Human Computer Interaction:

Socioeconomic Aspects and Effects on the Working Environment

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Summary

Information processing, with or without information technology, is of great significance today. On the one hand, the individual's role and position in a society can only be safeguarded by information skills, on the other, the information technologies have increased access to and the use of information and made them more abstract. Occupations and qualification groups which are mainly defined at information level show a high dominance in working life and in society.

Reducing human computer interaction to the traditional elements of keyboard and screen – with small additions – does not do justice to the significance of this interface. On the one hand, because these elements make only rudimentary use of the broad spectrum of human possibilities, on the other, because they are a heavy physical and psychological burden due to their one-sidedness. Steps to broaden these interfaces, as has been done in other technologies, therefore seem long overdue.

Changes in society are currently leading to a convergence in the use of information technologies in the private and business environment as well as in society as such. The significance of the different spheres of life has shifted dramatically: Neither working life nor leisure time are dominant, but rather a new area which is in between these two poles, yet provides room for activities.

If new forms of human computer interaction become established in this area in particular, they will have a massive influence on society as a whole. If they are only relevant in niches of leisure time or working life, however, they will hardly experience a breakthrough. The example of teleworking shows that technologies and new forms of organization only stand a chance under suitable framework conditions and when they meet acceptance.

1. Humans and Technology in the Information Society

One of the differences between humans and animals is that humans are able to make and use tools and to develop an adequate infrastructure. Nature has not protected humans against the adversities of life in general, they have had to care for their survival themselves.

These tools and infrastructures are usually summarized under the term "technology" (cf. mainly Lenk/Moser 1973, Dostal 1982). This has changed repeatedly in the awareness of humans over the course of the millenniums. When technology is understood as a tool, it is often considered familiar and humane; when it is understood as something autonomous, it is considered rather alien and threatening. Rarely has there been a single position on this matter;
interpretation has always been strongly influenced by individual points of view and involvement.

Times where technology was highly esteemed alternated with times of aversion to technology, scepticism, criticism or even the total rejection of technology. However, technology was never understood as a single entity: Some technologies were no longer perceived as such, others, however, very much so. This is apparently linked to the domestication and integration of technology, to whether it is considered useful and reasonable or hostile and destructive. The details of this discussion always show that the adoption of a technology is a very individual process, according to the age of the people concerned, their role in society, their professional position and the degree to which they are affected.

For about 50 years now, information technology has been developing at an unusual pace after having developed rather gradually in the early stages (cf. mainly Matis 2002): However, there have been "revolutions" before, which do not reveal such an impressive dynamism in hindsight (Gimpel 1980, Standage 1998), but which had a considerable impact on individual lives and society at the time.

According to Jacquard and Hollerith, information technology was initially purely mechanical but changed to the level of electromechanics with the invention of telegraphy and achieved considerable increases in performance coupled with an enormous fall in prices with the development of electronics and later microelectronics. The separation of hardware and software marked the birth of the computer, which allowed individual tasks of information processing to be solved using standardized hardware and individualized software. Examples on the consumer market show high performance, from chess computers to GPS-based navigation systems to the World Wide Web, the worldwide information network.

The interface between humans and computers has hardly changed during this period: In the early stages, punch cards or slips were used for data input and printed paper for data output; later, direct data input was possible via the keyboard and data output via the screen. Both interfaces were not originally introduced for computer use. The keyboard was taken over from the typewriter, the screen came from television. Only the mouse was developed specifically for the PC, the personal computer.

At the same time, an increasing number of computers were used in a concealed form in technical equipment and infrastructures, which were initially tested, for example, with telex machines and cash registers. On the one hand, the new devices were able to replace complex mechanics, on the other, they introduced additional features which gave them a new quality and changed their use. Today, it is almost impossible to see which devices use concealed computers and which can (still) do without a computer.

