if you do not know a programming language you will be like an invalid in a computerized society,

b) if you know a programming language you will be able to find a well paid job.

These two arguments were valid years ago but are not true any more:

a) citizens of the computerized society will not write programs, they will use computers in the CAX mode with prewritten cheap software because it will be sold by the hundred thousand copies (one should remember that the VISICALC software has been sold in over 400,000 copies),

b) if companies can afford to buy microcomputers, they can not afford the cost of having their employees write programs instead of doing their work. Moreover, those people who will be hired to write programs will be required to be specialists in programming which has little to do with the simple knowledge of a programming language.

Other specialists argue that programming has intellectual virtues and they compare it to mathematics or even Latin. Training in programming is supposed to teach children:

a) to "think logically" (whatever this means),

b) to formulate solutions in a clear, exhaustive and unambiguous way,

c) to be careful and handle all details,

d) etc.

Objectively, these people take their desire for reality.

The truth is that we would like future programmers to have the above qualities but experience has shown that the teaching of programming even intensively has been unable to develop these qualities for people who did not have them before hand.

The incredible large number of reports on the bad working methods and the low productivity of professional programmers are a proof of it as well as the cruel anecdotes which are well known in professional circles.

I shall only give two of these: "if we could manage to allow programmers to write their software in natural language, we would notice that the majority of them cannot write", "in software, the first 90% of a job take 90% of the time, the last 10% take also 90% of the time".

Some people argue that this was true up to now because we were not able to teach "good" programming but the "new" programming methods or such and such new "miracle-language" or "miracle-system" is going to change the situation. It may well be possible but it remains to be proved.

Moreover, which language should be taught?

the respectable one (FORTRAN),
the easy one (BASIC),
the pedagogical one (PASCAL),
the useful one (COBOL),
the modern ones (LISP, PROLOG, SMALLTALK,...),

and which will be the standard one in ten years from now? Will it be a natural language and if it is the case will it be Japanese?

Some specialists agree with the above arguments that a programming language is not really important but they insist on teaching algorithms.

The teaching of algorithms

The teaching of algorithms should teach children:

- to formulate correctly a problem,
- to analyse the problem and decompose it in relevant subproblems,
Knowledge and Communication in the Computer Age

- to solve the problem by writing the correct algorithms,

all this being also sometimes called “problem solving”.

Now, problems solving is an interesting concept because since it has been formalized in the 17th century by René Descartes who suggested to decompose a problem in sufficiently small sub-problems which can be solved at a glance, the only thing we have done is to add new keywords like “stepwise refinement” or “divide to conquer” which are just a paraphrase and do not bring anything new.

It is no surprise because the general concept of problem solving is so general that it is almost semantically empty.

Apart from academic problems, and even in that case, the solving method of any problem depends heavily on the relevant discipline in which the problem is formulated and is strongly isomorphic with the handful of paradigms characteristic of that discipline.

There is very little in common between solving a problem in astronomy and solving a problem in biology, except the fact that in each case there is a “problem-solving” problem. At that level of generality we can consider that the concept of problem-solving is semantically empty except if it is applied to a given discipline and in that case problem-solving is a bag of tricks and not a method.

In fact, what is common between the proposals of teaching programming and teaching problem-solving is the idea that there are “informatics methods” for solving problems and that the ultimate in problem-solving is writing a computer program that solves the problem.

This is a completely aberrant view of problem-solving in general and is nothing more than a tentative to make a theory out of what has been practice of analysts and programmers for the last 20 years or so. The classical problem solved by analysts and programmers was to automate a procedure or a set of procedures made by hand (like establishing payrolls or sorting files, etc) through the use of a computer program. No wonder if these people have tried to make a theory out of their daily activities.

Unfortunately, the general activity of problem-solving is not reducible to that specific work of automation of procedures and therefore the teaching of programming and/or algorithms is of no use except for professionals in informatics.

The real challenge lying before us is totally different. In our fast changing society new problems are arising all the time, and our role should be to prepare children to solve these problems which we don’t even know today, first of all by developing insight, intuition and imagination based on a solid understanding of the basic paradigms of sciences and second by helping them to analyse in a problem which part is relevant to their own intellectual effort and which part can be given to the computer used as an assistant. As Terry Winograd said “Computers should not be regarded as a mathematical abstraction but as systems with which people interact”.

It is my opinion that computers can be used in education towards that purpose and I shall come back to that subject later on.

Second scenario: the computer as an Intelligence amplifier

Most psychologists believe that children learn about the world through their interaction with the world and Piaget goes even further by saying that children develop their “logical-mathematical tools” through abstraction from their daily experiments with the world.

If we accept the idea that children learn about the world by doing and that therefore their vision of the world depends on the variety of their experiments then the use of computers raises a number of questions because with computers children can make types of experiments which are completely impossible without computers. What are these new experiments and do they (if at all) change the way children perceive the world?

a) there are simple drawing-softwares with which it is possible to make drawings on a screen with a light pen. In its simplest form such a software draws a straight line through any two successive positions of the lightpen. How do children use that possibility? How do they explain the automatic drawing?

b) a bit more sophisticated are icon driven drawing softwares where 2 points can define either a rectangle of a square or a circle depending on the icon chosen. Moreover a drawing or a part of it can be moved all over the screen can be made larger or smaller, etc. All these possibilities do not exist on paper. How do children use these possibilities? How much do they like it? How do they explain what they see?

c) if having drawn a closed line, the computer is able to fill in the enclosed surface with any color, what are the experiments children make to find out how it works (lifting a non-closed curve, superposing two surfaces with different colours, contour and surface in different colours, etc)?

d) if different basic drawings are available through icons in a menu (houses, trees, flowers, ships, windmills, boys, girls, animals, etc) do children use the icons separately or together to draw a landscape. After having used this drawing-software do they still draw on paper
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and if so what is the influence of the software on their future drawings?

e) what is the impact of a text processing package on the speed of learning of writing and spelling? What is kept and what is lost when children switch to hand writing? Is there a transfer between both activities?

f) the description of an action to be executed by a device later on upon request can be done either by pressing functional keys as in the case of the toy called "Big track" or by typing instructions on a keyboard. Which way is the easiest for children? Why?

g) what difference do children see between a mobile executing a list of instructions by moving on the floor and a mobile in the form of a triangle simulating a real mobile and moving on a screen (generally vertical)? What kind of relationship do they see between the mobile and its simulation?

h) the possibility to prescribe (in symbolic form) a set of actions to be executed later on by a device is given by the use of computers. How does that possibility change (or not) the notion of flow of time (past, present, future) for children?

i) to make a drawing on a screen, storing it in memory and calling it again at a later time is one level of abstraction higher than drawing on a piece of paper and storing it in a physical location where it can be found again. How does this different approach change the way a child conceives the concept of storing for later access? What difference does he/she make between storing in a computer and storing in a physical location? How does (s)he understand the necessity of naming an object before storing it in memory?

j) Piaget has insisted on the fact that the child becomes progressively conscious that he is an actor as compared to outside objects. A robot with a program can become an actor while being an object. Does this change the way a child understands the outside world and his relationship to that world?

There are many more questions along these lines and they are all open questions mainly because little research has been done on these and other fundamental problems.

There is a historical reason for that lack of fundamental research. Years ago some computer scientists developed various pieces of software and/or hardware aimed at the child - computer interaction and promoted these (mostly for commercial reasons) as the only tool for interaction. Psychologists and pedagogues were not sufficiently competent in computer science to define their own hardwaresoftware tools for investigating the child - computer interaction in terms of psychology and pedagogy, therefore the only research they did was to investigate the properties and possibilities of the products designed by the computer scientists with a tendency to draw universal conclusions as if these products were the only possible ones.

Recently as more and more psychologists and pedagogues have become familiar with computers, an increasing number of psychologists and pedagogues are defining by themselves their subjects of research in the area of child - computer interaction and are developing by themselves the hardware/software tools they need for their specific investigations.

This will hopefully bring to a stop wonderstories about "Children love computers". "They cannot stop typing on the keyboard". "They take the computer to bed" which may be true for some children but hide the fact that counter examples of children completely reluctant to computers can be mentioned as well and in equal number. Statistically children do not love or hate computers; when they can access one, they play a while with it and then they change for other games.

It will also hopefully bring to a stop stories about the wonderful properties of miracleprogramming-languages like LOGO which are supposed to make children become creative and explore and find out lots of things by themselves as opposed to the use of software packages which are accused to "program the child" To believe that the use of any specific programming language can make people become creative is either a naive view or an overoptimistic view of mankind in general and of children in particular which reminds of Jean Jacques Rousseau's "gentile savage" corrupted by civilization.

That so many optimistic assertions about the psychological impact of using LOGO, made without any element of proof as to their general validity, have been accepted by psychologists and pedagogues and that nobody ever mentioned a single drawback or dared raise an objection, can only be explained by the dominant social status of computer scientists and the complete lack of competence in computer science of psychologists and pedagogues.

Third scenario: Computer assisted activities

In this scenario, the role of the computer is the role of an assistant which will be used as a set of resources and services. In other terms, the future user of a computer will not be more concerned by computers "per se" than the citizen of our "electronified" society is concerned by electronics.

What he will be interested in is the quality
and variety of services available at his
terminal which will be an outlet of a complex
network system for communication,
information and processing and the use of
such a terminal will be socially accepted if and
only if its use is sufficiently simple, which
means compatible with the usual behaviour of
people in our society.
The history of informatics of these last
twenty years shows with evidence that a
considerable effort has been made by
professionals to simplify the use of computers
so as to put the machine at the service of man,
instead of obliging people to learn a complex
set of relevant details of the machine which in
fact was putting man at the service of the
machine. We have still to go further in that
direction to accomplish the statement of Arno
Penzias (Nobel Prize in 1978) “We must teach
computers to understand people”.
The computer as a source of services and
resources is going to play a major role in
education and in many countries there are
now projects in progress to use computers in
education.
In the early sixties, the main role of
computers in education was to replace
teachers. It was the so called tutorial mode
which simulated as well as possible the role of
the teacher in the classroom giving lectures,
asking questions, correcting answers and so
on. Witnesses of that tendency are the
numerous publications of that time trying to
show that computer-based education was
cheaper than institutional education.
The reason for the promotion of the tutorial
mode was the high price of computers which
made their use economically feasible in
education only if they were able to replace
teachers.
The tutorial mode is not bad in itself. It may
be very useful in a number of circumstances
(children who have to stay away from school
for a given period, rehearsal for the less gifted,
learning check list-type of activities like
maintenance, control, etc), but it is by no
means the solution because it is just ridiculous
to try to reduce all pedagogical processes with
all their complexity to that kind of
rudimentary mechanism which is much more
likely to develop conditioned reflexes in
children than anything else. The fact that it is
put at work through advanced technology and
with reference to Socrates does not change the
problem.
If we consider on the contrary that education
is a complex process where the aim of teaching
is to help each child to acquire knowledge not
for the purpose of memorizing it and becoming
able to answer questions, but with the purpose
to help each child to build for himself a
coherent mental representation of the world
around him so as to become able to act on this
very world with increasing chances of success
in his actions, than there is a wide variety of
possible uses of computers at each step of the
pedagogical process and not only for the child
but also for the teacher.
We have already mentioned the growing
tendency of using computers in the CAX mode.
If we apply this to education, than we have two
actors: the teacher and the child, and each of
them can be assisted by computer in their
activity.

Computer Aided Teaching

Very little has been done in this direction up to
now and therefore very few software packages
(which I shall call “teachware”) are available to
help teachers to improve their teaching in the
classroom.
One interesting application is the “electronic
blackboard” where the teacher uses the
keyboard to show texts and pictures. Many
different uses are possible
- increasing the number of examples,
- simulation of experiments
- presentation of cases where an unknown
  rule is applied and asking the class to find the
  rules, etc.
Some experimental teachware has been
developed in France and has given extremely
interesting results.
In one of these experiments (age 13-15), the
teacher shows a triangle where two points are
fixed and one of the points can be moved
through the keyboard. He asks how this last
point should be moved to get a triangle having
the same surface as the original one. After
discussion between the pupils a move is
proposed.
If the surface of the new triangle is equal to
the original one, the proposed point appears
green and the computer gives a “beep”; if it is
not the case, the new point appears red and
nothing happens. New discussion, new point,
etc, until a line of green points, parallel to the
fixed side, appears on the screen which
properly commented by the teachers allows
him to introduce the formula of the surface of
the triangle, which at the same time justifies
and explains what is shown on the screen.
What this factual description is unable to
describe is the excitement in the classroom, the
vividness of the discussions between the pupils
before making a decision and the pleasure of
those who, between all, guess that all the points
lie on a straight line.
What is important here is the emergence of a
new type of pedagogy where the computer, in
the hands of the teacher, plays an active role.
What is also important is the change
introduced in the relationship between the
teacher and the pupils where the teacher is not
the one who teaches the truth and gives bad
marks for a wrong answer. On the contrary, he
is encouraging the intuition, the imagination
and the creative thinking of the pupils and leaves to the computer to show if a pupil's proposal is wrong or right with the subsequent demonstration which helps to understand why some ideas were right and others not. This example gives only a slight idea of the wide range of possible uses of the computer by the teacher and much more research is necessary in this direction.

