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The New Informatics

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The discipline that used to be called "information systems" is changing its identity. In Sweden, we have emphasized this reorientation by changing our name from "administrative data processing" to "informatics." I will attempt to characterize this new informatics, describing it as a theory *and* design *oriented study of* information technology use*, an artificial science with the intertwined complex of people and information technology as its subject matter. I will end by giving some suggestions for how to think of a new curriculum.*

Looking around in Scandinavia in the Spring of 1997, it is obvious that research on information systems—informatics we now say in Sweden—is beginning to settle down into a rather rich variety of different approaches. Even if they are constantly changing, even if they are overlapping, merging and separating in a somewhat confusing manner, I still think it would be rather easy to characterize the different approaches in a way that most members of the community would accept. Furthermore, I think that such an attempt to define the different research approaches would further their development and encourage debate between them.

Such a reflection on current research orientations is important, I think, in view of the fact that our discipline has recently

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undergone some radical changes. Those changes are indicated by our changing the name of the discipline in Sweden from "administrative data processing" to "informatics." In what follows I want to give my own, very personal, view of this "new informatics," of how I see it emerging and what I hope it will become. I will do so against the general background of research in information systems and evolution of computer technology use, but my perspective will be mainly Scandinavian. Both research orientations and evolution of use differ radically from one country to another, and I am not trying to paint a complete picture, nor present a universal paradigm for research in our field.

The change of name was not uncontroversial. Protests were heard from computer scientists, and I myself certainly hesitated. Since "informatics" is the term used on the European continent, and in Norway, for all the computer science disciplines, was it not both rude and silly to use this very general term to name what is obviously a sub-discipline? Would "social informatics" not have been a better term for a discipline focusing on the use of information technology?

Perhaps, but "social informatics" sounds too much like a social science to me, without the design orientation so important in our discipline. Engineering has always been dominated by a production perspective (which indeed is only natural in an industrial era). Perhaps it is time (now that we enter a postindustrial era) to argue that engineering should change its focus to that of technology use? When information technology is used by people exchanging services, more than as control mechanisms in production systems, then computer engineers will have to become experts on human technology use. If so, then we can drop the "social" in "social informatics," and let those who want to forget about use add a prefix instead. (See Dahlbom & Mathiassen (1997) where this position is developed.)

The choice of a name for a discipline (company, football team, person) is more important than one might first think, sometimes contributing substantially to the developing identity of the discipline. (Traditional cultures all knew this, of course, and sometimes we modern do well to be a bit more appreciative of their insights.) It would have been nice to find a name that could unite and strengthen the various research approaches around the world that used to be related by a common interest in "information systems." I doubt that "informatics" can play that role. If I had been able to find a name for "information technology use," then I would have proposed that. But then again, it may not make much sense to try to unite the disciplines focusing on information technology use. As long as that use is undergoing rapid diversification, we should perhaps accept a confusing variety of partly overlapping approaches, constantly changing and constantly changing names.

1. Four Stages of Computer Technology Use

In the discussions preceding the name change, initiated by Pelle Ehn, one obvious alternative was suggested, but rejected. In referring to our discipline in English, we have long used the term "information systems," and what would have been more natural than to choose that as a name?

When the name "information systems" was discarded, this marked an important decision regarding the identity of our discipline. In order to fully appreciate that decision, let us look quickly at the extraordinary evolution of computers. This evolution has often been described in generations of hardware or programming languages. Technology is made for use, but strangely enough the use aspect is normally absent in such evolutionary tales. And yet, it is of course the evolution of computer technology use that is really astonishing. This I hope will be obvious from a quick look at the four stages of computer technology use that we can distinguish so far.

The first computing machines were built during the second world war. At first they were simply thought of as automatic versions of the mechanical calculating machines used in offices and retail stores at the time. In a request for funding in 1943 to the Army Ballistics Research Laboratory, John Mauchly described the machine he wanted to build, called ENIAC, Electronic Numerical Integrator and Calculator:

> …in every sense the electric analogue of the mechanical adding, multiplying and dividing machines which are manufactured for ordinary arithmetic purposes (quoted from Ceruzzi 1983)

One of the primary objectives was to build more efficient calculators to produce mathematical tables, in particular ballistic tables for military use. Such tables had been computed by people using calculators, but with the rapid development of weapons during the war, these human "computers," as they were called (Ceruzzi 1991), were unable to keep up. Efforts had been made to rationalize computing work by organizing it on the model of the typing pool, but these computing pools were now to be replaced by machine computers that were claimed to be faster, cheaper and more reliable.

All through the 50s, this original use of computers, as *computing machines*, continued to dominate. Computers were automata that were fed algorithms in order to make large computations. To program the machines meant turning calculation tasks into algorithms that the machines could handle. To become a programmer you had to master the science of calculation, numerical analysis.

To begin with, the domain of computer application seemed narrow and exclusive: some advanced research and technical development, mostly military, some recurrent very special calculation tasks for insurance companies and banks, and maybe a few other very special services. During the war, Thomas Watson, Sr., is said to have estimated the future world market to "maybe five computers." Similar misjudgments of truly bizarre proportions were made all through the 1950s, when estimating the usefulness of the developing computer technology. The prospects were that computers, interesting and impressive as they were, would never have more than a marginal impact on life and society.