For users at work, at home or any other place, the contact to technology has been primarily reduced to a computer-based interface. Today, technology is no longer "used" in its manifold shapes. A computerized "interface", which is screen- or keyboard-based, is used for handling technical equipment or infrastructures. This can be seen in its most compact form in mobile phones or in the remote controls for consumer electronics. With the growing complexity of products and infrastructures, this interface can help to reduce the complexity or ensure that devices are better adapted to people. This is what the projects presented here are attempting to do.
Such interfaces take into account technical conditions and possibilities as well as human skills which, in turn, are characterized by the conditions of interaction and their background, such as social processes and their evaluation. Examples of well-intended adaptations of high-performance technology which have not been accepted in practice show that, in addition to optimized technology interfaces, human motivation and acceptance – as diverse as it may be in the individual context of use – must be taken into account.

2. The Interface between Humans and Computers

Even the Greeks in their philosophy said that man was the measure of all things. The example of the young Greek using a wax tablet (figure 1), which corresponds to a laptop in its form and size, underlines the significance of this statement. The technology is primitive from a modern point of view, but apparently satisfied the need to store ideas in a written and/or graphical form. The operation was relatively easy and the safety of storage was relatively safe – if the right kind of wax was used and extreme temperatures were avoided. A power supply was not necessary, so that the equipment was certainly much lighter than a modern laptop with its heavy set of batteries.

The modern laptop, however, – which is operated in a similar way to the wax tablets of former times – now has a much higher performance capability. In addition to texts and images, colours and sounds can also be stored, and storage capacity is almost endless. There is an interface to telecommunication services which provides access to even more information domains. But when one analyzes average use, it becomes obvious that the capacity is only fully used in exceptional cases. Certainly, the average user will make use of functions beyond
those of the wax tablets of former times. This is due to the limitations of their functions on the one hand, but also to the tasks and qualifications profile of the users of antiquity.

Today, not only the possibilities have changed but also the needs. The relationship to work has clearly changed over the past 120 years (figure 2). In the sense of our topic, the three-sector model has been enlarged by a fourth sector, in which the working population which primarily performs tasks of information processing has been separated from the three classical sectors and has been aggregated in a specific information "sector" (cf. Porat 1977 and Dostal 1988 on method and results).

In 1882 – the year of the first census in the German Empire – almost 50 percent of the working population was active in the agricultural sector, where they certainly gathered and processed information which was primarily determined by nature. Sun, rain, the seasons, daylight and darkness, materials which were relatively fundamental, were perceived and analyzed for optimal cultivation of the soil and care of animals. Interfaces were and still are extremely diverse in this sector.

Later on, production was able to increase its significance. Here also, the diverse interfaces for craftsmen and industrial workers were important: A very detailed knowledge of materials, long-standing experience with processes, skillfulness in often complex tasks, the offsetting of faults or shortcomings in production equipment and materials. Here too, interfaces were diverse and often not recognizable for laymen. An important element of vocational qualifications was the ability to perceive specific, complex signals, such as the colour of a melt, the form of shavings, or the specific sounds of machines. In addition, this type of work was characterized by a team-oriented division of labour (figure 3) – once again an image of
Ancient Greece - so that the personal interaction in different contexts played an important role.

Under this model, the service sector did not undergo any specific development because there has always been much information processing in this area in particular. And particularly since the 1950s, there has been a division between traditional services, such as transportation and care services on the one hand, and administrative and control tasks, on the other. There were a number of interfaces in the traditional service sector as well as in the first two sectors, most of them leading to personal interaction between people.

In the information sector, the processing of information is - per definition - dominant. The coincidence of computer development and the increase in people working in the information sector will have happened by chance, but we know from surveys (figure 4) that the use of computers developed very tentatively at the beginning. The processing of information was mainly done on paper, and the large number of office workers in the last 50 years shows that occupations which deal exclusively with the processing of information have become more important with the growing information-related complexity of society and the world of work.