Another possible use of the computer to assist the teacher in the classroom is "guided discovery" which is the teacher's version of a game called "Microworld". For that purpose, the teacher uses a software package simulating an experimental phenomenon (physics, chemistry, biology, demography, geography, etc). Pupils work in groups on a terminal where they can change the parameters of the phenomenon and make experiments and are asked to discover the laws governing the phenomenon whereas the teacher goes from one group to another.

There are many different objectives:

- to put children in a research situation, i.e. construction of explanatory model of what has been observed. This is a real inductive way of reasoning and requires creative thinking at a rather high level of abstraction (children are working on a symbolic representation of a real event),

- to verify that children apply correctly the experimental method: experiment, hypothesis, verification of the hypothesis through experimentation, new hypothesis, etc, with examples and counter examples,

- to verify that children apply a strategy to make their experiments converge towards a conclusion and are not gaming around through trial and error.

- to help children to become autonomous in a situation which requires constructive thinking in the search for a solution.

Another interesting possibility for the teacher is the use of small databanks which can be used in many disciplines, the main purpose being to show that there are methods for asking the right questions and for refining these progressively and that there are also methods for making a distinction between relevant and non-relevant facts in the answers given by the computer.

Computer Aided Learning

Here we are interested in the assistance a computer can give to the pupil. I shall only mention video games or the so-called educational games because apart what I have said previously about the psychological impact of the specific properties of the computer, they have on the whole little pedagogical value.

Besides these, the tutorial mode or the drill and practice mode can help the less gifted children at home to improve their results provided their parents pay attention to it because I don't know many children volunteering for working after class hours even on a computer when it becomes daily practice.

More interesting is a text processing system with dictionary look-up which can be used to improve spelling or can encourage children to write either because it comes out neatly printed or it can be sent directly through electronic mail. Dictionaries or encyclopedias on computers including video disks are much more likely to be used by children because they are no more heavy books accessed through alphabetical order but give immediate answers with moving pictures on the screen to any question.

Finally, the most interesting is probably still to come as shown by a recent experiment in France. The example I shall describe is in elementary chemistry but it can be used in any discipline. The software is an expert system in chemistry but it is not used to answer questions. Instead of asking a question, the user submits a chemistry problem to the computer and asks the computer to explain step by step how it solves the problem. This is the first example I know of learning how to solve a problem by watching a computer solving that problem and giving step by step the rules which are followed to find the solution. This new direction seems very promising at least for simple problems and should be further investigated.

Long term implications

The use of computers with the variety of techniques which have been described are aiming at the improvement of present education by giving children more autonomy, more critical thinking, more possibilities to become creative.

Moreover, by having children working with computers, they become familiar with their future environment in the society of tomorrow and with the variety of tools which they will have at their disposal.

That computerized society is no science fiction: it is already a reality in an increasing number of industries in the form of CAX tools.

Because these tools give their users an increasing power on their environment by allowing them to solve problems which they would have been unable to solve, by allowing them to master more and more complex problems, it is indispensable to familiarize children with these tools not by giving them lectures on computers or programming but by giving them the opportunity to use these tools in the widest possible variety of situations.
To reach this objective, the knowledge about computers and programming is generally useless because writing a program of 50 or 100 instructions does not allow to understand anything about what a databank is, how to access and how to use it, in the same way as knowing how to pilot a plane is totally irrelevant to what one has to know to fly from Paris to Stockholm on a commercial airplane. In the first case, one has to learn how to control a plane with its problems in mechanics and aerodynamics, with its take-off and landing procedures, etc. In the second case, there are specialists to pilot the plane but the passenger is not concerned by these problems; what the passenger has to know is how to read a flight schedule, how to plan flight connections, how to make a seat reservation, the address of the air terminal, the duration of the ride to the airport, the maximum weight of his luggage, etc.

The image of the user in front of his computer with a programming language as his only resource is an image of the past. More and more computers are integrated in complex systems of information, communication and processing ranging from the local working station with dozens of sophisticated software packages where instructions are by the hundred thousand to local, regional and international networks. Each user will therefore be linked to thousands of other computers with access to informations and software packages available all over the world which he will be able to download in his own station for further use. This multiplication of more and more sophisticated software tools which will be accessible from any professional or private terminal is the major characteristic of the computerized society which is the society our children will live in and for which we have to prepare them.

The invention of printing has allowed to put at the disposal of everybody in book form the knowledge accumulated by past generations and has therefore contributed to the general progress of knowledge. The advent of the information, communication and processing system represents a radical change because these allow not only a faster and easier access to that accumulated knowledge, but they allow, moreover and this is completely new, to put at work methods and techniques by executing software packages written by others.

Up to now, we had to learn in books the description of the methods and techniques and try to apply these memorized methods to each problem encountered. By adding the information, communication and processing systems to the printed knowledge we are, without being always clearly conscious, leaving the era of discursive information (description of what we have to do to solve a problem), to enter the era of operational information (how to choose the software package which, when executed by a computer, will give the solution of the problem).

If we analyse the implications of this radical change, some remarks are in order:

a) it is absurd to believe that there will one day exist software packages which will solve all the problems or answer all the questions which men will ask,

b) the software packages which are massively developed today are packages which will assist men in the solution of problems by giving an aid to process automatically certain parts of his problems,

c) the use of these software packages is not trivial. It implies first of all to learn how to use them and it implies also that the user has sufficiently mastered the domain of the problem to be able to make a critical appraisal of the results given by the computer (no software will ever allow a specialist in biology to design a new machine-tool, and no computer will ever allow a TV-repair man to design VLSI circuits).

The contents, the techniques and the methods of all present day educational systems, from elementary school to university, are based implicitly on the hypothesis that for solving the problems which are given or will be given to the student, the student will have at his disposal his brain, a sheet of paper, a pencil and eventually some books. This very hypothesis is never explicitly stated but it is the very basis of all educational systems.

If, as I do believe, in a very near future any pupil or student will have permanent access to systems of information, communication and processing, where thousands of software packages will be available to help him to solve his problems, than it is clear that the preceding hypothesis is no more valid.

In other terms, the generalized access to systems of information, communication and processing will progressively put in question the methods, the techniques and the contents of all systems of education from elementary schools to university because that very access puts in question all the knowledge and all the know-how’s as we define them today.

Learn to think differently

One often hears these days that our problem today is to integrate informatics into all disciplines, but it should be evident at this stage that those who pretend reach the objective by teaching programming or algorithms are addressing the wrong problem.

If informatics is not the science of computers, it is not either the technique of programming. The computer is a machine and programming is a technique. Both together are tools for the
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processing of information which is the object and the major object of informatics.

When I speak of integrating informatics in all disciplines, I do not think about computers or programming, but I do think about information processing in the broadest sense and about what it can bring to the user.

The major characteristic of what has happened in informatics in the last years is the fast emergence of computer assisted or computer aided techniques (what I have called CAX) which are, in the strict sense, processing systems more and more sophisticated in an ever increasing number of areas (electronics, avionics, medicine, biology, mechanics, architecture, office work, etc).

Some experts minimize this phenomenon by calling it "press-button informatics", but I believe that this phenomenon is the most important since the invention of the computer.

It is important for two reasons. First of all, it is going to give us more and more powerful tools which will inevitably put in question all knowledges and all know-how's and, second, it is going to concern everybody in his professional and private life. It is clearly evident that these tools, because they relieve the user of all long and fastidious routine work, require also from him more imagination, more intuition, more creativity to invent alternative solutions to be tested on the computer and require moreover the capacity to judge critically any result given by the computer which, in turn, implies a different and deeper type of knowledge.

However, even a superficial analysis of the contents of education shows that a large part of education is devoted to the teaching of analytical methods which lead to the decomposition of a problem in successive steps down to the level where each subproblem can be solved by hand.

This is not only normal, it is indispensable in a situation where there is no other resource than paper and pencil.

If we consider however that analytical methods are in their vast majority algorithms then it is clear that, sooner or later, we shall have software packages which implement automatically these methods and everybody will be able to use them including at school.

As it is highly probable that, in not too far a time, every child in school will have in his pocket a computer as they have today a pocket-calculator (should I remind you that the very first pocket calculator was put on the market only 15 years ago at a price of 700 $ US) with a wide variety of powerful software packages, than it becomes evident that our present education at all levels will be growingly misadapted. It is therefore not too early to begin to think about which modifications should be introduced in the contents as well as in the methods of education (it is already the case in certain states of the US).

It has often been said that informatics was going to bring deep changes in our intellectual habits because of its intrinsic logic and, to accelerate these changes, it was urgent to teach the techniques of informatics to everybody and mainly to children. The implicit hypothesis was that we could prepare our society to the unavoidable changes by teaching algorithms to everybody through top-down analysis, data-structures, rigorous logical thinking, iteration loops, recursion and proofs of programs.

The difficulty here is that this very proposal is not anything else than a tentative to rise at a respectable level of cultural value and to spread to the whole of society what has been the essentials of the activity of professional programmers for the last 10 or 20 years. An even greater difficulty is that this type of proposal is exactly the type of conditioning by the past which exist each time a new tool is invented, as I did mention at the beginning of my talk.

But the greatest difficulty of all is that this type of proposal is in contradiction with the most recent trends of the evolution in the use of computers towards a generalized CAX activity.

The generalized use of computers is going to change our mental habits not because of the aforementioned reasons.

What is going to happen is that, through the effect of economic competition or because of the simple necessity of survival of industrialized countries, more and more sophisticated informatic tools will be introduced elsewhere.

What is going to happen is that everybody will have to use in his professional life first and in his private life afterwards such powerful tools that they would have been properly unthinkable 10 or 20 years ago.

This will lead unavoidably, through daily practice, to formulate all problems differently because they will be solved through the use of much more powerful tools and this will lead people quite naturally to think differently (long distance travel problems are considered differently today from what they were before the invention of the rail road, the car or the airplane and this has changed deeply the way we look at the world in general).

The advent of CAX tools and their generalized use in the next ten years is going to put in question all our know-how's, and the teaching of computers and programming is by no means an answer to that question. What is in question is much deeper, it is the question of how we are going to change our whole systems of education so as to take into account the existence of these powerful tools and how we are going to integrate these in a new set of coherent curricula at all levels so as to educate everybody to make the most efficient use of these tools starting at the elementary school and up to university.
Terry Winograd has said that "there is one thing which computers cannot do and which people do quite naturally: "think";" but it has also been said that the way we think is to a considerable extent conditioned by the nature and the kind of tools we use.

The advent of CAX tools is therefore opening a whole new era where men will be relieved from a considerable amount of routine intellectual activities and mechanical thinking and this gives us for the first time in history a unique occasion for using education to develop insight, imagination and creativity, which are more than ever necessary to make the best use of these tools.

Dr Hamming has said that "The purpose of computing is insight and not numbers" and I would like to paraphrase his statement by saying that the ultimate purpose of computing should not be to turn people into servants of the computer but to develop in people those qualities which are unique to men, in other terms, the ultimate purpose of computing should be to help people to become more human.
Questions and Answers

Q: You raised a very fundamental question concerning the implementation process of computers. In many countries politicians rush to meet the rather vague concept of "the Information society" by putting hardware in schools. Then they try to think what to do with these machines.

This policy mistake is quite costly. You mentioned that first comes teacher training, then software and last hardware. Professor Turkle suggested in an interview that before starting with computers in schools, every teacher should be issued one. What is your reaction concerning that suggestion? Will putting thousands of teachers back to the desks again, solve the rather costly policy mistake being made today?

A: I have a natural tendency not to be normative because most of the things you mention are not under my control. It is very difficult to say "you should-you should not" because I have no part in deciding anything at that level. I agree with what you say. The only thing we can do is to try and help officials not to go in a direction which we can predict is closed. We can try to give a "gentle push" in order to change the decision a little bit in the right way, if enough people push in the right way maybe the resultant can be a change in an official decision.

One of the difficulties I have experienced in France is that ministers are people who are very busy. One can not expect or hope to discuss with a minister more than five minutes. In five minutes you have to explain something that perhaps takes an hour, which of course is impossible.

The minister can easily understand if you say: "Many people, many parents want to have computers in schools". His response will probably be: "How much does it cost?" If you say: "Two million dollars", he may very well answer: "OK, bring the cheque." Then your five minutes are up.

If you try to explain to the minister that the problem begins with teacher training which means that a minimum of hundred thousand people has to go through training, his questions will be: How much? How long? It is impossible to answer.

If you say: We need five years to train the teachers - it is not his problem. He is elected for two years.

The problem raised is a complicated problem because it has to do with political decisions and the way political decisions are taken. One may not like it but it is the way things go. You are perfectly right that when it comes to this large number of people to be trained, to be convinced, to be given software and so on, the problem is very complicated. Decisions which are made are not always completely wrong. I would not say so, but they are not necessarily in the right direction.

Q: You have outlined three scenarios of which you very quickly do away with the first one. In the second scenario you speak, among other things, about computer-aided teaching. You say that what is important is the emergence of a new type of pedagogy where the computer in the hands of the teacher, if the teacher so wants to, may play an important role. Moreover you foresee a new relationship between the teacher and the pupil.