When, in the early 60s, computers began to be used as information systems, it was their capacity to handle large sets of data that became the focus of attention. Computerized information systems were used by companies and government agencies to register and keep track of people, products, payments, taxes, and so on. This second stage of computer technology use was made possible by the development of technology, notably the development of memory mechanisms. But this development would have meant little without the change in use. And this change did not follow automatically on the technical development. On the contrary, it was difficult to foresee and understand. Listen, for example, to Howard Aiken, physicist at Harvard, who in collaboration with IBM had designed the Mark computers, speaking as late as 1956:

> …if it should ever turn out that the basic logics of a machine designed for the numerical solution of differential equations coincide with the logics of a machine intended to make bills for a department store, I would regard this as the most amazing coincidence that I have ever encountered (quoted from Ceruzzi 1986)

Information systems were introduced in large organizations with the ambition to automate administrative work. At the same time computers were beginning to be used to control and monitor production processes in industry. Thus was born the idea of "management information systems," of information systems for administrative control and monitoring. Attempts were made, with each new development of the technology, to turn administrative work into a rational, industrial production process. Thus, when personal computers were first introduced in large organizations, it was under the somewhat misleading banner of "office automation."

Attempts were made all through the 70s to introduce home computing, but when eventually personal computers really became a commercial success, it was due to their use in offices, as spreadsheets, word processors, and desktop publishing tools. The 80s became the decade of the PC and the use of computers again shifted its center of gravity. Numerical analysts were happily playing with super computers and new parallel architectures, relational data bases made the information systems really useful in managing complex organizations, and companies began complaining about the complexity of their information systems architectures, and yet, what everyone talked about was *personal computing*.

Interacting with the computing machines of the 50s and with the data machines of the 70s was difficult. The focus on personal computing meant a focus on graphical interfaces, menus, push buttons, and direct manipulation. Human-computer interaction became an exciting domain for designers, and "interface design" became a notion spreading outside the computer industry proper.

While the personal computer became portable and the big operators were grappling with the problems of making a pocket version, networks and client-server technology were introduced in the late 80s. And with the networks a development began that again would change the focus of information technology use.

It began, innocently enough, with an interest in cooperative use of applications—HCI turned into CSCW—but soon turned into a major effort to use network technology to combine the databases of the 70s with the word processing and calculations of the 80s. In this way we got a technology making it possible to distribute, sort, and cooperate with, all the documents and spreadsheets produced on the PCs. Again, there was a promise of turning office work into just another production process, and management consultants got down to business, gauging customer value, measuring workflows, redesigning and automating work.

If things had stopped there, with internal client-server networks, document management, process engineering, and customer orientation, the networks would have remained a major business innovation, changing office work, but that is all. It was when network thinking was combined with a political and media attention to Internet that interest in information technology really "exploded." Computer technology became a medium of communication, not only for office work, but for entertainment, education, news, marketing, and so on. Speculations began about a future, interactive, synthesis of television, telephones, and computers in a global communication medium, a world of information in which people would work and live. In the way people once moved from the country to the cities, they would move again, to the Net.

This most recent use of computers has again moved the focus of our attention, and introduced a whole new way of speaking about the technology: *information technology* (IT), Internet, infrastructures, infobahns, interactive video, multimedia, cyberspace, networks.

With the current use of computers, the technology has really become pervasive. It has moved from the workshops of computing in the 50s, to the accounting offices of management in the 70s, to the offices, universities and advertising agencies of the 80s, to the world of media, entertainment and general education of the 90s.

Through all of these stages of radically changing use, certain things have remained constant. One is the stability of the fundamental technology. Computer technology is still processor and memory, and even if parallel architectures have been added to von Neumann's original design, that design still holds as a good description of the computer.

Another thing that has remained constant is the utter surprise which has marked each of the transitions. I have given one example of this already. Other examples are easy to find. When microcomputers were first introduced on the market by California enthusiasts in the 70s, it was for the use of programming, to learn "digital thinking," as they said (Pfaffenberger 1988). Later we were expected to build information systems (for recipes, home economy, stamp collections, and so on) on our home computers. As late as 1980, Swedish experts advised the government not to buy personal computers, "because there is no future in that technology." Ask your colleagues how many of them were prepared for the Internet revolution.

2. Technology Use

If we look at these four stages of computer technology use, it is easy to see that our discipline was born in, and for a long time defined by, the second stage. When personal computing and human-computer interaction was all the rage in the mid-1980s, we stuck to our methods for developing mainframe based information systems. We went on thinking and talking about our discipline in terms of development of information systems in organizations, extending the notion of information system to cover other forms of computer technology use, such as word processing, desktop publishing, and communication. To exemplify, listen to Nijssen & Halpin (1989) in their "modern introduction to information systems," defining their fundamental concept:

> "Basically, information systems are used to maintain, and answer queries about, a store of information. Although such tasks can be performed manually, we confine our attention to computerized information systems. Most current information systems are called database systems. The data base itself is the collection of facts (data) stored by the system. The system is used to define what kinds of data are permitted, to supervise the addition, deletion and modification of data, and to answer questions about the data.

