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RESEARCH MEMORANDUM

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SYMBIOTIC APPROACHES TO WORK AND TECHNOLOGY

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Symbiotic design methods aim to take into account technical, social and organizational criteria simultaneously. Over the years, many symbiotic methods have been developed and applied in various countries. Nevertheless, the diagnosis that only technical criteria receive attention in the design of production systems, is still made repeatedly.

Examples of symbiotic approaches are presented at three different levels: technical systems, organizations, and the process. From these, discussion points are generated concerning the character of the approaches, the importance of economic motives, the impact of national environments, the necessity of a guided design process, the use of symbiotic methods, and the roles of participants in the design process.

INTRODUCTION

Many social scientists claim that the one-sided interest of technicians in technical aspects as a result of which social and organizational issues are neglected, leads to the creation and implementation of inadequately functioning systems. During the last forty years individual researchers and research groups have recognized the existence of this hiatus, and tried to design production systems that were labelled 'sociotechnical' (Emery, 1959; Mumford, 1983), 'human centred' (Badham, 1991) or 'anthropocentric' (Rauner and Ruth, 1991; Wobbe, 1992). In the remainder the common denominator for such design methods is 'symbiotic', thereby stressing the necessity of cooperation between technical and social scientists in designing production systems. Although the importance of symbiotic approaches has been stressed repeatedly during the last forty years as a prescriptive device, it is striking that descriptive studies time and again demonstrate that these prescriptions seem to have contributed little to the design of new production systems in practice. Thus, the diagnosis that technical systems fail to achieve their goals due to a lack of consideration for organizational and social issues can hardly be called new. Repeatedly, researchers have pointed to insufficient performance of production systems because social, organizational and\or human factors were ignored when the system was designed. Despite this repeated diagnosis, the same problems occur over and over again (Perrow, 1983; Wall, Clegg and Kemp, 1986; Majchrzak, 1988; de Sitter, 1989; Warner, Wobbe and Brödner, 1990; Alsène, Lefebvre and Auclair, 1992; de Freyssenet, 1992; Heming, 1992).

Perhaps this conclusion is too gloomy. But even if true, that would be reason the more to pay attention to such methods. The approaches developed in the course of time need to be inventoried and studied, so that lessons can be learned in a systematic way from experiences of previous researchers. Furthermore, researchers currently working in this field are likely to gain from active interaction with colleagues. The workshop 'Symbiotic Approaches: Work and Technology' aims to stimulate discussion between researchers in order to put the conceptual ideas and later the practical designs resulting from these conceptual ideas on a higher plane. Questions are piling up. If the above impression is correct, why have previous symbiotic methods not realized their promising potential? What actions need to be undertaken to create more favorable conditions for the implementation of contemporary symbiotic approaches? What are the basic differences and similarities between the different symbiotic methods? Is there anything 'new under the sun', or are these approaches basically the same?

Before even starting to discuss such questions, more insight is needed into the similarities and differences between symbiotic approaches as developed in several countries. Symbiotic approaches are applied at the level of technical systems, but also at higher levels of aggregation such as organization design. Whereas the first involves the incorporation of social criteria into the design of technical systems, the latter is concerned with characteristics that technical systems need to have in order to function effectively in the environment in which they are embedded. Furthermore, the process of elucidating the social criteria with which technical systems have to comply needs ample attention as well. These criteria often become known only when the design process is in full swing. The subsequent sections deal with these aspects in the following sequence: the design of (individual) technical systems is discussed first, then implications of organizational criteria are discussed, and finally the design process is given attention. Each of these sections discusses two examples. The paper closes with some discussion points which may serve as an input for the discussion during the workshop.