The question coming into my mind is: do you believe in these changes because you perceive an enormous strength of the computers themselves or do you believe in these changes because you believe such changes are on their way, with driving forces other than computers and other than computerization of society?

A: I believe that the authors of the Carnegie report "The Fourth Revolution", published in 1972 are right. They say that it is not because computers exist that they should be used in education. That is not a good reason. To teach with computers is more demanding and more difficult, it takes more time and more effort than teaching the traditional way. Therefore, computers in education will survive if, and only if, those teachers involved, after the novelty have faded, will continue, insist and make it a daily practice. So my answer is that nothing will happen in education without a definite will of the teachers.

Introducing computers in education implies training teachers. I would add though that introducing computers in schools is no guarantee of anything. On the contrary. A good teacher with a computer will be a better teacher. A bad teacher with a computer will be worse than without a computer. He will leave the computer with the children and read the newspaper.

So what will happen will not happen because of outside pressure. It will happen because I believe that there is a vast majority of teachers who are interested in what they are doing. Who try to find more efficient methods, new methods and new ways of doing things. I know of many teachers, at least in France, spending extra hours all the time trying to include new methods in their teaching in a constructive way. It really comes from the teachers and from nothing else. Computers can be given to every school and it will not change anything.
Knowledge and Communication in the Computer Age
Donald A. Schön is Ford Professor of Urban Studies and Education at MIT. He has among other things studied the question of professional knowledge, what it is, what it means and the changing public confidence in it - general questions of high significance in the computer age. Among his books: "The reflective Practitioner. How Professionals think in Action" (1983).
I would like to talk about a battle or struggle which I think is going on in universities as well as in the professions. It is a struggle about views of knowledge, professional practice and about the proper kind of education. The computer comes into it because the computer is in part a trigger and in part a stake in this struggle. The struggle has to do with views of knowledge or what I call epistemologies of practice.

Let me take you back to 1963. There was an issue of a publication called Daedalus which was devoted to the professions. That issue made it clear that nowhere in the history of American society had the professions been so triumphant. Every article in that review was a celebration of the profession of medicine, sciences, psychiatry, engineering etc. The only problem that could be noticed was that there was too much technical information being generated.

However, nine years later the tune was completely different. When I first came to MIT in 1972 the first thing that I did was to organize a meeting of people interested in professional education. There were some leading practitioners and heads of professional schools. What they said was that there had been an undermining of the professions.

With the undermining of the professions comes the undermining of what I like to call the technological program of which the professions are the leading edge. There had been an erosion of the professionals' claim to produce ethical standards above the norm for society and to produce expertise useful to solve societies problems.

Why had the tune changed? Well, between 1963 and 1972 there was for example the Vietnam war which was professionally engineered. This event as well as other events during that time made the leading edge professionals aware of the salience of certain indeterminate zones of practice. The professionals had become aware of the great importance of uncertainty, for example. Uncertainty in the sense of having more information than one can handle. In the course of becoming aware of uncertainty they had become aware of a dilemma I would like to describe as the dilemma of rigor or relevance.

Underneath the dilemma of rigor or relevance is a particular epistemology of practice. Let me define it for you by referring to a very interesting article by a man named Nathan Glazer, called The Schools of the Minor Professions. It was published in 1975. Glazer distinguishes between two kinds of professions, "major" and "minor". The "major" professions are law, business and medicine. The "minor" ones are all the others. What Glazer says about them is that the "major" professions have clear and self-consistent ends, a stable institutional context of practice and a systematic body of professional knowledge. None of the "minor" professions have those things. As a consequence, Glazer says, the "minor" professions are always subject to a dilemma. They are continuously importing high status representatives of disciplines from the "major" professions and the sciences in order to increase their prestige.

If you look at Glazers' argument it depends on the notion that practical knowledge consists in the adaptation of means to ends. His focus on self-consistent and precisely measurable ends implies that idea, as well as the notion that practical knowledge becomes professional when instrumental rationality is based upon science. So we have the following definition of professional knowledge: It is the adjustment of means to ends through the application of science. That idea central to the emergence of the modern research university, raises a problem of what to do with the professions.

In 1916 the Norwegian-American economist Torstein Veblen wrote The Order of Higher Learning in America. In that book he vented his anger at the trustees of the University of Chicago because they were proposing to admit a business school to the university. What, he asked, does a lower school of business have to do with a higher school of the university? The professors of business will be unable to produce anything like scholarship or research but they will feel obliged to attempt to do so because they are in an university. The result will be embarrassing to everybody.

Veblen lost his battle and the business school did enter the university. It was followed by the medical school, engineering school, the schools of psychiatry, library science etc. But the price these schools had to pay for entry into the university was to buy into the universities' predominant epistemology. This was derived from positivism and was basically the notion that scholarly knowledge should approximate in so far as possible to a certain view of scientific knowledge.

The consequence of all this was to generate two institutional implications, both still with us today, which make the university a Veblenian instrument regardless of what any individual within it wishes.

The first of these is the normative professional curriculum, whose sequence is: first teach the relevant basic science, then teach the relevant applied science, then give a practicum whose purpose is to apply the science to solving the everyday problems - a sequence that makes sense only if we accept technical rationality, the positivistic epistemology of practice.

The second institutional consequence was to separate research from practice. If our model of research is scientific research in the
We are living in a kind of vestigial start describing her to you, but for you that description would give the wrong answer in our description of how to do it. This sort of ordinary knowing in action really gets us through life. There are times, however, when it does not and then we get surprised. But we have a rather remarkable capacity, which is to respond to surprise in the midst of action. We can deliver what I call reflection-in-action. My favorite example is jazz. Jazz is collective improvisation, it is a number of people together responding to surprise, but responding to it in such a way as to make a coherent piece with others who are also improvising. Here, a group of individuals respond to surprise by rethinking and redoing their responses in the midst of action.

Another wonderful example is ordinary conversation. A good conversation is neither wholly predictable nor wholly unpredictable. It is wholly unpredictable; it is crazy. A good conversation lies between boredom and insanity. In it, we are continually responding to surprise within the framework of a set of routines which we understand and manipulate effectively in terms of our own knowing in action. What is interesting about these capacities is that they do not require intellectualization and they need not take place in words.

We also have the capacity to reflect on our reflection-in-action. This is a process in which we move from the observation of action to reflection on that action, We move to a description useful for further action, and to critique of that description, which we can then test and explore through the next thing we do. Action, observation, reflection, description, critique and further action. This cycle of reflection on reflection-in-action is also something we also know how to do - albeit in varying degrees of skill and awareness of what we are doing. In all this, I have been attempting to give you an impressionistic picture of a different epistemology of practice. It is an epistemology of practice which finds the source of knowledge embedded in the routines and improvisations of everyday action. It is an epistemology of practice that recognizes artistry, not as a mysterious entity but as something to be reflected upon and described. It is an epistemology of practice which I think is rooted in constructionism. It is very close to the notion that in our perceptions and actions, in our descriptions and notations, in our ways of framing problems, we construct a world of
practice in which we live. I am going to use the term "reflective practice" to refer to this idea.

Let me now contrast the two epistemologies of practice. Technical rationality sees professional competence as the application of science to the solving of instrumental problems. Reflective practice treats technical problem solving as a subclass of intelligent processes within a context of problem framing through skills about which technical itself can tell us nothing. Reflective practice focuses on artistry and reflection on artistry, something we intuitively and spontaneously know how to do and can come in some measure to be able to describe. What this is not, however, is a distinction between art and science. It is rather a distinction between two epistemologies, two different ways of thinking about science and about art. I think the two different ways can be usefully described as retrospective and prospective.

Technical rationality treats science as a set of products, a body of knowledge that scientists produce and codify in technical journals and textbooks. These products take the form of symbolic generalizations. They are constructed in relation to certain fixed references, like number lines or coordinate maps. From this point of view what can be understood is the process of testing hypotheses, but the generation of hypotheses is left essentially mysterious.

Similarly, on the retrospective view, painting, sculpture, music or poetry, is seen as product. The process that goes into it remains private and basically mysterious. Most people who are researchers understand that there is an art of doing research - an art of doing science which is partly an art of analysis, like the analysis of structures, an art of framing problems and questions, and especially an art of understanding phenomena. If we view science and art before they become "products", if we look at how people do those things then we see them both as forms of reflective practice. From this perspective, they seem much more alike than unalike.

I want very quickly to touch on some of the implications of this distinction between epistemologies of practice. There is, I think a kind of squeeze play, squeezing us in the direction of technical rationality.

By the late seventies there was a resurgence of technical rationality in the universities. For example, the psychology department at MIT was renamed the Brain and Cognitive Science department. The civil engineering department got rid of all their social scientist and anthropologist and went back to things they could actually measure. The Harvard Business School, based upon the case study method, a method that encourages reflective practice, is now in the midst of a

Here the computer enters the story. In this battle of epistemologies, one of the roles of the computer is to support the systems of control by which we try to remove indeterminate zones of practice from practice. Management information systems that control what managers will do. Proceduralized systems that control how an operator at Three Mile Island will behave under stress. Expert systems that will replace the incompetence of physicians before patients who "does not fit the book". In these control systems, the computer plays a central role.

The question I want to raise is whether the
computer will be co-opted on behalf of resurgent technical rationality, or whether it will be engaged in support of the reflective practice.

Let me give you two vignettes to suggest how this question comes to bear on education.

In the work Sherry Turkle and I have been doing at MIT, we came across something interesting in the civil engineering department. It is a program called GROWL TIGER, a tool that allows people to draw and quickly analyze structures. Students use this software in very different ways. In one sense, they use it as a tool, simply to get rid of the tedious work of calculation. But some students use it not as an expert system and not primarily as an instrument of calculation, but as a kind of microworld in which to play around. As they create and analyze structures, they allow themselves to get surprised and their surprises become puzzles that they can think about. They create hypotheses and explore test hypotheses by modifying and testing their structures, all within the boundaries of the microworld.

Here is how one student described it: "I applied a wind load and I saw the building lean a little. I saw the continuity of how it would have behaved if it weren't going to fracture and fail catastrophically. I saw that if I wanted to get rid of some deflection in the floor girder, I could stiffen up the wall columns. Then I saw that by making some columns a bit wider without necessarily changing the weight or even lowering the weight, I could make the building stiffer."

He discovered that by removing some materials from some of those columns, he could actually increase the resistance of the building to load. This became a fascinating issue for him which he pursued on his own for weeks thereafter. For him, the little program became a microworld in which he could build his capacity for reflection-in-action in design.

The second vignette is not about computers directly. It could be taken, rather, as a metaphor for thinking about computers.

Two colleagues of mine at MIT did a project which they called the Teacher Project. They worked with some seven teachers from elementary schools, in seminars over a period of several years. In the course of that work, they tried to help the teachers look at how they themselves learned.

One day, they showed the teachers a video tape. The video tape was of two boys and there was an opaque screen between them. Each boy had before him a bunch of pattern blocks of different sizes, shapes and colors. One boy had a pattern and the other boy just a lot of blocks. The boy with the pattern was supposed to instruct the other boy to build his pattern.

The teachers watched the tape and, as they did so, saw the second boy who received instructions seeming to become more and more confused. His pattern looked more and more bizarre. The teachers said things like, "He seems to be a slow learner, he has a rather low attention span, he doesn't have the basic skills of mastery that he needs."

At a certain point in watching the tape, one of the researchers said: "Wait a minute. I think the first boy gave a mistaken direction that couldn't be followed. He said: Put down a green square, but there are no green squares. There are only orange squares. The only green things are triangles."

The nice thing about a video tape is that you can turn it back. So they turned back the video tape and looked again. This time, they saw that the researcher was right. The first boy had given an impossible direction. The second boy then began to look to them like a virtuoso follower of directions, valiantly improvising in spite of the fact that he had been given an impossible task.

Looking back on that activity, the teachers said, "We gave the kid reason." The notion of "giving the kid reason" became a central idea for them throughout the remainder of their work in the seminar.

Giving kids reason means that we act as though the things the child does, and the silly questions he asks, make a kind of sense. Our problem is to discover the sense they make, which makes us into researchers and makes teaching into on-the-spot experiment and reflection. Teaching becomes, potentially, a reflective practice. Professional education for teachers begins to look like coaching aimed at helping teachers become reflective practitioners.

In such a context, the interesting uses of the computer would, like GROWL TIGER, serve not to expedite or control practice but rather to enhance the teacher's capacity for reflection-in-action.
Questions and Answers

Q: You stress that what you are saying is not to be taken as an attack on science and research in general. Do you think, with our intellectual traditions and the social institutions of universities, there is a possibility of stepping back and look at what the issues are, which we are supposed to deal with? What do they look like, and how can we get this into teaching?

A: It is a very revolutionary view. For university researchers, it would mean to stop doing research and become people who try to help practitioners do research. We would become people who help practitioners reflect on their own practice. We would become guides, coaches and providers of frameworks for practitioners. That is a radical change in what we would do, how we would spend our time, where we would physically be and how we would earn our money. It would be a very different kind of world we would be living in.

The tradition of traditional institutional forces of the university are very strong and they are reassuring themselves. When, on the other hand, I began this work in the early seventies the only schools that were interested were the "minor" schools, like urban planning.