What is ironic is that when the authors in the short introduction where this definition is given (indeed even on the very same, first, page) want to stress the importance of their book, they refer to the importance of word processing and computerized typesetting—which according to their definition are *not* information systems!

The decision in Sweden, therefore, not to call our discipline "information systems," but "informatics" is important for the way in which it marks the end of a commitment to second stage computer technology use. If we missed the personal computing stage, we will make sure to be the *avant garde* of the Internet era. In the 90s we have rather quickly begun to direct our attention to information technology, to networks, Internet, and multimedia. Rather than going on about "developing information systems" we are beginning to speak of our discipline in terms of "using information technology."

We may very well wonder what this shift in terminology will mean, except for the fact that it expresses our interest in contributing to the fourth-stage use of computer technology. The notion of "information system," as it was defined by Börje Langefors in the 1960s (*cf.* Langefors 1995), was a social concept including the organization using the data system, interpreting its data, turning them into information. This is a difficult notion to work with and, in practice, it proved difficult to avoid speaking as if the information system was identical with the underlying data processing system. Be that as it may, Langefors gave the Scandinavian approach to information systems a clear understanding of the importance of the user and a social perspective:

> This Infological approach was based on the observation that the users should have real control of the system design and that this could be made possible by exploiting the fact that the main system design is an organizational design and that the needs analysis can be free from technological aspects and language. A new kind of analysts/designers, the Infological systemeers, was introduced. They have an organizational, human orientation, not a machine orientation." (quoted from my introduction to Langefors 1995)

Some may very well wonder if, when exchanging "information system" for "information technology," we will lose the social perspective stressed by Langefors. Will we become more technology oriented, less interested in human aspects of computer technology use?

When our discipline was founded in the 1960s it was motivated by the use of information technology as data processing systems in administration. Such systems were developed in projects, and the discipline educated the practitioners in those projects and did research on the nature of, and methods used, in such projects. Since then the use of information technology has diversified, and our discipline has (belatedly) followed suit, now encompassing a rich variety of forms of information technology use: personal computing, communication, electronic publishing, air traffic control, road transport informatics, intelligent houses, and so on. The focus has shifted from information systems to information technology, and from systems development to technology use. Looking back now, both of these changes seem very natural. Again, we can use Börje Langefors, the founder of our discipline in Sweden, as an example to explain why this is so.

Langefors's interest in data processing systems was motivated by a more general interest in the use of information technology, and his notion of "information system" was meant to support such a general interest (Langefors 1995, chap. 1). Over the years, information systems were to become—in theory if not in practice—more narrowly understood as database systems, and other uses of information technology were neglected (see Dahlbom 1992). With his notion "information system" Langefors wanted to direct our attention away from the data processing system towards the use of that system in the organization. And even if, over the years, the practice in Scandinavia came to be more and more focused on the systems development project, the academic discipline kept spending its main energy on understanding the users and their way of using the technology. Thus, when we now say that we are less interested in information systems and systems development, than in information technology and its use, we are really much less radical than it may first seem, expressing as we do a good old Langeforsian view of the discipline.

3. People and Technology

The computing machines were invented at a time when the profession of human computers was rapidly growing. The computers soon made human computers obsolete. Certainly, to this very day, much computing is being done by people, but there is nothing like the massive, organized computing that we would have seen were it not for computing machines. And, of course, were it not for computing machines, we would not have the scale of computing that we have today. Think only of how many human computers we would need to perform the computing of contemporary banking! And with only human computers we would have nothing like the international financial market, with all its turbulence, that we have today.

So, even if we count only the very first computer technology use, the use of computers as computing machines, we can truthfully say that computers have had an enormous impact on modern society. And, if we go on to consider the use of computers as information systems, for word processing and desktop publishing, and for communication, it is obvious that computer technology has radically changed the world we live in, the artifacts of daily use, the activities we engage in, the ways we do work and find pleasure, the ways we interact and find isolation. And yet, this way of thinking of technology—as a form of life (Winner 1986), as an artificial world shaping our lives—is not the way people tend to think of technology.

No, technology is often conceived as a cause of effects, be it economic growth and strategic advantages or exploitation and deskilling, and not as an artificial world, a form of life. Social scientists study the effects of technology and leaves the technology itself to engineering to deal with. But when technology is seen to be a part of society, rather than a force affecting society from the outside, then technology becomes more interesting in itself, as a social phenomenon.

Our understanding (or misunderstanding) of computer technology will often emphasize one type of technology or technology use. Let me give four examples: technology as tool, system, medium, or interface.

First, technology can be identified with tools, instruments, small machines, things that facilitate work (calculators and hair dryers) or entertain (video games and CD-players). When technological development is thought of as the development of such tools, it is a fairly uncomplicated process. Development simply means more and, hopefully, better tools, instruments, gadgets. Life will go on in pretty much the same way as before, only it will be more comfortable and more fun. Now and then we will be worried by how all these gadgets draw our attention away from more important things in life—how they make us superficial, passive, materialistic, and so on—but those worries will come and go. Gadgets make us think of technology as tools and support, and even if these gadgets can divert our attention from eternal values, their influence on our lives seems marginal and mostly harmless.