SYMBIOTIC APPROACHES

Technical systems. Arguably, the level of individual technical systems has been given most attention in the development of symbiotic methods. These often concentrate on the design of the man-machine interface, ergonomic requirements in general and the consequences for worker skills and learning. Many symbiotic systems have been developed in Germany (Scherff, 1989; Brödner, 1990; Hacker, Hallensleben and Teske-el Kodwa, 1992), partly as a result of the stimulus given by substantial government funding in the form of the program *Humanisierung der Arbeit* (Humanization of Work) and its successor *Arbeit und Technik* (Work and Technology) (Herzog, 1990). Within the EC, many projects have been carried out sponsored by the ESPRIT (Cooley, 1988) and FAST-programs (Gottschalch, 1992), although its success varies from moderate in Northern Europe to rather modest within the southern EC-members (Wobbe, 1992). Scandinavia also fulfils a prominent role with the UTOPIA-project (Bødker, Ehn, Kyng, Kammersgaard and Sundblad, 1987) as an outstanding example. Whereas most researchers concentrate on manufacturing (Zarakovsky and Shlaen, 1991), information systems in general (Blackler, 1988) and knowledge-based systems (Kirby, 1992) have also been subject of research.

In 1989, the presentation of several programming packages under the name of *Werkstattorientiertes Programmierverfahren WOP* (Shopfloor-oriented programming) draw a lot of attention and aroused great enthusiasm. Traditionally, Computerized Numerical Control- or CNC-machines are programmed by writing abstract programs. This proved to be an insurmountable hindrance for many traditional craftsmen, who found themselves conducting standard tasks such as loading and monitoring after the introduction of CNC-machines. Such a change of jobs was often seen as inevitable because the intellectual requirements posed by the traditional way of programming was often perceived to be too high for traditional craftsmen. WOP meant to bring programming back to these craftsmen. With this purpose in mind, WOP has a user interface which presents objects and operations graphically. This allows (traditionally) skilled workers to use and maintain their existing knowledge. The sequence of operations is not determined automatically, but the worker remains in control. He is able to generate and evaluate alternative programs. Complex cutting forms are available in preprogrammed modules to assist the worker programming. The programs can be simulated and tested graphically. Tests by a leading German manufacturer indicated that WOP was far more economical than existing programming packages, a finding which held for all degrees of parts complexity. Furthermore, the program can be mastered quickly (Brödner, 1991; Herzog, 1991).

A second example concerns a relatively new development, namely knowledge-based systems. As is generally the case when new technical systems are developed and gradually implemented, technical aspects predominate. There is evidence that organizational and social aspects such as, maintenance problems and degradation of work respectively, are neglected (Benders and Manders, 1993). Yet, human-centered knowledge-based systems are emerging, too (Danielsen, 1991; Kirby, 1992).

Kirby (1992) describes the development of a human-centred approach to the development of knowledge-based systems, called CAPS: 'Computer Assisted Problem Solving'. CAPS aims to overcome the disadvantages of traditional knowledge-based systems by considering three issues:
1. subject matter ('knowledge domain') of the advisory system;
2. the nature of the advice given by the system;
3. user control.

Unlike traditional systems, CAPS does not aim to replace a human (expert) by a technical system, but this system is seen as an instrument to support human decision-making: advice is given rather than binding commands. User control is guaranteed by using a hypertext system. This allows users to request data on a particular topic. Information on related topics, so-called 'buttons', is highlighted, and can be accessed as well. In order to avoid that a user gets lost in an overload of information when selecting different buttons, it is necessary to formulate a problem-solving strategy into the organization of nodes and links in the system. So far, a prototype system has been developed to assist design engineers.

Organizational design. Technical systems as such are only one element of a production system. The performance of production systems partly depends on machinery, yet the people that work around and with these machines, and the structure of relationships between men and machines are equally important factors. Symbiotic design approaches claim to give these factors more consideration than conventional approaches.

The Swedes have for long fulfilled the role of the world's leading symbiotic designers, with Volvo and Saab as key actors (Bennett and Karlsson, 1992). Volvo's Uddevalla plant has been a sociotechnical showcase, which gained worldwide attention. The design process took several years. The ultimate result was an assembly plant with six product shops, centered in groups of three around two inspection shops where the cars are tested. Every product shop contained eight parallel teams of approximately ten persons. These teams assemble complete cars in two-hour cycles. Material supply for this new type of assembly plant demanded much attention, resulting in a highly automated system supplying the product shops from centrally located material shops. Ergonomic conditions received a great deal of attention too (Ellegård, Engström and Nilsson, 1991).