Now the schools of business, law and medicine are involved in trying to rethink the question of how to conduct professional education. I think the computer can be a pawn in this struggle. Depending on decision of epistemology we think very differently about what to do with the computer.

Q: So this new technology can be used to pursue reflection-in-practice? You don't necessarily see it as a prolongation of traditional technical rationality?

A: There are certain contradictions inherent in trying to answer questions about the computer in this way. We can do many interesting things with kids and computers, if we have wonderful teachers standing by the computer. The issue is what we do in the face of a large scale national pressure to distribute computers on mass, without teachers able to work with them.

I think, nevertheless, our stance ought to be to try and use the wave of computers in education which is now underway. We should try to surf on it and get support for the development of prototypical examples which represent uses of the computer to enhance human capability for reflection.

Q: Won't your idea of reflection-in-action strengthen the role of the experts, leaving to much to them?

A: If I am understood as saying that people have a knowing-in-action which they don't know how to describe and that this is to be trusted as a "black box", then it provides that kind of argument.

What I am asking for is for the professional to try and make that knowing-in-action transparent. The relevant question is: What is the theory of action? What is the frame that underlies the judgement and the behavior that the professional is delivering?

In my own interactions with professionals, lawyers, accountants and doctors, I have tried to help them make their knowing-in-action transparent. They often find it extremely threatening, not being used to make their reasoning explicit, public and having to reflect on it.

There is always the danger, as in all of our descriptions of that kind, that the descriptions are mistaken, not fitting what we are actually doing. A different kind of education of such practitioners would make them less threatened by the experience of discovering that their descriptions do not fit.

I do not think the idea of reflection-in-action becomes a crutch for authoritarianism, as long as it is coupled with a demand that reasoning be made explicit, public and subject to examination and test.

Q: We live in a positivistic civilization, in positivistic institutions. The institutions think through us. If you are saying that you are doing work at MIT that is not positivistic, I would say that you are an idealist. What is your comment?

A: MIT is a cathedral of positivism, but it is not perfect. Not everyone follows the "dominant religion".

When you say: "the institutions think through us", that statement is in a sense true, but I think we have some freedom and responsibilities for how we chose to define our practice.

One very concrete example: How are we going to define our research in relation to the people that we think may be its beneficiaries? Are we going to define people exclusively as the subjects of the research that we do? Are we going to take the position that it will take a long time to build a theory adequate to apply to
the practice of lawyers, nurses, teachers, etc and therefore not get our hands dirty, or will we take the position that there is opportunity for a kind of mutuality between researchers and practitioners in which we can "give them reason". I think we have the choice.

What gives me courage and optimism is the sense that there are people all over the world who are choosing to do so. Some of them are in this room. There is a movement in the professional schools around the world. People are confronting these questions and are making choices about the kind of work they want to do. They are making choices on how they want to treat their own ignorance, their own uncertainty and their relationship to their institution. To some extent they are taking steps to influence the direction of their institution.

That is why I define it as a struggle. The institution does not only think through us and our thinking is not wholly circumscribed by the institution. We have choices.
Industrialized Information and Personal Knowledge
Lars Ingelstam

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Knowledge and Communication in the Computer Age

Summary

There is a common-sense assumption underlying this lecture, namely that a widening gap exists between the amount of information offered and the human capacity to receive, absorb and make use of it. A possible overflow of information in the future is a threat to the formation and care of "true" knowledge. In order to come to grips with this problem I will start out from theories about the post-industrial society, more precisely such theories that focus on the difference between the industrial mode of production and the service mode.

I then suggest how these theories would apply to the illusive "products" that are the key categories of this conference: data, information and knowledge that seem to relate in an interesting and non-trivial way to what economists have come to call services.

Finally I will discuss two aspects of the gap between information and human capacity. One has to do with the level of noise, and the other with the fragmentation - or snippeting - of information. The social and cultural effects likely to occur if the theories of information expansion give basically correct predictions, call not only for further research but for reevaluation of public policies as well.

A post-industrial society?

It seems necessary to prelude the discussion of the so-called information society of the future by a short account of the transition from an agricultural through an industrial phase of development into some kind of post-industrial future. The sequence of phases becomes very precise in e. g. figures for Sweden. (Figure 1).

![Figure 1. Development of employment in three major sectors (Swedish official statistics)](image)

We focus on the relative importance, in terms of labor, of three sectors of production: agriculture, industry and services and find that, over 100 years, there has been a gradual phasing out of agriculture, from around 80% of the labor force down to some 3-4% as of today. At the same time the level of production has increased by a large multiple. Land is being taken out of production - and still output is quantitatively adequate for the feeding of the population.

At the same time industrial work increases, up to the beginning of the 1960's. The years from 1890 to 1915 are usually regarded as the breakthrough period for Sweden as an industrial state. From the beginning or middle of the 1960's, however, the relative share of industry begins to decrease. Work in the service sector has increased steadily during the whole period. In particular in the period 1950 - 1970 the service growth was high and steady. In Sweden this is closely related to the expansion of the public sector, in particular education and various forms of care. It also coincides with

Towards a Service Economy?

- United States
- Sweden
- Canada
- Switzerland
- Germany
- Denmark
- Norway
- France
- Belgium
- Netherlands
- New Zealand
- Finland
- United Kingdom
- Japan
- Australia
- Italy
- Austria
- Post-industrial transition?
- Luxembourg
- Portugal
- Spain
- Greece
- Ireland
- Korea
- Turkey
- In Category 1, both manufacturing and intermediate employment proportions rose over the period, in Category 2, one or both fell

![Graph](image)
with the opening of the labor market on a fairly large scale to women.

One might believe that this pattern is particular to the "Swedish model" or tied to the special economic history of this country. Comparative data from several countries suggest, however, that the pattern observed has a much more general nature. The key seems to be the beginning of decline of employment in the industrial (secondary) sector. If countries are grouped in two categories, those in which industrial employment has started to go down, and those where it is still rising, it turns out that the richer (in terms of GNP) a country has become the more likely it is to be in the post-transition/post-industrial phase. (Figure 2).

The data all refer to OECD countries and strongly suggest some "law-like" behavior (1). This direction has also been part and parcel of most utopian writings on the post-industrial society, although expressed in less technical terms. It has often been said that technology will liberate men from unnecessary toil. Agriculture and industry need not take up more than a small part of the time available to the citizens.

Presently, however, the shrinking volume of industrial work more often turns the attention the other way: stressing that labor-saving technology will force a lot of people out of work. In this case the "vision" of a post-industrial future will degenerate into a dual society, where a majority might be employed full-time and enjoy the benefits of social security, while a (growing) minority has to put up with odd jobs, compensation payments and have to make up the best they can in a grey or black sector of the economy.

From the diagram in Fig 1 the expansion of the service sector looks like a very natural (and relieving) future option. Rather than mass unemployment the continuation of the trends into a service society looks natural. This would look even more promising to those who have e. g. the Swedish experience of a fast and successful expansion of the public services in mind.

A conventional wisdom puts it somewhat like this: After a country becomes industrialized, it is led along a development path that represents a general transition away from material goods production and towards services. Productivity gains in industry through labor-saving machinery allow the larger part of the labor force to go over into services.

The service society option looks both promising and feasible, at least at a first glance. In fact it may be neither.

The service cost dilemma.

When a society becomes richer, in the direct and crude sense of the word, this has primarily to do with the growth of the material basis for life: food, housing, consumer goods. In short these products have the property to become all the more easily available over time because of technical development.

The other part of the economically registered production, services, has a different relation to technical development. Basically a service provides something directly tied to the human hour: the "product" is human time in a rather straightforward sense. In an often quoted article US economist William J Baumol (2) asks us to think about a horn quintet playing a 30 minutes long piece of music. That takes 2.5 hours of human time, rehearsals and other extras not counted. Any attempt to rationalize by playing 3% quicker tempo, yearly, or sacking one player every 12:th year or so "is likely to be viewed with concern by critics and audiences alike". The service of playing chamber music is not subject to the cumulative rise in productivity so characteristic for industry. (There are other ways, however, of applying industrial "progress" to music, which will be a part of my argument later.)

What has now been said about the difference over time between industrial goods and services has, in spite of the strong simplification, a considerable value as explanation when it comes to predicting the future. (Figures 3,4.)

Abstrackly and generally stated, industrial goods tend to be less and less costly in terms of human time, and conversely human time embodied in services tends to get more and more expensive in terms of goods (and of money). This effect is rather marginal from one year to the next, but over a longer time it is
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quite shattering: as a rough average one can use a doubling in the price relation over 20 years. For some products it goes much faster; a washing machine costs no more than 15% of what it did 30 years ago. The tremendous cheapening of computers, communications equipment and consumer electronics is well known to all of us.

\[\text{Figure 3: Dynamlcs of services.}\]

Holding this dichotomy between services and industrial goods in mind, several important observations can be made about the likely and possible developments of our societies. They modify and complicate considerably both the optimistic and the pessimistic "industry futures" referred to above, as well as the service-society scenario.

A first but very general hypothesis can be formulated, namely that "services" as products will fare worse and worse on the market, unless demand for them is completely price inelastic (which seems unlikely). Many of them will eventually be priced out of economic circulation altogether. Material commodities will dominate the economy while human-based services will be pushed back.

Though this rather mechanical formulation of a post-industrial dilemma is interesting enough in itself, the analysis has to incorporate the social and cultural manifestations of it. Clearly, behavioral science theories, such as Abraham Maslow's well-known hierarchy of human needs, suggest that as the society becomes richer demand will increasingly be directed at certain types of services, rather than towards industrial goods. This induces us to think again about likely responses from the market. As services become more, and industrial goods less, expensive, then it is natural that the economic actor tries to fill needs, related to the more expensive kind of production, instead (as far as possible) with what is less dear. This tilts demand rather from services toward goods! We ought to ask whether there exist some escape routes from what Baumol (2) calls "cumulative decay" and Burenstam Linder (3) perceives as "the decadence period for growth"

Such escape routes do exist. One is the **Informalization** of services: such activities that do not survive on the market may reappear and even thrive in the unpaid part of the economy. This is possible because the prize a person subjectively would set on his own time may be considerably lower in self-chosen activities than in paid work. A more flexible organization in time and space may also work in favour of informal solutions.

Another interesting development is the movement towards a **self-service economy**. Such services that were earlier, at least in principle, available on the market (domestic assistance, washing, performances of theatre or music, simple repairs) can instead be performed in a self-service mode, in which the consumer puts in his/her own time but has the benefit of industrially produced tools (kitchen machines, washer, TV and record-player, handtools and prefabricated replacement parts). This tendency is well documented by now and is very important for the future. It becomes amplified by the fact that time available outside formal work is also likely to increase. Tools and equipment for self-service activities have improved rapidly: the market is responding to a strong economic interest on the part of the households.

The two modes now discussed reflect the fact that the "service cost dilemma" (figure 3) makes it more and more advantageous for households to perform services for themselves. Clearly, systems for taxation, social levies and transfers also contribute to the relative profitability: in the short run these also make it more appealing to provide one's own time rather than buying that of others.

The third important "escape route" is the **Industrialization of services**. This means that products that have traditionally been closely tied to human time move into a more industrial mode, opening the possibility of a cumulative increase in productivity (see curve D in fig 3). Such examples that come to mind are eating out places, office cleaning, routine bank business - and all sorts of information supply. Since the latter point deserves further attention I will return to the **Industrialization of information** later.
The information society?

It is now time to approach the ideas about information and the so-called information society more directly. The post-industrial development patterns discussed so far are based on a subdivision of paid work into three sectors: agriculture, industry and services. One can of course go on from there to identify information as a distinct category of services. But it turns out that information has such peculiar properties that it is preferable to start with the classification from scratch.

Marc Uri Porat, US economist, published a study ten years ago, in which he tried to substantiate the popular claim that a lot of what we do is really creating and processing information (4). He went through the economy of the United States with the aim to identify such economic activity that has to do primarily with information, as distinguished from physical production, transport, care etc. Information is defined in a straightforward manner: data that have been organized and are ready to be communicated. (There is no requirement that they have been received or understood; that is definitely another question!). If the economy is separated into two domains, information and non-information, Porat is able to put figures on their respective volumes.

Looking first at industry, one finds both information industry as such (including both hardware and software) and information activities in non-information industries. By adding these together, Porat finds that 46% of GNP is bound up in information activities. Counting instead labor time, and including such work that has to do primarily with symbols and information, he finds that close to 50% of all those employed are “information workers” and that their incomes add up to 53% of all labor income.

Porat’s definition is wide, and as “information workers” we find poets and telephone repairmen, teacher and designers, TV-reporters and postmen. But in this sense there is no doubt that we are already deep into an information society. To a very high degree, our paid work is a question of creating, processing, sorting and distributing information.

It is also not difficult to show that the share taken up by information is growing and has been for some time. It would be too easy, however, to simply state that this expansion will continue. Almost certainly this will happen, in one way or another, but the more interesting question is what kind of information society we can expect.

Information - a kind of service?

Some of the activities in the information sector are also services in the sense used before: produced and offered as relatively “pure” human time. This is true for education, the performing arts and other forms of culture, personal advice, bibliographic work and many others. We can name these person-bound information services.