**Use of computerized tools in Germany 1999**

Source: BIBB/IAB, 1979 bis 1999

**different jobs - same infrastructure**
The use of computers in these information activities was mainly on the basis of keyboard and screen, irrespective of the underlying task structure. The homogeneity of the interfaces with the computerized information system and the tools used was already ridiculed 20 years ago (figure 5). Occupations were no longer characterized by the tools of work (as shown in figure 3) but simply by the personal outfit of the experts.

This homogeneous interface – screen and keyboard – has imposed itself on a broad basis. It has only marginally been extended by mouse and loudspeaker. All efforts towards ergonomic optimization failed due to the fact that familiarity with this infrastructure – about 2 billion people worldwide are using computers in this way – is a reality in the education economy and is difficult to change. In principle, keyboard and mouse, as well as the screen, are adapted to the human measure in the sense of antiquity, but they are not optimal interfaces. Results in the field of occupational medicine speak clearly against this interface, because different forms of stress occur and manifest themselves in the chronic impairment of posture and eyesight. The miniaturized keyboards used in mobile phones and remote controls are rather an impediment to people, even if – young people particularly – develop great skills in using them.

3. Employment, Leisure Time, Society

The translation of the diversity of interfaces in the traditional fields of work to tasks in information processing is therefore long overdue. What is today's reality and which path should be taken?

The specificity of information technology and steps towards its development have also determined its forms of use. Initially, there were complicated and cost-intensive infrastructures and devices. Their use was only economical where there was a tradition of investment, exploitation and economic profitability. Computers were therefore initially mainly used at professional level in companies and the administration and were mainly used by employees in the form of a division of labour. This also explains the type of initial use as well as the choice of interfaces with the computer.

In the world of employment, the entrepreneur or the employer invests in tools, material and infrastructures and allots tasks to employees. In extreme cases, the employer enforces specific forms of use, reduces employees' options and can also determine operations without further explanation and justification. Innovators in this environment do not necessarily depend on acceptance by their employees. They could impose the optimal human computer interaction from their point of view.

It is insignificant whether these instructions are sustainable in the real world of work. The more complex the business activities are, the more the company depends on cooperation between its employees, the more important is the acceptance of the employees concerned. However, particularly within the framework of instructions based on the division of labour, there are many occupational areas in which people are used for tasks where frictionless functioning can be forced. In such an environment, work processes can be enforced without a human-centred workplace layout, particularly when alternative jobs are not available in sufficient numbers or quality.

The situation is totally different when it comes to leisure time. Without the pressure of employment, people are free to determine whether they are willing to use a technology, infrastructure or computer interface. They can refuse or can insist on traditional structures. Only if they are convinced of the new structures will they accept and use them. The obstacle
to the use of new technologies in leisure time is heightened by the fact that, contrary to use at the workplace, the infrastructure used in leisure time either has to be purchased at one's own expense or has to be paid from one's own budget.

Thus, characteristics for use in leisure time differ from those at the workplace. It has been shown that the technology and infrastructure experienced in one's job are transferred to the private area, with a certain delay, and that in turn behaviour in the private area is transferred to the sphere of employment. This convergence characterizes the relation with computers as well as their acceptance – as a whole as well as with regard to different forms and types of use.

In addition to employment and leisure time, the social situation is important. While leisure time is mainly self-determined and employment is mainly determined by others, other mechanisms apply to the integration into society. Here, specific legal standards are relevant; political constellations, integrative fields of cooperation and ethical requirements become apparent. Social infrastructure is characterized by different interests on the one hand. On the other, obligations vary widely. The relations with information systems are manifold in the sphere of society. Self-determined docking points, such as those in private presentations on the Internet, as well as mandatory requirements, such as compliance with copyright provisions, are initially open. Understanding rather than massive force is required if people are to stick to the – written and unwritten – rules.

4. The Weight of Gainful Employment during life
It is reasonable to monitor the German population by age and status in order to evaluate the relevance of gainful employment and other status areas (figure 6). Only 40 to 45% of a population are included in work processes. All others are either children and young people, many are – still or yet again – in training, and an increasingly large part of the population is of an age where gainful employment has come to an end.