Secondly, a more complex type of technology can be found in the large scale industrial production systems, the factories, that play such an important role in industrial societies. These production systems are constructed to run complex machines, and they are themselves such machines. Industrial work is dominated by machine technology, and the central role played by work in modern society gives this technology a dominating role in modern life. But its dominance extends well beyond the life of industrial workers. Machine technology, factories, serve as models for all kinds of organized activity in modern society. Offices, schools, hospitals, and so on, are all factories. Factories force upon us the image of technology as a system which controls us, a machine in which we are minor parts to be replaced when malfunctioning. Machines are big and complex, and technological development makes them bigger and more complex, increasing their power over our lives.

A modern industrialized society depends on large scale transport and communication infrastructures: road systems, electric networks, water and gas, sewage, telephone, Internet. This sort of technology can be thought of as the skeleton, nervous system and blood system of the social animal. If this is what you think of when you hear the word "technology," then technological development will be viewed as a complex and pervasive social change process. Such infrastructural technology makes possible (regulates) our behavior, customs, interaction patterns, our time. Water pipes, electricity, roads, telephones, mass media, provide a framework for our use of time, structuring our day.

Infrastructures, network technology, can be thought of as systems, along the line of factories, and viewed as working in close conjunction with the industrial production systems of modern society. But we can also think of (some of) those networks as a *third* variety of technology, as media connecting people, making possible interaction and cooperation. Media differ from systems in not forcing themselves upon us. They resemble tools in the way they are there for us to use at our own leisure and for our own purpose. When we think of roads as a system we focus on traffic jams on our way to work. When we think of those same roads as a medium we focus instead on the freedom they give us to go anywhere and see all kinds of people. What is a system to a producer or operator, is often a medium to the user—at least when it is functioning well. The more pervasive media become, when society becomes a "media society," then media turn into systems.

Typically, we hold the tools in our hands, so they are obviously obtrusive. And yet they tend to withdraw into the background as we use them. Factories and media are even more in the background, as we attend to tools, tasks, and people. What we focus upon is the surface of things, the interface of our social, cultural and natural environment, rather than the mechanisms behind the surface. But that surface is becoming more and more technical. When we think of technology as interface, we introduce a *fourth* variety of technology, one that has its place in the foreground. And, wherever we turn, there is technology. The food we eat, the water we drink, the ground we walk on—everything is artificial, produced, modified by people. To think of technological development as development of the interface obviously raises the question "How would you like the world to be?" That question has no simple answer.

Computers invite us to think of them in all these four different ways. We can even use these varieties of technology to tell the story of computer technology development from the perspective of its use. The computer systems and management information systems of the 60s and 70s were *systems* for control of machines and organizations respectively. The personal computers of the 80s, with their word processing, spreadsheets, and desktop publishing software, were *tools*. Personal computing also made the *interface* a focus of attention, and made people dream of a world covered with computer displays—giving it a benign and informative interface. The networks of the 90s are *media*, and the information society of the 70s, that became a design society in the 80s, is now turning into a communication and media society.

Our discipline has always defended a people perspective. Sometimes this has been combined with a rather superficial view of the relations between people and technology, and sometimes it has even meant a negative attitude to technology. Mustering support from the social sciences and humanities in our battles with narrow minded computer engineers, some of us have acquired bedfellows who know nothing at all about technology. But since there is no doubt that technology still is the most important social force in our modern society, it is of the utmost importance that we take technology seriously and develop an understanding of its changing and complex roles in human affairs. Such an understanding cannot be based on an outdated and simplified dichotomy like the one between people and technology.

The distinction between people and technology is one of a whole family of similar dichotomies, such as organism–environment, inherited–acquired, mind–body, individual–society, which all seem to take for granted that a complex domain of interactions can be neatly divided into two separate areas. To begin to understand the role of technology in shaping society, we may have to change the way we think and talk of technology. We speak of using technology, of how technology can be used to control people or support a work organization. We speak of using computers and of human-computer interaction. We debate whether technology determines society or the other way around, choosing between technological determinism and social constructivism. In all this talk, we presuppose an apparently innocuous distinction between technology and people, between technology and society.

The dichotomy between technology and people (society) has shaped our academic and educational systems and defined professional identities. (Dahlbom & Mathiassen 1997). To become an engineer you learn about machines. If you are interested in people you study psychology or sociology. Decision makers in the modern industrialized world are either engineers, with no social or psychological education, or they are economists or lawyers who know nothing about technology. The dichotomy is often used as a support for *humanism*, in a romantic attempt to define our essence by dissociation from technology: human beings are alive and spiritual while technology is dead and material; like the rest of the material world, technology is external to people and society.

And yet it does not take much examination to see how inadequate this dichotomy is, how it expresses a misunderstanding of both people and technology. Simply put, people and technology are not distinct but intertwined, but the dichotomy is so entrenched in our language that it is difficult to even formulate a more reasonable alternative. As soon as we want to speak of the relations between people and technology, our language forces this dichotomy upon us: people *and* technology, people *using* technology, the *consequences* of technology *on* society, society *shaping* technology.

When people use manual tools or work with machines in factories, this dichotomy seems obvious: there are people and there are tools (machines), and they are obviously distinct. But as soon as we begin to see that technology comes in many different forms and guises—as systems, networks, media, shaping our world and the very conditions of our everyday existence, and shaping us—we see how misleading the dichotomy is.