The person-bound information services will face great difficulties on the market. For them, the service cost dilemma will be felt very directly. Such services as personalized advice, chamber music and translation, will appear as more and more expensive and partly be pushed off the market, partly retreat into niches for the very rich, or for highly specialized functions. The continuous rise of the prize level would also choke the public service sector into stagnation or decline, putting an end to the development of the modern European welfare state.

Industrialization of information services.

But just as for services in general a change of mode is possible. By industrialization one can mean applying any of the following ways of rationalization to the production process, singly or in combination:

(a) replace labor by mechanizing or automating production
(b) divide and specialize functions in the work process
(c) increase scale of production and/or size of series
(d) increase scale of distribution.

All these methods are of course used and applied in connection with information, as well as with other services. However, with a gradual change over time in the production, even changes in the “product” must be observed. We need to recognize some sort of limit beyond which the “service” could not possibly be called a service any more: when a self-diagnosing kit, bought in the pharmacy, is supposed to replace the doctor, or a videotape a live opera performance. In these cases the service has eventually become industrialized into a thing.

Whether this is good or bad or immaterial is a matter of personal and collective judgment. Psychological, cognitive and cultural aspects would have to be balanced against the possible advantages in cost. To illustrate by a few examples, I would imagine that bank withdrawal machines are considered an advantage by most, that we are highly ambivalent towards the video-culture and that finally most of us would prefer a live doctor to an expert system when we are ill.

To sum up: large parts of information production have a lot in common with industrial production of goods, in the sense that it can be technified and mass-produced. It enjoys at least the same cost advantages over
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time as the most successful products of the industrial epoch. The technical advantages reside not so much in the production in the strictest sense. In order to create the text of a newspaper, the content of a TV-program, a piece of computer software or simply a convincing concept, one still has to count on a rather fixed amount of human time, and often rather expensive such time.

The potential for rationalization lies rather in formatting, packing and distribution. This results in a cost picture that is often more "industrial" than in classical industrial mass production itself. (Figure 5.)

The fixed costs may be high, but then the cost per piece is very modest. (In parts of the economic literature this is taken to extremes and information is treated as a "free good", that can be distributed - and even sold - over and over again without being in any way depleted.)

The industrial mode of information service production, in contrast to the person-bound mode, looks very promising from a technical and commercial viewpoint. Predictions have been published that it would provide the push needed to get even industrial employment out of its present down-slope (Figure 1), give the sagging industrial economies a shot in the arm and perhaps create a new so-called Kondratieff wave (5).

On this point I think that a large dose of scepticism is warranted. The subsectors in question are not particularly large now, and existing predictions have to take into account the massive potential for rationalization and mass production which are the prerequisites for success on the markets. The net effects on employment may be positive but probably not very considerable, and have to be seen against the labor-saving potential of information technology in offices and other places of work (6).

From the technical and economic logic, however, we can predict that huge volumes of information production will be forthcoming. Many formerly personal services can be converted into the industrialized service mode, and hence enjoy the cost advantages of cumulative technical improvement. Information-related goods and services may be provided at low prices and win considerable markets.

Economic progress - and cultural change.

It is always difficult to judge technical change before it has happened, but in my view it is necessary to try. Fifty years ago some 90% of the messages received by an average grown person were personal, addressed to him and in most cases expecting an answer. Today some 90% of what we receive is impersonal, mass-produced and mass-distributed. The tendency to industrialization of services is, inevitably, linked to a degree of depersonalization when viewed from the standpoint of the user of the service. (Certain industries and organizations are certainly aware of this and attempt a pseudo-personalization in the form of direct mail and similar techniques.)

A social process can look extremely different, when seen from the side of the consumer/client/user rather than that of the producer/sender/vendor. The rest of these reflections about the information society will take their starting-point in the users’ and customer’s perspective. They focus on the effects on the culture rather than the economic and technical boundary conditions.

Information and personal knowledge.

The information environment in which all cultures and all political systems will live is assumed to be richer, or we should rather say denser, in the future than it is today. The technical conditions for sending mass messages will be excellent and varied: all the way from mailed advertisements to satellite TV. Our daily lives will be more and more filled by information.

But what happens to our knowledge, consciousness and culture in such an ever more dense information environment? The first and crucially important fact to note is that we, as human beings, are essentially the same. While the capacity for sending and transmitting information has increased 1000-fold and more through technological advance, we humans who supposedly are the recipients and beneficiaries of all this, are only as smart or clumsy as we have always been. Our limitations, in the brain and the senses, are...
biological constants over centuries. This simple truth can remind us that, as the technical possibilities expand, the advantages for society and the benefits in human terms may be very much different from what is reflected in figures of "purely" technical progress.

One elementary necessity is to distinguish between information and knowledge. While the former may be appropriately described as data that have been organized and can be communicated, knowledge is something more. For something to qualify as knowledge it has to be in some degree processed, digested and internalized by a human recipient (student, listener, reader etc). In many countries, as in mine, the official school policy has for a long time put great emphasis on the fact that turnover of information in the growing industrial state is very rapid. Knowledge became de-emphasized. Attention is now coming back to knowledge: the competence to know how and where information can be acquired is after all only one part - not the most crucial one, in my view - of the process of gaining knowledge about the world.

**Information, signal and noise.**

The distinction between signal and noise, is well known to technicians since Shannon and Weaver's basic work on information theory in the 1940:s. It has not been widely used in the social or humanistic sciences. I will follow a suggestion by professor Lars Gyllensten, physician, author and former Secretary of the Swedish Academy, who takes up the distinction between information and noise in an essay from 1975 (7). Referring to certain results in brain research he claims that "it is crucial to distinguish between the two kinds of sensory input: the passive noise and the actively perceived, sought and processed information".

This leads, according to Gyllensten, to two kinds of problems. One is that considerable work must be put into sorting, seeking, and selecting information in order to find that which is relevant. This is the stress of the privileged: those who are able to sort and who have a certain obligation to "keep informed": to integrate large amounts of information into their conceptual and symbolic pictures of the world. There are indications that an over-supply of information forces a person to so much processing and administration that it affects negatively his or her efficiency in the real task to be performed. This is the common dilemma of journalists, scientists, politicians and managers.

The other problem is somewhat the reverse: how shall people in general be motivated to sort out in a determined way real information, relevant for their own knowledge formation, from the large and noisy flow of data? Perhaps the motivation to take on the toilsome selection and assimilation is far too weak for many. Technical development and the structure of the information sector and media seem to support the tendency that information is being received in a half-hearted and uninformed way. It may become pseudo-information, noise masquerading as information.

**The information environment and "snippeting".**

My last point is also related to the growing volume of information and the ways we have to transform it into meaningful knowledge: the pedagogical problem of the emerging information society.

Start by remembering the TV news any day. In 30 minutes or less we are thrown between far away natural disasters, a new drug, the death of a famous musician, a new savings scheme for the social sector - and a number of other things. In parcels of 1-4 minutes we shall be given the essentials of what has happened in the world. The result is snippeting (a translation of the in Swedish term snufftering from snuft, meaning cut-off piece, fragment, short sequence of e.g. music). It is one of the most common forms of blocking and destroying knowledge in our time.

TV and its news broadcasts is only one example of a phenomenon which in reality has a much wider scope. Its depth and dissemination are also not exclusively a function of the spread of communications technology.

Snippeting means that information or "knowledge" appears in a number of relatively independent small parcels, modules, fragment, pieces. Examples abound. In the course systems of the universities modules covering 2, 3 or 4 weeks of study play a growing role. Often it is neither intended nor possible to establish some sort of didactic or intellectual connection between them. The mass media's distribution of news has already been mentioned. The growing flow of information from public authorities, even those most eager to inform, comes to us in a patchy and snippeted form. Advertisements and other commercial messages are intended to induce us to buy, not to create coherent information.

In the primary and secondary schools snippeting is well-known (although not always under that label). Increasingly one observes that textbooks and curricula display "an unorganized heap of details, whose inner connection mostly remains unclear" to quote a Swedish university professor.

The mass media contribute through their structure to a snippeted attitude to knowledge. Many, including Neil Postman, professor of media ecology at New York University, argue that the compulsory school must regard it as

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**Lars Ingelstam**

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one of it’s major tasks to counter the
snipping that is spread through TV to the
children. He is concerned not so much about
the contents of the programs but the very
structure imposed on knowledge by the
medium. Any compromise with the
pedagogical principles of the TV medium
appear, from this perspective, as an
abomination. Contextual understanding, toil
and text on paper should be the cultural
mandate of the school (8).

On the theoretical level there exists an
important connection between snipping and
the post-industrial dilemma described earlier.
Technical development makes it easier and
cheaper to distribute information. But more
basically, industrial progress leads to an
increase in the economic value of time. This
induces all parts of society to fill the time
available with more and more activity (9),
including information activity. Hence
snipping in all its forms can be regarded as
an expression of an ambition to "cover" as
much as possible in the time available. Mass
media, teachers, information officers,
lecturers - they all try to use, as efficiently as
possible, the time during which they can count
on the audience’s attention. In that way
overview tends to be replaced by "orientation",
learning by registration, and knowledge by
information.

This might also lead to even worse cultural
damage than superficiality. If large groups of
people are continually fed information and
impressions that are difficult or impossible to
fit into a context, they might decide that the
world is in fact incomprehensible. Reality
does not form a meaningful whole, and there is
really no point in trying to make it make sense
either. It seems to me that this might lead to
very serious damage to the culture, and lead the
way lead towards fascism or apathy, or both.
This fact alone, would be a strong case for
intensified research on knowledge and
communication in the computer age.

Notes and references.

1. Gershuny, Jonathan: After Industrial
   Society: The Emerging Self-service Economy.

2. Baumol, William J: "Macroeconomics of
   Unbalanced Growth: the Anatomy of Urban
   Crisis." The American Economic Review, Vol

3. Burenstam-Linder, Staffan: The Harried

4. Porat, Marc Uri: The Information Economy.
   U S Department of Commerce, Washington DC,
   May 1977.

5. Some of the best discussion on this matter
   has been initiated by the Science Policy
   Research Unit at the University of Sussex, UK.
   for instance
   C Freeman (ed) Long Waves in the World
   Economy. London 1983
   Gershuny, J and Miles, I: The New Service
   Economy, London 1983

6. Leontief, Wassily and Duchin, Faye: The
   Future Impact of Automation on Workers.

   1973:23.

8. Postman, Neil: Teaching as a Conserving
   Activity, New York 1979, and Amusing

9. In fact this is a strong simplification. We do
   not know very much about the mechanisms
   that make the increasing value of time, or
   rather it’s manifestation as “rush”, spread to
   other areas. Some ideas are found in
   Burenstam-Linder (note 3) and Hirsch, Fred:
Questions and Answers

Q: Your point or thesis is that we are the same as we used to be. Our biological capacities to handle information are the same. We have not changed in these respects. I do not think that is true. It is true that biologically we are the same, but I do not know if it is true that we use our biology in the same way. We have done lots of things with our intellectual capacities, which have expanded our capacity to handle information. The move from an oral culture to a culture of writing is such a move that expanded our capacity to handle knowledge in a tremendous way and which has nothing to do with our biology.

You say that the amount of information is so huge now we have to get it in snippets, and that there is a danger of us drowning in those snippets.

It seems to me as if you are saying that educators should be called upon to shut out information from their students. That it is dangerous for the students to get too much information. Don't we have a moral obligation to keep informed of what is happening in world?

A: I think we are far beyond what is pedagogically and psychologically reasonable. You speak quite lightly of us having a mental representation in which we can really fit in all the snippets. All the information about other planets, molecules and uprisen in Kuala Lumpur or whatever. That is simply not true. This is why I try to argue for a different paradigm, a different framing of this problem of snippetting.

I can agree with you to some extent that for people like us it is a moral obligation to keep informed. We can cope with it. We have all these tools available.

There is, however, still the question of mental representation. It is not just a problem of chunking, it is a question of ordering and structure. My argument although brief is that we are beyond the point of being able to handle all the snippets of information. For reasons that have nothing to do with the volume of information and really nothing, or very little, to do with the structure of knowledge as it is given to us. I think in a way it is reasonable to shut out information. At least abandon the practice common to all teachers that on all levels down to the first grades push more and more, shorter and shorter pieces of information into the curriculum. It is suboptimal, it is wrong and it does not produce the type of learning we want. It is immoral from the same standards that you say it is immoral not to know everything.

Q: Who should hold, steer and control the networks of information? Is it the enterprises, the banks, IBM or the librarians in the world who should steer this big network of information? How about the pricing of the ware "information"? Will it have a very high price? Will anyone be able to buy it? What should the society look like? Do you have any comments?

A: Parts of this cuts into, I hope, the next lecture by my colleague Thomas Söderqvist.

I think you picked up the right questions: Who is controlling information? Is the state loosing out? Is the community of intellectuals loosing out? Are we all "priced out" of the market? Is it correct that university professors should be compared on the market with chief engineers of industry? What types of economic comparisons will be reasonable? Will it be reasonable to seal off certain sectors and hold them outside the economic type of evaluation? Is that possible at all?