However, the personal volume of work of those who are registered as working populations has considerably decreased in recent years. The personal lifetime work volume in former times was approximately 80,000 hours (cf. Fourastié 1954). As Fourastié predicted, it has by now decreased to about 40,000 hours. Lifetime outside of gainful employment has therefore strongly increased in significance. Today, life outside gainful employment certainly characterizes people more than was the case in former times.

A longer training period, more free time during gainful employment as well as early retirement mean that people are spending a considerable part of their lives outside the world of work. Detailed surveys (figure 7), however, show that work is done during this "leisure time", and even today with a larger volume than in gainful employment (cf. Statistisches Bundesamt 1998, page 42 f.). In this area, it is primarily women who are working about 35 hours per week in private households and provide care for relatives (the volume of men is about 19 hours per week).
However, such a general view is not very reasonable due to the growing individualization. The open use potential of computers (laptops in particular) as well as of telecommunications can lead to a situation where the personal volume of work does not decrease in every case but continues to increase steadily with some groups (figure 8). The "delimitation" of work is a phenomenon which is currently playing a major role in the sociological discussion (cf. for example Baethge/Wilkens 2001). New provisions are therefore necessary to ensure a fair distribution of work in the information society and – where it is the basis for the distribution of opportunities in life – it is also necessary to offer opportunities for employment also to those who do not belong to the group of highly qualified or highly motivated people.

Finally, the option of life beyond gainful employment should be discussed without any reservation. This phenomenon already exists with the long-term unemployed but is only accepted in society after a longer or shorter period of gainful employment, while early retirement is indeed a recognized alternative which is considered to be positive.

5. The Use of Computers
The significance of the different technologies and their use is largely shown by the relevance and intensity of the use of computers at home, at work and in society.
5.1 The Use of Computers at Home

According to a (pilot) study of the Federal Statistical Office (2003 a), German households in 2002 were relatively well equipped with IT devices and integrated strongly into information systems (figure 9). In an international comparison, for example, Germany, where 44% of the households have Internet access, ranks before Japan (35%) and the average of the 15 EU countries (40%), but behind the US with 51%. If we look at individuals (population aged 10 and over), a total of 61% have access to a computer and 46% have access to the Internet. However, this depends very much on the status: Among students, all (100%) have a computer and 97% have access to the Internet, while only 19% of retired people have a computer and 12% have access to the Internet.

These rates have increased considerably only in recent years. It has taken a relatively long time until this equipment level was reached. Whether such equipment is purchased and used apparently depends on the generation to which people belong and on their working experience. Young people grow up with technology and cannot imagine life without these tools and infrastructures (a particularly obvious example is the use of mobile phones). Middle-aged people are familiar with it from their work and have gradually recognized that technology can also be useful in private life. Only the older generation shows a certain distance to computer infrastructures, although they have readily accepted other forms of IT, such as TV and telephone.

It is now expected that the different IT devices are integrated into one cohesive unit in the households – as has been achieved quite some time ago in companies. With this integration, it
becomes necessary to consider new interfaces. People wish to have practical and simple IT interfaces at home. If convincing solutions are offered, a large market will develop in this segment.

5.2 The Use of Computers at Work
IT has penetrated companies to a greater extent than households (figure 10). More than two thirds of the companies are using computers and the Internet, one third present themselves on the Internet. What becomes clear is that not only companies of the New Economy make intensive use of new technologies, but also companies of the Old Economy have rapidly recognized that they can benefit from computerized communication. Of course, IT-oriented companies are using computers a lot more (the use intensity of computers in the IT sector is 96%) than, for example, the manufacturing sector (46%) or trade (56%).

Still, by far not all companies are computerized and integrated into worldwide information systems. However, these results should not be overinterpreted. In contrast to surveys among people, surveys among companies do not have a uniform basis, as companies are very heterogeneous and their economic activities vary. After all, their relation to information varies by branch and tasks. The size of companies is particularly important: While large companies are almost completely computerized, this is not (yet) the case with small and medium-sized enterprises.