In the modern world, technology has become so much more than a value neutral tool; technology has become an expression of our interests, an implementation of our values, an extension of our selves, a form for our lives. What used to be tools and machines that we could keep at arms length, has crept up on us, turning into something with which we constantly interact. People and technology have become intertwined. You cannot understand the one without understanding the other.

4. Theory

Here in Scandinavia, our discipline grew out of the practice of developing information systems. To begin with, much research was itself an example of the practice: Research projects were systems development projects in which you had more time and freedom to learn and in which the pressure was to produce scientific reports rather than functioning systems. (An influential alternative was formulated by Kristen Nygaard in his action oriented research approach. See Nygaard (1992) for a retrospective review.) You used the practice to learn about the practice. The aim of research was defined accordingly: to contribute to the improvement of practice. Typically, that contribution would be in the form of a method, methodology, or guidelines for some aspect of the complex business of systems development.

More theoretical research was oriented towards explicating the central notion of information system, with Börje Langefors (1966, 1995) as a major contributor. In order to improve the practice of systems development, to make better systems, it was necessary to understand the nature of the systems we were developing. Langefors's idea, to define an information system as a sociotechnical rather than a technical system, to distinguish between information processing and data processing, played an important role when defining the discipline.

Now, that information systems are only one among many varieties of computer technology use, it becomes important to develop a conceptual scheme for categorizing those varieties. Just as we once developed conceptual frameworks for analyzing and designing information processing in organizations, so we must now formulate conceptual schemas for a variety of human conduct involving the use of computer technology. Here we will, of course, be able to rely on theories and concepts from the social sciences, but too often we will find that our particular approach requires novel conceptualizations. Just like engineering for so long has managed to conceptualize technology without taking into consideration its use, so the social sciences have had a tendency to describe human conduct as if it went on without the aid of technical artifacts.

I will only give a few examples from the research we do in, and around, the *Internet project* (http//:internet.adb.gu.se) to exemplify what I mean by theory. Pål Sørgaard and Lars Bo Eriksen (Sørgaard, forthcoming, Eriksen & Sørgaard 1996) use the dialectical theory of Dahlbom & Mathiassen (1993) with its three approaches to systems development—construction, evolution, and intervention—to distinguish three approaches to Web implementation: technology oriented, tradition oriented, and change oriented. With this theory, they can give an illuminating analysis of different ways of implementing Web publishing, as well as discuss possible trends and strategies for change.

Ole Hanseth and Eric Monteiro (Hanseth 1996) use the Latour-Callon-Law actor-network theory to analyze current information infrastructure development and use practices, proposing design and development process alternatives based on this theory. Actor-network theory is one of the key theories developed within the field of science and technology studies (STS). The essential element of the theory is the way it links technological and non-technological elements as equals into networks (Latour 1991). This feature makes the theory powerful as a tool for studying technological and non-technological "systems" together as a unified whole, with particular attention to the interdependencies and interactions of technological and non-technological elements.

There has been much talk about the "information explosion" creating an information overload, putting a strain on our cognitive capacities, but few attempts have been made to describe the phenomenon of overload in more depth. Focusing on the increasing use of information technology for communication rather than information retrieval and processing, Fredrik Ljungberg and Carsten Sørensen (Ljungberg 1996, Ljungberg & Sørensen 1996) are developing a theory of communication overflow, identifying dimensions and mechanisms involved in increasing and handling overflow. While information overload focuses on the wealth of information in mass media and databases, communication overflow concerns the wealth and obtrusive nature of communicative interaction.

Together with Michael Mandahl I have developed a general conceptual schema for categorizing information technology use, in terms of four dimensions: infrastructure, organization, activities, and mission (Dahlbom & Mandahl 1994). There are of course numerous ways in which such schemas can be put together, but this one has the advantage of being based on Aristotle's analysis of change. It can be used to understand how companies by acquiring a certain technology inadvertently may commit themselves to a certain way of organizing.

When analyzing change, Aristotle relied on four explanatory principles, usually called "causes." These are, the *material* cause, "that out of which a thing comes to be," the formal cause, "the form or the archetype, i.e. the definition of the essence," the efficient cause, "the primary source of the change," and the final cause, "the end or that for the sake of which a thing is done." We can use these four principles to analyze modern organizations.

Material cause refers to the material from which an organization is made. It comprises whatever you must have when you start out, that which is common to organizations of this kind, the answer to your question: "What do I need to make an organization?" The material is the organization's infrastructure, and that structure includes capital, technology, personnel, with their basic education and competence, buildings and, indirectly, systems of transport, finance, laws, markets, etc. in society at large, making organizations possible.

The formal cause refers to the organization as such, the way the business is managed. In the scientific study of modern organizations, in organization theory, it is this formal aspect that has generally been in the foreground while the material, the efficient, and the final causes have only marginally been dealt with. Thus, standard definitions of organization in modern organization theory follow Max Weber in treating the division and coordination of labor as the two fundamental aspects of organizations. Such definitions suffer from "idealism," Marx would say, in his own theory stressing the material basis, the productive forces, explaining organizational change in terms of conflicts between matter and form, between productive forces and relations of production. That Marx is more of an Aristotelian than modern organization theory, does not prevent him from neglecting the other two causes in Aristotle's schema, however.