It has been a hope that a social unit like the family will be sort of sealed off from the normal workings and logics of the market. It has not been very successful either. Sometimes one can be rather pessimistic about who sets the standards. Some of the things I have showed make me sad. They make me willing to join forces with professor Weizenbaum in private resistance. Hopefully even collective resistance but at least personal resistance.

Do we have an information technology policy at all which takes the culture dimensions into account, even the elementary ethical principles we have suggested? I think not. I think both research and practice are grossly technocratic and should not be. We all have to fight for that in contexts like this, and if we can, on the open political arena.
Thomas Söderqvist

Knowledge is Power
A critical Approach to the Information Society

Thomas Söderqvist

Thomas Söderqvist is PhD in Theory of Science at Gothenburg University. He is an associate professor at Roskilde University, Denmark. He has a particular interest in the history of and conflict in the information society. Editor of "Intellectuals, Universities and the State" (1987).
The topic for this session is the relation between knowledge and power in the information society. To be sure this is not a much discussed topic in the growing literature on the information society. You can find hints to it in the literature here and there, but you will not be able to find any serious and comprehensive treatments of it. Most people talk about the earthily paradise that could be created by means of computerized communication networks and automatized production. And when they talk about the negative aspects of the information society, they concentrate upon seemingly more substantial issues - such as problems of personal integrity, structural unemployment, or the risk of loosing what has been called "tacit knowledge". So, people write a lot about "know-that" and "know-how". But very little on "know-pow".

Before going into the knowledge-power business, however, I would like to spend some time on the information society itself. What is an information society? What kind of an animal are we dealing with? And what does it mean to explain that animal? What is the most fruitful scientific approach to the information society? Should we look at the structural level, or at the level of individuals? The answers to these and related questions are not without importance for our understanding of the topic of knowledge and power.

As you have noted, the notion of an information society has been with us for quite a long time now, and it has been used in a number of meanings. Some have used it as synonymous with a society dominated by [whatever that means] the use of computers for processing of large amounts of data. Others have [quite rightly] pointed out that all societies, throughout all history, can be characterized as information societies on the plea that processing data about our natural and social surroundings is the differentia specifica of human civilization.

Talking about an information society in the second and more extensive sense makes the notion somewhat meaningless. We might as well talk about human culture. Talking about an information society in the first, restricted sense makes the notion of an information society a little too fashionable to my taste: After all, computers can only speed up the kind of data processing which was earlier dealt with by means of pen and paper.

To solve this problem of definition I will draw your attention to the old wisdom known to philosophers of science: that knowledge has logical priority over data. They say that data can neither be stored, nor retrieved without a knowledgeable human subject, who decides which data should be inputted, and how the output data should be utilized. So knowledge is the crucial variable to consider here. To my best understanding, we should substitute the notion of a knowledge society for the notion of an information society.

Having made that definition we encounter a new problem. Is the animal concrete or abstract? Should the knowledge society be understood as a stage in the history of mankind, or is it just a theoretical construct?

I have a lot of respect for those authors, such as Alvin Toffler, who have hazarded the vision of a new stage (for example a third wave) in human evolution. And I would be happy to spare some of my retirement years, thirty years from now, on re-reading history trying to reconceptualize modern history as the rise of a knowledge society. I even have some ideas how one should proceed. For example, I think one should start with the emergence of the universities in the late Middle Ages, continue with the rise of printing and book distribution, and the rise of a centralized state administration, population censuses, and end up with the establishment of mass education and mass media during the 19th and early 20th centuries. In that historical perspective, which I think is the only reasonable one, computers will be referred to in a concluding footnote, a large footnote, but still a footnote. So, parenthetically, I have just abandoned the notion of a computer age which this conference is based upon.

To make a historical treatise of this kind (which, by the way, is the task for a whole bunch of historians) would correspond to what two generations of post-war historians have been busy doing when tracking the rise of modern, capitalist, industrial society. With one important exception, however. Marxist historians have seen the key to society in the way people produced. The worker was the subject of history, either individually or as a collective, as a working class. When writing the history of the knowledge society we should instead see man as a reasoner, knowledge-producing man as the subject of history. Man as creator of knowledge institutions.

When writing history the animal is a concrete one. But the whole enterprise rests on another, implicit understanding of what we might mean when talking about the knowledge society, namely an abstract, theoretical object. To continue comparing my approach with Marxism might help to illuminate this point. Marxists write history, they think of a "mode of production" as the theoretical construct by means of which they can pinpoint the most essential features of a society. "The mode of production" has no existence in the real world. It is somewhat like the strings and balls of Newtonian physics. But the Marxists also talk about a "social formation", which is the real, existing, complex society out there, e.g., Sweden in the 1980's, somewhat like the real existing apples and planets in the Newtonian analogy.
Thus, we could distinguish between the knowledge society in the concrete, historical sense, corresponding to the Marxists' "social formation", and the knowledge society as a theoretical construct, corresponding to the Marxists' "mode of production". A Californian historian, Marc Poster at the University of California Irvine campus has, by the way, claimed the concept "mode of information" for the information society's correspondence to the "mode of production".

But I am not very happy about the concept of information. It is too ambiguous. It can refer to objective, physical information, which gives too many associations to computers, and it can refer to something subjective, "the knowing subject". I do not like this ambiguity. I would prefer to use something else. "Mode of knowledge" sounds silly. Gernot Böhme has suggested "the knowledge structure of society".

When talking about the knowledge society from now on I will talk about it in the abstract sense. That also means that the knowledge society is really a knowledge society. It only makes sense if we ignore all economic, political, social role etc. categories. That is what I call a sui generis (literally in its own making, or in its own terms) analysis of the knowledge society. Of course, when talking about the knowledge society in the concrete sense, as a social formation, we must, of course, consider other variables, such as economy, politics etc. But that is another problem, which does not have to bother us here - remember the balls and strings of Newtonian physics.

What I have said so far (that the so called information society should be considered as a knowledge society, that it should be treated as a theoretical construct, and understood in its own making) is important to bear in mind when we discuss the topic of knowledge and power. The idea of knowledge class conflicts, knowledge stratification etc. which I will return to, rests upon this. Before getting there, however, I will shortly take up yet another problem, namely that of anchoring a structural theory of the knowledge society in a theory of knowledgeable man, Homo cognitans.

Those of us who came to the universities in the 1960's and 1970's were socialized into an explanatory framework that emphasized functional and structural explanations. Parsons's theory of social function, with its emphasis on normative structure, is one example. Marxism in all its varieties, with its emphasis on explaining events with reference to the "need of capital" etc. is another. And if we succeed in establishing a theory of "the knowledge structure of society" that would be a third example.

This is not the way things are explained in the natural sciences, however. Modern genetics, for example, earns its success from trying to find explanations for complex biological structures and functions at the molecular level. In the social sciences this approach has been called "methodological individualism", not to be confused with ethical individualism. In the radical version of methodological individualism, statements concerning phenomena at the level of society are to be translated into statements about events concerning individual human beings and their face-to-face intentional interaction.

I think it would be fruitful also to try to behave like methodological individualists when we approach the problem of the knowledge society. That is, the emergence of knowledge and information institutions, the educational systems, the research system, the publishing world, the media etc. should not be explained with reference to their "internal structure" or "function in the knowledge society", but with reference to the intentional actions of knowledgeable human agents in face-to-face interactions.

Of course, this is not a new invention in the social sciences. This is what George Herbert Mead and the symbolic interactionists, and more radically, Alfred Schütz and the social phenomenologists, and Garfinkel and the ethnomethodologists have been claiming for decades now. The reason why I make the point here is, of course, that so far we have seen no attempts towards this kind of explanatory strategy in the literature dealing with the so called information society.

Neither Mead, nor Schütz (but perhaps Garfinkel) knew about cognitive science. If they had known, I am sure that they would have considered the findings of cognitive science, including cognitive psychology, a most interesting attempt towards a methodological individualist understanding of the knowledge society. After all, cognitive psychology and artificial intelligence research have provided us with a powerful explanatory framework for dealing with Homo cognitans. I say this with some hesitation, because I know, as well as you do, that cognitive science has severe limitations - it makes so many simplifications (for example, it excludes the whole area of emotionality and the embodied character of human interaction), that, like all scientific theories, it may be of limited use for a deeper understanding of what it means to be human. Nevertheless we can not escape cognitive science - and we should try to see how far we can use it in formulating an explanatory programme for the study of the so call information society, alias knowledge society.

So far I have tried to define the so called information society, and I have offered two possible explanatory strategies by means of which we can approach it - a structuralist and a reductionist. Now I am ready to go into the
main topic of this session, that is knowledge and power, the "know-how" problem. Already Francis Bacon claimed that knowledge is power. But what do we mean by that? There are many definitions of power - I want to stick to the one that sees power as a relation, in which one party, willingly or unwillingly restricts the other party's ability to act. Action is a wide concept. It can mean physical action, it can mean economic action, political action etc. Correspondingly we can talk about physical power (violence), economic power, political power etc.

Is knowledge also action? Usually we think of knowledge as a store of concepts, hypotheses and theories about the world. Knowledge is stored in books and in heads. But we can also think of knowledge in a way similar to the way modern linguists think of language. After Austin and Searle it has become common wisdom among linguists to recognize speech acts. To speak is to act.

Similarly knowledge is action. Of course, already the American pragmatists knew that. And phenomenological philosophers, such as Husserl, took the existence of acts of consciousness, such as acts of perception, acts of memory, acts of fantasy etc., as the foundation for their philosophy of intentionality.

But if knowledge is action, it is also power. Let's consider two actors, A and B. For some reason, e.g. better education (formal or informal), A is better able than B to conceptualize not only his own sensations, but also the sensations of B. Stein Bråten of the University of Oslo has tried to understand relations of this kind in cognitive psychological and cybernetic terms. He starts to assume that two actors can have what he calls different model strength. When they interact in an open information exchange system, the actor with the higher model strength will increase his model strength at the model-weak actor's expense. This is the cognitive counterpart to the Matthew-effect: "Unto everyone that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath" (Matthew 25:29).

Similarly, family therapists have given a lot of terrifying examples of what happens when one member of the family conceptualizes, interprets, theorizes about another member of the family. Those of you who saw the movie "Family Life" in the early 1970's know how the mother set the stage and defined her daughter's reality, including the most intimate details. As a result the daughter "disappeared", so to say, as a person.

Family terror is a nasty example. But communication scientists can give ample support to the general picture. In the Department of Communication at this university they study powerful communication in courtrooms. They see power in courtroom dialogue as the control of a major part of the territory that is to be shared by the parties. This is done, for example, by the sheer amount of speech: he who dominates is the one who talks the most. Or by what they call topical dominance: the powerful party determines what topics should be treated. A third way of exercising control is when someone manages to direct and control the other party's actions by asking questions.

The kind of empirical work being done on this problem here in Linköping by Per Linell and Karin Aronsson and their students could, in my opinion, serve as a paradigm for future research. What is most fruitful is that they lean heavily on the ethnomethodological tradition of analyzing situated language action - I referred to that a few minutes ago. It is fruitful, in my opinion, because ethnomethodologists have understood that the problem of power in conversations must be analyzed according to the sui generis (in its own making) criterion which I discussed earlier. Conventional sociolinguistic studies of language and power believe that discourse power derives from power statuses acquired outside conversation (e.g., economic power, or political power) and drawn into the conversation as a resource. John Heritage, in his extraordinary lucid account of ethnomethodology, points out that this is an unnecessary stipulation. Summarizing a number of conversation analyses he says: "It is through the specific, detailed and local design of turns and sequences /in a conversation/ that 'institutional' contexts /for example, power/ are observably and reportably - e.g. accountably - brought into being". And he continues: "Notwithstanding the panoply and power of place and role, it is within the local sequences of talk and only there, that these institutions /for example, the institution of power/ are ultimately and accountably talked into being" (Heritage 1984:p290).

I have spent some time on this, because I find it very important as a programmatic statement. But once we have embarked upon an empirical analysis of locally designed power relations, we are faced with a problem which the ethnods have not been able to solve so far, namely the problem of the relation between microstudies of conversations and descriptions of society. It's nice that we have achieved a methodology for studying knowledge-power relations in courtroom settings, in classrooms, in television broadcasts, at political meetings, in man-machine interaction etc. But how do we come from there to the power structure of the knowledge society? And what do I mean by the power structure of the knowledge society?

Let me once again make a comparison with the Marxist analysis of the capitalist "mode of production". Marx claimed that specific production relations are related to the mode of
production. He identified these production relations as the relation between the bourgeoisie (the capitalists) and the wage earners, that is, the two major classes of capitalism. Economic power in capitalism equals the power of the bourgeois class. Although this analysis may have been valid 50 years ago, I don't believe it is today. But I believe that the general form of his class analysis is still valid. So, we can discern a corresponding set of class relations in the knowledge society (in the 'mode of information' as Marc Poster would have it)?