5.3 The Convergence of Workplaces and the Infrastructure at Home
The falling prices of computers and communication services have led to a re-arrangement of specific forms of use of computers and information systems at home and at work. With regard to the infrastructure, no big differences can be seen today. The traditional computer is a product for consumption as well as a product for investment and does not show a division into "professional" and "non-professional" features. Obvious differences exist in the safety concepts, in capacities for background computing power and in the access to the services provided. Apart from these differences, the private computer shows a trend toward the multimedia sphere with additional features.

*The example of teleworking*

Due to the convergence of equipment at work and at home, new work models with an open allocation of time and space were discussed at an early stage. In the 1980s, a time when full employment and labour shortages were on people's minds, teleworking, particularly at home, was considered to be a possible way of integrating those groups into gainful employment which were not able to commute to work over long distances due to other obligations or burdens. The result was a strange coalition of mothers with young children, people with disabilities and prisoners. At that time, only simple office work was considered for teleworking at home. This form of teleworking at home did not go beyond some funded projects. Nor were teleworking centres able to survive without subsidies.

Then different forms of teleworking developed. As demonstrated above, it has become an additional form of work beside the traditional office-based work, which is practiced by highly qualified people with creative jobs in particular. A new survey of the Federal Statistical
Office shows that about 10% of all households include employees who perform specific tasks on their computers at home which are linked with their employers via the Internet. They account for 22% of all people who are online. Of course, the different status groups make very different use of these possibilities (figure 11). Freelancers – understandably – to a high degree, employees and the civil service are centerfield, while workers use computers at home only occasionally for work-related tasks.

Most people search for information (80%), more than half of them write e-mails at home and one out of five sends work done at home to his/her place of work. Thus, the homogeneous infrastructure at home and at work has led to forms of work which we know from school: There is homework to be done.

6. The New Image of Work

Due to the informatization and mainly the ubiquity of professional IT infrastructure, traditional delimitations between work, leisure time and social activities have become less relevant. Today, there is much overlap between activities which are fully, partly or not at all geared to employment. Still, in most countries traditional forms of office work have been retained. The necessary information interfaces could be realized everywhere, but they are still mainly found at the office. All other work models are only important in niches.

The reasons have hardly been analyzed. Within the framework of supporting scientific research on teleworking, reasons have come up which are characterized by history on the one hand – society becomes suspicious in the case of alternative forms of work, because work has to be done at the place of work -, on the other hand, people expect that there should be a balance between household-related leisure time and company-related work. These obsolete perceptions are mainly shaped by the decision-makers in the companies, the majority of whom were socialized at a time when work was primarily standardized. At the same time, these office-based forms of work offer clear framework conditions and a mixture of personal and technology-based communication. Wherever a safe job depends on traditional patterns of behaviour, new forms of labour will be given little attention.

The situation is quite different with people who - as freelancer or at management level - do not have to or want to subject themselves to the usual standards. For them, such new possibilities of flexibilization are very interesting and they are willing to use them if the interfaces available are sufficiently comfortable. They thus show a similar attitude as any household does: They take an independent decision on the procurement of the infrastructure and its use.

It is possible that, in the long term, these people also change the work environment of the other members of staff. Maybe at some point they are no longer willing to provide their employees with a personal place of work which is defined in space. Maybe they demand an extra free from all those who still want to work in an office (figure 12).

The interfaces to the world of information are certainly also decisive for an open world of work with high information skills. The traditional keyboard and screen seem to be an accepted and widely used solution. However, for the future it will be decisive that people on the lower edge of the skills range are given a less abstract access to the world of information and that the players on the upper edge are not hampered by difficult equipment in their creative use and generation of information.
New forms of human computer interaction should therefore develop from the extremes. The elites on the one hand and the people who need support on the other require interfaces that are better geared to human needs. The solutions will move from these two poles to the broad centre where the computer screen is still dominant. However, this process will be influenced by a large number of different framework conditions and will require a lot of time.

**Literature**