The efficient cause is the daily activity performed by the members of the organization. Nothing will happen just by bringing together and organizing a bunch of competent people, supplying them with tools and material, unless they get down to work. The modern way of doing things is by organization (management), and organization is a powerful cause, but it needs the tacit support of activity (by people or machines). When you have organized your work day, you still have to get the work done.

The final cause is that for which all the work is being done, the ultimate goal or the "mission" of the organization. If the organization is perfectly rational everything going on in it should contribute to its goal or purpose. It is unusual that organizations have a clear conception of their goals. The final cause is a topic of ongoing investigation and elaboration rather than something explicitly formulated and uncontroversial.

Our discipline has been dominated by systems thinking and in spite of a number of "humanistic," "organic," and "soft" alternatives, systems have normally (at least tacitly) been understood as stable mechanisms. Once you have begun thinking about an organization as a system it becomes very difficult to see it as a process. To systems thinking, change is always understood as taking place against a stable background: it is a change in the system. And it does not really matter how much one stresses that systems are always enclosed in larger systems or that they are "open," when the whole idea of systems thinking is to view an entity in isolation, to avoid having to consider a complex context.

Aristotle's alternative to systems thinking encompasses systems (formal cause) with their goals (final cause), but by adding the infrastructure (material cause) which in a complex world knows no boundaries, and business activities (efficient cause), his process thinking avoids getting trapped in an isolated, unchanging system. In contrast to systems thinking an Aristotelian theory of organizations may very well regard infrastructure and activities as more stable than organization and goals. We go on performing the same activities with a different organization and for a different reason.

Systems thinking has encouraged a management perspective on organizations and their use of computer technology. It has neglected three of the dimensions that we have used Aristotle's theory of change to distinguish. We can use this theory to criticize systems thinking and advocate a more complex view of organizations. To stress the importance of activities and infrastructure over goals and organization will mean to argue in favor of networked organizations.

These are only a few examples of what I mean by theory. The term "theory" is used in many ways in the sciences and in the philosophies of science. As I understand it, the notion of "theory" is really a romantic notion (Dahlbom & Mathiassen 1993), stressing the importance of going beyond the observable phenomena to deeper, hidden layers of reality, in order to define concepts and identify general laws, in terms of which the chaotic flux of observable facts can be systematized and explained. Often the term is "deromanticized" to mean, simply, an alternative conceptual schema to the one used by common sense, but the ambition remains the same, namely to bring order and sense to a complex world. To develop theory, then, means to introduce new concepts, dichotomies, taxonomies. You cannot introduce new concepts, of course, without at the same time introducing general laws, conceptual truths, of a sort, with which you define those concepts and relate them to each other and to concepts already available.

5. Design

When we say that the subject matter of informatics is information technology use, we immediately have to add that this interest is design oriented. We are interested in the use of technology because we are interested in changing and improving that use. Informatics is an artificial science (Dahlbom 1993). Unlike the natural sciences with their explicit interest in nature, the subject matter of informatics is the world we live in, the world of artifacts, an artificial world. Unlike the humanities with its interest in understanding the past, informatics is interested in designing the future. And, unlike the social sciences that rarely dare come close to technology, informatics is not afraid of getting its hands dirty with scripts and protocols, since they are integral elements in the complex combine of information technology use.

Traditional science seeks knowledge of a given world. In scientific research we "discover" what the world is like. If you are more interested in "inventing" the world, then you'll have to do so outside science. This means that if you are interested in the world we live in, the world of artifacts, then in order to be "scientific" you must refrain from investigating possibilities for change and improvements. If the traditional view of science is permitted to rule, as it so often is in the social sciences with their ambition to be scientifically respectable, then the motivation for doing social science in the first place—making a contribution to the realization of a good society—must be disguised in order to be admitted.

When Simon first introduced the notion of "a science of artificial phenomena," he lamented the fact that the professional schools, seeking scientific status, had turned their back on design:

> In view of the key role of design in professional activity, it is ironic that in this century the natural sciences have almost driven the sciences of the artificial from professional school curricula. Engineering schools have become schools of physics and mathematics; medical schools have become schools of biological science; business schools have become schools of finite mathematics...Few doctoral dissertations in first-rate professional schools today deal with genuine design problems, as distinguished from problems in solid-state physics or stochastic processes. (Simon (1969, p. 56)

Whatever we do with our discipline—and there will be many changes— we should make sure to protect our design interest. We have a lot to learn from other disciplines, and we have a lot to gain from close cooperation with researchers in disciplines like computer science, psychology, linguistics, and sociology, but we should make sure not to learn so much from them that we lose our design orientation with an interest in the contingent and exceptional more than in the general, in local design principles more than in general laws, in patents more than in publications, in heuristics and innovations more than in methods and proofs, in the good and beautiful more than in the true.

With information technology we are rapidly transforming our society, our organizations, our work, and our lives. All these changes go together. You cannot understand one of them without having at least a notion of the big picture. When we try to see the role played by information technology in these changes, when we try to design good uses of information technology, we resemble archeologists trying to reconstruct an ancient culture in terms of a few technical artifacts left behind. Our interest, of course, is different. We are interested not in describing some definite, actual culture of the past, but in evaluating and choosing between the possible future cultures that could be built on the type of technology we are now busy developing (Dahlbom forthcoming, Dahlbom & Janlert forthcoming).