In fact, several attempts have been made to understand the relation between knowledge classes, the "knows" and the "know-nots" as an American anarchist, Max Nomad, called them in the 1930's. There is a long tradition for seeing intellectuals and the intelligentsia as a "new knowledge class". There are many ways of conceptualizing this class relation: Helmhut Schelsky talked about the antagonism between "die Intellektuellen und die Anderen", Alvin Gouldner tried to describe the intellectual class as sharing a culture of critical discourse and modelled the class relation on Basil Bernsteins distinctions between elaborated and restricted language codes. In our recent volume titled "Intellectuals, Universities and the State in Contemporary Western Societies" we have tried to give a comprehensive picture of the research done in this field.

I will not go into detail on the issue of the new class for example, the theory of the new class is ambiguous, because most contributors of the field confuse intellectuals as a pure knowledge class with their associated economic and political privileges. I will only conclude that, so far we have not been able to formulate any consistent theory that can bridge the account of knowledge-power on the level of society (for example, a theory of intellectuals), and accounts of knowledge-power on the level of face-to-face conversation, for example, courtroom conversation. I think that many of those who work in this field would agree with me that being able to bridge these two levels of description is a most pressing research problem - and if we could formulate such a theoretical bridge, it would be a great step forward to a unified understanding of the knowledge society.

Having come so far in my lecture I might stop. But I would nevertheless like to make a few concluding remarks on the problem of reflexivity. Imagine that it would be possible to establish a logically consistent and empirically well-founded theory of knowledge-power! Imagine that this theory becomes as popular as Marxist theory was in the early 20th century! Would that be counted as a step towards emancipation from the knowledge-power regime? Or would the attempt to establish such a theory only strengthen the existing power pattern of the knowledge society?

Surely, people have done some serious thinking about this problem. Michel Foucault, who invented his intellectual energy in examining, through historical case studies, how the knowledge-power regime has colonized larger and larger spheres of human conduct (the prison system, the history of sexuality etc) was very much concerned not to establish a theory of power, because that would, in his view, be a contribution to the objectification of man. Members of the Frankfurter School, such as Theodor Adorno and Max Horkheimer, were also aware of the dark side of the Enlightenment, although, in contrast to Foucault, they put their faith in a Self-Enlightenment, that is, a rational discourse that is able to cast light upon its own dominance function.

My own position on this problem is not fully developed. As you may have realized I don't believe that institutionalized schooling, education or research can lead to an emancipation from the power of knowledge - they are institutions for the maintenance of the knowledge-power regime. On the other hand, I don't believe in a Pol Potian crushing of intellectuals and their knowledge centres ether.

One avenue of action would be to support alternative forms of knowledge and education, modelled on, for example, Summerhill or Montessori principles. But alternative knowledge centres will probably remain marginal. I think the strategic problem for the resistance against the knowledge-power regime is how to expose the essence of intellectual power - the idea of objective knowledge. Do not misunderstand me, the illusion of objective knowledge is a wonderful, and quite useful illusion. We can lean upon it for inventing new species by gene splicing, and for splitting the atom. I think that the idea of objective knowledge is one of the most beautiful constructs of the Western civilization. At the same time, however, it is exactly this construct, or illusion as I prefer to call it, which becomes effectual when knowledge becomes powerful action.

There are communities where knowledge power is powerful, but where all the members of the community have approximately the same capacity for dominating each other, they balance each other. These are the communities that Alvin Gouldner called "cultures of critical discourse", i.e., the communities of the different scientific specialists, the communities of authors, physicians, journalists, men of law, etc. What constitutes these communities is, among other things, that they all know how their knowledge is in fact produced. All molecular biologists know these small tricks one has to use for producing knowledge claims.
out of columns of figures and excerpts from scientific articles of their colleagues. All physicians know how tentative a medical diagnosis is, and they all know the tacit rules you must go by. All journalists know how to piece together fragments of interviews with international news agency telegrams to create a good story.

Ordinary people do not know that. They believe that men and women of science somehow "detect" molecules and stars out there, and that journalists report on "what is". Once again I want to draw on the findings of ethnomethodology. Because what the ethnos have shown, very convincingly I believe, in their so called "laboratory studies" (and I am thinking of Latour's and Woolgar's, Knorr-Cetina's, Eric Livingstone's and others, including Garfinkel's own works) - what they have shown is that objective, rational, formal, and impersonal knowledge, is something that is produced and grounded in a local, contingent and historical setting.

Once people understand that what all these kinds of intellectuals refer to as objective knowledge is nothing but human constructs, the knowledge-power regime will crumble. If we were able to demonstrate, on a large scale, that knowledge has a human, subjective origin, I think that we would be able to dismount the power base.

So I think that the ethnosc, together with different brands of constructivist thinkers, are on the right track. I have only one, but very important point of criticism to make. It has to do with the fact that they are convinced Certesians, and that they believe that man, when he produces objective knowledge, is a rational being only. So what I miss in the ethnosc and the constructivists' deconstruction of objectivity is an understanding of the emotional and embodied character of knowledge production. I would rather like to see them taking a Pascalian standpoint.

What do I mean by that? I will not go into detail. My time is gone. But I usually end my lectures nowadays with some music - and for all you ethnosc here today - there are at least a handful of you gathered here - I have chosen to play an excerpt from Laurie Anderson's soundtrack "Late Show" to show what I mean with a Pascalian standpoint. It's Laurie herself on the keyboards, and it's William Burroughs who has supplied the voice:

"Listen, listen, listen ... listen to your heartbeat."

Reference:

Questions and Answers

Q: What you have said is essentially a "recipe" for how to take on the information society. Included in this general "recipe" is a number of methodological "recipes".

My commentary concerns how you brush computers aside. You said that computers will only be afforded a footnote in the story about the knowledge structure of society. One of the arguments you offer is that computers only affect the speed in knowledge production, the speed of procedures that was formerly done by pen and pencil.

I think, however, that this is not exactly true to your "recipe" of studying the knowledge structure of society in analogy with the Marxist concept of "mode of production". It seems to me that computers have something important to do with the forces of knowledge production. Computers are the instruments of detection and computation. Marxists stress heavily that the forces of instruments of production are of extreme importance in understanding what a "mode of production" is and where it goes. The enormous, physical opportunities for increasing detection capacity, computation and access systems to knowledge seems to me to be of great importance, so within your framework of a knowledge structure of society, computers should be important.

A: What I think is important is the problem of where computers fit in. Should computers be put into focus?

I would like to decenter computers, take them out of the picture. I am afraid that too narrow a focus on computers as tools, sets aside what I think to be the more basic kind of questions. Questions like: how can we conceptualize knowledge relations between people, how we can conceptualize these as power relations and what remedies there are against these kinds of relations? After having found a way of dealing with those questions, I think we can put the computers back into the picture again.

In a way I think you give me right. I said that computers just speed up what was made by pen and pencil. You used the words increasing access to data bases, increasing computation - but what is that if not computers speeding up what was formerly done by pen and paper. I think the problem is whether we consider computers as something qualitatively new, adding to knowledge relations and knowledge structures of society, or whether they are adding quantitatively to something else, perhaps more important to understand before we look at computers. That is my basic argument for why I want to brush computers aside, why I do not want take them as the central focus of my discussion.

It does not mean that they are not important. They are very important for our lives, but they are not that important in our explanation of what is going on.

Q: You compare your approach with Marxism, but Marx had the task, not only to analyze the society, but also to change the society. My question then is: which interests are the new class defending, which interests should the dominated class achieve and what are their interests in this struggle?

A: What I think is on stake is the privilege of defining the world, the privilege of saying: What is out there? What is in here? The privilege of having access to the frames, the schemes, the metaphors, the theories, the concepts, different kinds of knowledge etc. To structure the world for others through different information channels like video, television, newspaper articles, conferences or books. I think that is on stake. It is not economic or political privileges, simply the privilege of being able to define the world.

But there are problems, not everyone can tell what the world should look like or what should be done about it. I think the only way towards a solution is to show how the recipes, metaphors, concepts, theories, etc are situated in the local contingent historical production of those people who bring them forth.

Q: You said something about knowledge power which made it sound just like physical power. It was as if there were no connections to political power, economic power etc. Does not this power have an institutional base? If it does, is that base not to a large extent a political base? Who are the people with knowledge power in our society if not the ones that by political or economic powers are invested with knowledge power?

A: That is a good question. To my best knowledge what we call economic power, legal power or political power can be reduced to either what I call knowledge power or physical power. These are the two basic forms of action that restrict other people’s actions. From these two bases we can derive both historically and institutionally what has been known as economic power, legal power etc.

Let me take political power as an example. Political power rests to a large extent on the politician’s or the leader’s ability to getting believers around him. He has to act in a way that make people find his statements being true. This kind of power is based on a relation between somebody who says how things are and somebody who believes that these things are true or morally right.
There is a discussion whether economic power or political power exist in itself as an independent concept. I do not believe that is true. In the end, I think, these concepts can all be reduced to or understood in terms of either physical power or what I have here called knowledge power.

Q: I am a little uneasy about the methodological individualism or reductionism that you propose. You argue that the best way to tackle the idea of the knowledge society is to start on the microlevel in the general attitude of methodological individualism and to somehow bridge the gap and arrive at a macro-theory of the knowledge structure on a society level. I am not sure if this is possible and whether it is a good recipe to be a consistent methodological individualist.

Instead of reductionism or methodological individualism I would rather propose some kind of methodological pluralism. A pluralism where we switch from the collectivistic stand to the individualistic stand in relation to what we are focusing on - be it the emergence, the actual production, or the use or reproduction of knowledge.

A: Maybe I was not too clear on this point. Your idea of a kind of pluralistic attitude would be my choice, too. The problem is how to balance a more structuralist or collectivistic approach with a more individualistic approach and make them fruitful towards each other. One would need to find bridges, build bridge concepts and bridge theories between an extreme individualistic approach and a more traditional structural or functional approach.
On the Status of Knowledge in the Information Society

Joseph Weizenbaum

Joseph Weizenbaum is Professor of Computer Science at MIT. Inventor of the famous natural-language processing System ELIZA. He completed his well-known book "Computer Power and Human reason" (1976) while a fellow of the Center for Advanced Study in the Behavioural Sciences at Stanford, California.
Knowledge and Communication in the Computer Age

I think that from the very beginning, which is to say thirty years ago, we in the Western society have vastly exaggerated the importance of the computer. I also think we do so now. You probably wonder how anyone can say that the computer is not as important as we think.

Let me show you what I mean by using as an analogy the steam engine. We know that the steam engine, and here I am using a shorthand, that the steam engine caused the industrial revolution. We also know that the industrial revolution really did make an enormous difference and revolutionized the world. It certainly was not true; say a hundred years ago, that there was a large cry in the society, even among the educated, that children had better study thermodynamics because of the importance of the steam engine.

Let me give you another example. A hundred years ago it became possible to send a telegram from anywhere to anywhere else in the United States. I can easily imagine that some people said, "This is a revolutionary development. We are entering a new age - it is the communication age. The telegraph is really going to change our society. The ability to communicate more or less instantly will change our society in very important ways. Our children are going to live and work in a very different world than the one that we adults have lived in. Therefore everybody have better learn Morse code".

I think that is where we are today with respect to computer languages.

That is the sense in which I think that the computer is not all that important. On the other hand, and that has to be said too, the computer is of crucial importance in certain respects. For example as a metaphor. Until the computer came along the Newtonian metaphor, the mechanical metaphor dominated. Many people, including physicists, did not think that they understood a certain phenomenon unless they could imagine it in some mechanical analogue, with rods, gears and pistons.

Now the idea of the computer has taken over. It is becoming the dominant metaphor. One can see the computer entering our daily language. Another example of how important the computer metaphor is, is that it is chiefly responsible for breaking the iron hold that behaviourism had on American academic psychology until around 1955. The computer has brought along another way of thinking about thinking that has a much more explanatory power and is much richer than behaviourism.

There is a lot of talk about the computer age, the information age and the information society etc. That is exaggerated too, I think. There is a population, a group of scientists, perhaps I should say academics, who really believe in the computer age. Who in a certain sense really believe in the computer.

I am conscious of the remark that there is no such thing as the computer. However, there is also no such thing as the monolithic communist conspiracy to conquer the world. Nevertheless, the monolithic communist conspiracy to conquer the world, although it does not exist, dominates American politics and has done so for a very long time. In other words, it does not matter whether the thing actually exists or not. Indeed there are many people who make a very good living playing the monolithic communist conspiracy game.

I think the same thing is true about the computer. There are lots of people who make a good living keeping the idea of the computer alive.

I am talking particularly of the artificial intelligence community. They apparently have come to believe that they have won. In a certain sense I think that they have. They are celebrating their victory in books like "The Fifth Generation" by Edward Feigenbaum and Pamela McCorduck. A statement appears near the beginning of that book that is very relevant to what we are talking about here. That statement is "The essential thing about the computer is that it produces knowledge". Later it says that "in the near future the computer will be the main source of knowledge and even wisdom in the society".

I find those statements astonishing. For a professional computer scientist to say that is approximately equivalent to a professional physicist saying that an atomic energy plant produces energy. Of course it does not do that. What it does is to transform one form of energy into another form of energy, and a computer transforms bit strings. In any case, there is an enormous momentum that has been started by perhaps a rather small group of people.

Data and information

It seems to me, and I think that other scholars have said the same thing, that data becomes information in the light of a hypothesis.

Let's take the New York telephone directory. It is full of names, telephone numbers and addresses. It is full of data. That data becomes information in the light of a hypothesis. Suppose, for example, that I conjecture that Armenians tend to live near one another. They gather together in a clan. I can use the N Y telephone directory with the knowledge that Armenian names almost always end with "ian". Saxnian for example. I can go through the telephone directory, perhaps best with a computer and make a list of all the addresses of people whose last names end with -ian. I can then go through that list and see whether my hypothesis was right. What this means is that

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the kind of transformation of data that goes on in order to make information out of it presupposes resident knowledge. I have to know something in order to be able to do that. The question that I am putting forward to the data is like a hypothesis. The question itself very often reveals just how much I already know. That makes the idea of knowledge stored in computers somewhat problematical. I do not suggest that it is an impossible concept. Not at all. Knowledge is stored in computers in a form of programs and fragments of programs and sometimes even in the form of hardware.

The point that I want to pull out of this is that the way knowledge is put into a computer clearly reflected someone’s hypothesis. It is not simply piled up in there. The point is that the user, the ultimate interpreter of that what we now call output is in a relationship with the people who put knowledge into the computer.

One of the things that happens with the organization of knowledge in computers is that the organization itself, that is the whole system, very rapidly becomes incomprehensible. I do not say “not comprehended”. I make the much stronger statement that such systems are incomprehensible. No amount of effort now can make them comprehensible. In part, this is because a large scale organization’s data, information and knowledge is a function of its history, and it’s history gets lost in the very act of its construction.

Reproduction of digital Information

Another property of these systems of considerable importance is that they may be copied. One can also make copies of the copies. When copying, say a cassette tape of a piece of music, it degenerates slightly with each copying until finally it can not be heard at all. The reproduction of digital information is absolute. In a certain sense it makes that organization immortal. Let me clarify what I mean.

I can take a computer that I might have obtained years ago and at some point take out one of its memory boards and replace it with something else. Something digitally equivalent to what I started with. I have now changed the computer, but, in terms of its digital description, I have not changed it at all. I can take out another board, perhaps in this case something that does not particularly have to do with storage and change it with a digitally equivalent board. After half a year it is possible that there remains no remnant of the original computer at all. I have replaced everything but functionally it is still exactly the same computer, that is, its input - output behavior has not changed at all. It still has the same, exactly the same logical description. I can build another computer on the basis of that description that will then be logically identical to the original. It will not have deteriorated in the copying. Digital information is infinitely copyable without deterioration.

Today we are digitalizing communication. That means, for example, that I can speak into a telephone and the other person hears me not in terms of analogue waves that go up and down to reflect the tone of my voice, but in terms of numbers. In terms of a whole string of zeros and ones which represent, let me say, the presence and absence of pulses. A compact disc is such a recording of music. So when you have a compact disc, of say Mahler’s second symphony, that music on the disc, is a number. It is a number of zeros and ones and it is very, very long. If you copy that number exactly then you will get another perfect reproduction of what’s on the first disc. Without any deterioration. There is a kind of deathlessness and immortality about that that I think will have some effects.

Quantization

The computer tempts us to engage in quantization. Quantization is not the same as quantification. Quantization is making little quanta of things, little packages of things. In the computer age and in the information society information is parcelled out to us in little packages. In the TV news, for example, things come at you for thirty seconds. Perhaps you get the news of an aircrash somewhere and during the next thirty seconds. If in the United States, you might very well have a commercial advertising soap. The next thirty seconds you are likely to have a detailed explanation of what Gorbachev said yesterday. These things come at you in little quanta. But these quanta are absolutely unrelated to one another.

I think what has happened and is happening, is that we are getting into the habit of quantizing in the social realm as well. We tend to not think of people being indistinguishable for one another or one person being closer to another person than any other.

We witness an ongoing quantization and an increasing abstractness of everyday life.

Simulation

In our schools children see simulations of physical events. I am thinking of a particular experiment that I saw in which the behaviour of a wire was being simulated. An English physicist named Hooke who discovered what is now called Hooke’s law, which says that, if you put a weight on a wire the wire will stretch a little bit. If you put the same size weight on again, the wire will stretch just as much as it
did before up to a certain point beyond which it stretches more than it did before. In other words the stretching of the wire, its elasticity, is not linear. That is Hook's law.

What I saw was a simulation of this. The children watched a big screen showing a wire and a tray of weights. One weight after another was hooked onto the wire and we could see it stretch a little bit each time. In the corner of the screen a graph was being developed which showed with each unit weight how much the wire stretched. The graph developed as a straight line. But after a while, it started curving up. That was when the nonlinearity came in.

At some point a child in the class said that he did not understand. The teacher's response was to start the simulation over again. The simulation showed exactly the same thing but at the point at which the child became confused, the simulation was stopped. Then something could be explained.

Two things about that are vital to what I am trying to say here. One is that in that classroom, or certainly in the school building one could have found a wire, a hook and some weights. Why simulate this experiment when, in fact, it can be done in reality. Secondly, when the experiment was repeated, it came out the second time exactly as it did the first time. Nature is not like that. If, in a high school chemistry class you ask the children to do an experiment and write a report and if they all come in with reports corresponding exactly to the theory, then you know none of them has performed the experiment. Nature just is not like that. I think that there is an idealization going on, an abstraction that has consequences. Children in fact do not learn reality from this.

Terminology and credos

Let me now talk a little bit about redefinition of terms.

Life and living: Sherry Turkle tells us that children think about it differently now than they did before. They have a new standard of comparison, perhaps.

Thought and thinking: The artificial intelligentsia tells us that there is no aspect of human thought or of human thinking which is not subject to computability.

The terms of audience, image and reality virtually drive our foreign policy in the USA. If the President does or does not do something it is discussed in terms of what message he wants to send, to what audience and what it does to his image.

The connection between lying and computation is terribly important. The computer is said to contain knowledge and consequently, what one finds out from the computer is true and dependable. It turns out that it is very easy to put information into the computer, but stuff that is not true, but stuff that will compute to something, which turns out not to be true.

The brain and the computer: One of my colleagues has said many times, and keeps repeating it, that "the brain is merely a meat machine". The body, the human body, is merely the peripheral equipment. Consequently the body is essentially irrelevant when it comes to questions of intelligence and thinking.

I will stop with that list and instead get to the credos of our time.

Herb Simon, one of the really great and important pioneers in artificial intelligence and computation in the United States, has in a response to me, and to the sort of things I say, said that knowledge is better than ignorance. Surely that is true. What is left out, however, is the question: at what price?

For example, we are very interested to know how the brain actually functions. We want that knowledge. Having that knowledge would be better than being ignorant of that knowledge. We are not however, willing to subject every third baby born in hospitals in Boston to open brain surgery even if that could tell us how the brain functions. Not knowledge at any price!

Participation is better than passivity. This generally refers to some thing that one either watches or that one participates in. It does not say anything about what that thing is. Are all things better participated in than watched, for example? Are there any other alternatives? Other than simply participation or watching.

America adopted the television set as the great baby sitter. Children sit in front of the television while their parents are busy somewhere else for hours at the time. Along comes the computer game. Children used to sit in front of the TV passively watching a submarine captain sinking a freighter. Is it not better that with the computer game they can be the captain, they can fire the torpedo that kills all those people?

Faster is better than slower. The question is, better for what? IBM recently completed a computer that is not for sale and will probably not be marketed for a long time. They call it GF11. G stands for giga which means ten to the ninth power and the F stand for flops. A flop is a floating point operation, a kind of multiplication. Giga flops mean ten billion floating point operations per second, an unimaginable speed. The eleven means that it does eleven of those. Eleven times ten to the ninth floating point operations per second. What for? IBM is now working on a thing called TF3. T stands for terra which is a thousand times faster still. Three trillion floating point operations per seconds. Whether
they can actually do it or not is not known at the moment, but the question: "What for?" is not asked.

This brings me to the next credo, which I am sure many of you have said and certainly most of you believe. The computer is merely a tool. How many times has that been said? What is meant by that? I think what is meant by that is that the computer itself is valuefree, it is neutral. In the American context, let me restrict myself to that, there is no question that any improvement in computer vision or computer speech understanding or other results of computer science research is immediately introduced into weapon systems by the military. The computer like any other tool, a sword, a pistol, a hammer or whatever has a meaning. It is not neutral. It gains its meaning from the social context in which it is embedded. The social context in which the computer is embedded is one in which the computer from the very beginning was developed in order to make killing more people more efficient. Most of the computer research and development in the United States has been devoted to that goal ever since.

Finally: Ours is the best of all possible worlds. When one says that ours is the best of all possible worlds, who is this "ours"? Is it us white people for example, or is it Khomeini and his people. Who is it? Is it the Soviet people? When we say that all children now have little card computers is that really true? Do the majority of children in the world have little card computers? No. What that means is that all children in whom we are at all interested have these.

Finally and with that I will close. The response of the optimist and of the pessimist to the ascertainment: Ours is the best of all possible worlds. The optimist says enthusiastically "That's right!" Then the pessimist answers: "Yes, unfortunately".

Thank you very much.
Questions and Answers

Q: I would like to ask you about one of the credos of our time which you mentioned. The credo that the computer is merely a tool. You said that it gains its meaning from the social context in which it is developed and then you continued "it has always been closely related to the military". Does that mean that you think it is a weapon?

I like to look upon myself as belonging to a group of computer scientists who think that we could use another paradigm within computer science. That is, we could develop computers and associate software so that they could become tools for a specific craft or specific profession. I would like you to comment on that.

A: Of course it is possible to design the computer to be a tool for a specific professional use. However, the world is full of dilemmas which we have to acknowledge. Take the CAT scanner, computer-aided tomography, as an example. That technology depends on image enhancement. Image enhancement is precisely the same technique that guides cruise missiles to their target. It is all in the same family. The two are bound up and you cannot say that you will work on one and not on the other. Especially not if the person who signs your pay cheque is the Pentagon. That puts every researcher in a dilemma. The question of what kind of research one can do arises. I have no answer to that question. What is harmful, however, is to delude yourself and think that your world is innocent and tell yourself lies like "the computer is merely a tool". Our task must be to create a reality in which we can use the genius of human beings to design computers like CAT scanners without at the same time committing suicide. That is the task!

Q: We must acknowledge the impossibility of uninvventing computers. Do you agree that they are here, and there is no way of uninvventing them? That they are just like any other new technology which has "gotten its roots" into society.

A: You say that we cannot uninvvent the computer and that this is true for other technologies as well. I do not think that is true. I do not want to start a movement to uninvvent the computer, but it would be nice if we forgot how to build, for example, hydrogen bombs. It is however possible to forget technology. A lot of the technology that the human species has invented, is in fact no longer buildable. We have forgotten how to do it. I have a watch here. It is a mechanical watch which is 24 years old. I am sure that in another fifteen years I will not be able to find anyone to repair or to maintain this watch. Maybe in twenty-five years from now no one will be able to make a watch like this.

Several hundred years ago the Japanese decided that there should be no guns in Japan. At that time they had both guns, rifles, and pistols. They made a decision and there were no guns in Japan for the next several hundred years. They forgot how to make them just as we and they themselves have forgotten to make some of the Samurai swords that they used to make.

These are small examples but I do not think one can say that we cannot uninvvent a technology which we have. We can forget and we have done it many times.
ORGANIZER, PROGRAM ETC.

In The Faculty of Arts and Science at Linköping University research is pursued and research training given under four broad problem areas known as temas (themes). These are Health and Society, Communication Studies, Technology and Social Change, and Water and Environmental Studies. In fall 1988 a fifth theme will start, focusing on children.

Background
Modern information technology has brought radically new conditions for human knowledge both for the individual human being and on common, collective levels as well. How is the knowledge of today built up, how is it distributed? What do these changing conditions mean for basic human qualities such as personality, responsibility and communication between human beings? How is knowledge used, by whom and for what purposes in a changing and increasingly complex society? Does the intelligibility of life and reality change?

All these questions are present in different senses and to different extents in various parts of life and society. The aim of the symposium in November 1987 is to shed light on the importance of some of the questions. Particular attention will be paid to children and young people growing up in the new computer culture.

Outline of the symposium
Distinguished researchers from USA and Europe will give lectures on selected topics within the framework of the symposium. The lectures will be followed by comments, questions and discussions. A final panel discussion about research objectives within the field will conclude the symposium.

PROGRAM
MONDAY, NOV 2 1987
Registration.
Opening: Sven Erlander, Vice-chancellor, University of Linköping.
   Introduction: Ingemar Lind, Dean, Institute of Tema Research, University of Linköping.
Lectures: Computers and Psychological Development.
   Sherry Turkle.
   Jacques Hebenstreit.
   Reflective Practice and Policy Controversies.
   Donald A. Schön.

TUESDAY, NOV 3 1987
Industrialized Information and Personal Knowledge.
Lars Ingelstam.

Knowledge is Power - a critical Approach to the Information Society.
Thomas Söderqvist.

On the Status of Knowledge in the Information Society.
Joseph Weizenbaum.

Research on what, for whom, and by whom?
Panel discussion. Moderator: Peter Seipel, Stockholm University.

Close.
The Symposium:

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