People and their lives are themselves artifacts, constructed, and the major material in that construction is technology. When we say we study artifacts, it is not computers or computer systems we mean, but information technology use, conceived as a complex and changing combine of people and technology. To think of this combine as an artifact means to approach it with a design attitude, asking questions like: This could be different? What is wrong with it? How could it be improved?

Since information technology use is our business, and that use is rapidly developing and diversifying, we have to develop and diversify too. We want to contribute to that process rather than just observe and describe it. We are interested in new ideas rather than in statistically secured minutiae, in intervention rather than description. There is a need for careful, pedestrian collection of facts in our field, certainly, but too often such research turns into an "anthropology of the past" rather than an experimental "archeology of the future" which is our interest.

Working with a rapidly developing technology, one always runs the risk of protecting the past rather than contributing to the future. This is true whether you do research, teach, consult or develop software. Thus, we protected the mainframes against the invasion of personal computers, and so today many of us are building fire walls to protect our organizations against Internet technologies. Such protective tendencies should be questioned, however difficult it may be to accept the fact that yesterday's expertise has become a liability rather than an asset. It may not be true generally that technology will solve the problems it creates, if only it continues to develop, but it certainly is true of computing. In the land of computers you will not find security by holding on to the past, but by throwing yourself over the edge of the future.

6. A New Curriculum

As long as it is systems development that is our topic, we know how to educate our students. But how do you educate them when the focus has shifted towards information technology use? What are they supposed to be doing out there, when they are no longer developing systems?

Part of the answer is simple. As computer technology moves on through its stages of use, it does not shed its old stages, but they are accumulated to define an increasingly rich and diversified area of use. The different stages with their different uses together constitute a general framework for informatics, within which any curriculum will have to seek its particular area of concentration.

To turn computers into powerful computing machines you need to know numerical methods and algorithms; to develop information systems you must master business modelling, systems design, and project organization; personal computing requires psychological theories of human-computer interaction, skills in interface design, and how to do usability studies; and to support networking you must understand human communication and cooperation, network technology and multimedia production, and the role of cyberspace as a new arena for human enterprise.

It is interesting to see how these four stages have taken informatics through a tour of the traditional university, crossing and recrossing faculty boundaries. Starting out in numerical analysis, we quickly moved into business administration, hesitated to take the step into cognitive science, and are now being courted by sociologists and ethnographers. Through all these moves, we have had a foot in technology, of course, but depending on what stage you choose to stress in your particular curriculum, you will have very different companions. Your choice of collaborators will also be determined by what particular area of use it is that you emphasize, of course: business, education, media, traffic, social service, health care, and so on.

Underlying these four areas of competence are two more general knowledge fields, the contents of which certainly will change with the evolution of use, but yet retain their respective identities. I am thinking of theory and technology. Together they make up the general competence of information technology use.

Theory is the field of what computers can do, the roles they play, and could play, in human affairs. This is where you learn about the stages of use, and thus hopefully acquire an open attitude to, and curiosity about, the future use of the technology. This is where you learn fundamental concepts like “information system,” “infrastructure,” “communication overflow,” and the like. You study general theory, but you also learn about what you can do with currently available software.

Technology is a rich subject matter encompassing both knowledge of what a computer is, and how to program, fundamental concepts of computing as well as details about different programming languages and tools. Technology also includes knowledge about the state of the art in hardware and software, what is available on the market, and how to technically test and evaluate hardware and software. Technology is the place where we meet our colleagues in the other branches of informatics, and the dividing lines will, hopefully, never be clear or distinct.

Developing information systems for administrative use is different from developing software for missile control, but software development and software engineering still have a lot to learn from each other. Generating workflow applications for a customer organization is different from writing micro code for mass market application generators, and yet workflow consultants and programmers ought to be able to speak to each other. Designing web pages is different from configuring a Unix server, and yet it doesn't hurt to know a bit of what both of these tasks involve. In informatics, we educate systems developers, workflow consultants and web page designers, rather than software engineers, software house programmers and computer engineers, but as technology and use develops, the line is constantly being crossed and moving. In our research and education in informatics we focus on use, but with a design orientation, and it is technology that is our number one instrument of change.

Informatics differs from computer science generally by defining its subject matter, information technology, as a social phenomenon. Another way to organize our curriculum could begin by distinguishing important aspects of technology as a social phenomenon. One suggestion, then, and I owe this to a discussion with Lars Mathiassen, would define a general introduction to information technology as comprised of four subjects: development, use, management, and technology. Such an introduction might be offered as something of a core curriculum for information society, but it can also constitute a general framework for distinguishing different specialities within the general informatics area. Computer engineers become experts on the technology and how to develop it, but they know very little of its management and use. At business schools they concentrate on how to manage the technology, learning very little about the technology itself and its development. In the new informatics, our focus of attention is on the use of information technology, but informatics is a broader discipline, less specialized than the others, even if its orientation may differ from place to place. With a creative understanding of the potentials of information technology use as our basis, we can either specialize in improving use, developing technology, or managing technology.

Yet another way to organize our curriculum could be to use the kind of taxonomies of technology use introduced above. We could teach our students the role of information technology as infrastructure, how it is used to support different activities, how it can be used for coordination, communication and control, and, finally, its role in developing, defining, realizing, controlling, and evaluating organizational goals. Such a curriculum would not have to be all that different from one organized by the development, use, and management of technology. An interest in technology and its development can be described as an interest in infrastructure, while an interest in use takes an interest in what the users actually do, in activities. An interest in management is an interest in organization and mission.

Informatics, as I understand it, is a discipline tracking (leading) the development of information technology, with the ambition to put that technology to good use, acting both on the technology and on the organization of its use. It has not always been easy to change the curriculum to meet the demands of new forms of technology use. Tracking (not to say "leading") a technology going through swift and surprising changes in use puts a strain on educators and educational programs. Information systems developers were taught numerical methods well into the 70s, interface designers were taught JSP in the late 80s, and intranet developers are still being brought up on relational database design. Such conservatism of the curriculum is unfortunate, I believe, in the way it supports the conservatism of big, bureaucratic business in a time when companies would do well to adjust more quickly to the demands of a postindustrial service society. But such conservatism is much worse when it characterizes not only the curriculum but the whole discipline, keeping it stuck in the information systems ruts of the second stage of information technology use.

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References

Ceruzzi, P. E., (1983). *Reckoners. The Prehistory of the Digital Computer, 1935-1945*. Westport, Conn.: Greenwood Press.

Ceruzzi, P. E., (1986). An Unforeseen Revolution: Computers and Expectations, 1935–1985. In J. J. Corn (ed.). *Imagining Tomorrow. History, Technology, and the American Future*. Cambridge, MA: The MIT Press.

Ceruzzi, P. E., (1991). When Computers Were Human. *Annals of the History of Computing*, 13:237-244.

Dahlbom, B., (1992). Systems Development as a Research Discipline. In K. Ivanov (ed.). *Proceedings of the 14th IRIS. Institute of Information Processing*, Umeå University 1992.

Dahlbom, B., (1993). En vetenskap om artefakter. *VEST: Tidskrift för vetenskapsstudier*, 6(4).

Dahlbom, B., (forthcoming). Going to the Future. In J. Berleur *et al.* (eds). *Proceedings of the IFIP-WG9.2/9.5 Corfu Conference on "Culture and Democracy Revisited in the Global Information Society.*

Dahlbom, B. & Janlert, L.-E., (forthcoming). *Computer Future*.

Dahlbom, B. & Mandahl, M., (1994). A Theory of Information Technology Use. In P. Kerola *et al.* (eds). *Precedings of the 17th Information Systems Research Seminar in Scandinavia*. University of Oulu, Department of Information Processing.

Dahlbom, B. & Mathiassen, L., (1993). *Computers in Context. The Philosophy and Practice of Systems Design*. Oxford: Blackwell.

Dahlbom, B. & Mathiassen, L., (1997). The Future of Our Profession. *The Communications of the ACM*, 40(6), June.

Eriksen, L. B. & Sørgaard, P., (1996). Organisational Implementation of WWW in Scandinavian Newspapers: Traditional Approaches Dominate. In Dahlbom, B. *et al* (eds). *Proceedings of IRIS 19. Gothenburg Studies in Informatics*, Report 8. Göteborg.

Langefors, B., (1966). *Theoretical Analysis of Information Systems*. Lund: Studentlitteratur.

Langefors, B., (1995). *Essays on Infology.* Lund: Studentlitteratur.

Latour, B., (1991). Technology is Society Made Durable. In J. Law (ed.). *A Sociology of Monsters*. London: Routledge.

Ljungberg, F., (1996). An Initial Exploration of Communication Overflow. In *Proceedings of the 2nd International Conference on the Design of Cooperative Systems (COOP'96)*, Sophia Antipolis, France, edited by the COOP group, INRIA, France.

Ljungberg, F. & Sørensen, C., (1996). Communication Deficiency and Switching Mechanisms. In J. D. Coelho *et al.* (eds). *Proceedings of the 4th European Conference on Information Systems (ECIS'96)*, Lisbon, Portugal, Ficha Técnica, vol. 2, pp. 1113-1119.

Hanseth, O., (1996). *Information Technology as Infrastructure*. Gothenburg Studies in Informatics, Report 10, 1996. Department of Informatics, Göteborg University.

Nijssen, G. M. & Halping, T. A., (1988). *Conceptual Schema and Relational Database Design*. Prentice-Hall.

Nygaard, K., (1992). How Many Choices Do We Make? How Many Are Difficult? In C. Floyd *et al.* (eds). *Software Development and Reality Construction*. Berlin: Springer-Verlag.

Pfaffenberger, B., (1988). The Social Meaning of the Personal Computer: Or, Why the Personal Computer Revolution Was No Revolution. *Anthropological Quarterly*, 61(1).

Simon, H. A., (1969). *The Sciences of the Artificial*. Cambridge, MA: The MIT Press. A second, extended, edition was published in 1981.

Sørgaard, P., (forthcoming). *Work Behind the Service: Web Publishing and Changes in Document Production*.

Winner, L., (1986). Technology as a Form of Life. In *The Whale and the Reactor*. Chicago: The University of Chicago Press.

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