The plant is claimed to have performed well, both in social and economic terms. The number of assembly hours per car was falling rapidly from an initially high level to a level comparable to Volvo's traditional Torslanda plant and beyond, a reputation for product quality was quickly built up, and its ability to handle a large product variety was impressive (Engström and Medbo, 1993). Despite this promising performance, Volvo decided to close the plant. A host of reasons have been reported, including a strong fall in the demand for cars as well as Volvo's future partner Renault's objection against such a sociotechnical plant.

For adherents of the Swedish sociotechnical approach, a comforting thought may be found in the new direction of some 'lean' producers in Japan. Lean producers have been criticized for the detrimental social effects of this way of producing (Fucini and Fucini, 1990). The fact that Japanese car assemblers faced serious labor market shortages around 1990 in their home country indicates that assembly work is not perceived as being attractive. This left the Japanese with the same problem as the Swedes in the 1970s and 1980s; Jürgens (1992) even claims that Honda found an example in Uddevalla plant. Several leading Japanese car producers are now said to be moving towards 'worker-friendly' ways of producing. These reforms include Toyota's pilot factory at Tahara and its new workshops (Berggren, 1993), the extension of Nissan's Kanda plant and its Iwaki engine plant, and Mazda's Hofu assembly plant. Measures include the introduction of ergonomic improvements, the creation of a pleasant physical work environment and in some cases the elimination of the conveyor belt. At the same time, these companies strive towards increasing levels of automation to reduce the need for human labor. Assembly, up till now the domain of manual labor, is to be automated as far as possible. However, the exact content of a alleged 'worker-friendly' move, the differences and similarities between Japanese and Western approaches, and the question whether such moves will last even when labor market shortages are disappearing, are all matters to be resolved empirically.

Process. The descriptions of the technical and organizational levels focus on structural characteristics. These can also be considered as the result of a design process, which is the subject of the following discussion. Whereas some symbiotic systems can be bought off the shelf, they will always have to be implemented in a specific work organization. More often than not, however, symbiotic approaches involve tailor-made solutions, requiring an intense and lengthy design process in which technicians and workers play key parts. Sustained managerial commitment to the project is vital. Whether or not such symbiotic projects need a structured design methodology is subject to debate, as eclectic approaches are used as well.

The ETHICS design methodology, meaning 'Effective Technical and Human Implementation of Computer-Based Systems', was developed in the UK (Mumford, 1983). ETHICS has three goals:

1. to legitimize a value position in which future users at all levels participate in system design;
2. to enable design groups to take job satisfaction criteria into account, next to economic and technical criteria;
3. to ensure that a new technical system is embedded in a well functioning organization.

ETHICS has clearly been influenced by classical socio-technical ideas as developed at the Tavistock Institute and by L. Davis. Participation of users in system design, job satisfaction and the integration of technology, people, tasks and the organizational environment form essential elements. A design group, preferably of eight to ten members, is to follow a systematic, fiveteen-step procedure. It has been used by UK firms as well as a US manufacturer, leading to 'well designed "total" systems', as Mumford claims. Also, ETHICS does not require more man days in development than conventional methods, but its lead time is longer.

Depla (1988) describes a far more eclectic approach. Recognizing that organizations have a large freedom of choice with respect to factors affecting work design, he describes efforts by a militant Dutch union to change the traditional and pragmatic attitude toward work design as reflected in a plan with the prozaic name 'Slaughterline 2000'. This plan meant to fully automate the process of slaughtering pigs, mainly by robotization. This plan's feasibility was questioned because of technical and economic reasons, leading to a more pragmatic alteration. Yet, what stayed was the neglect of attention for the quality of working life. This led the union to formulate an alternative, not as a 'definite counterplan made by social scientists that opposes the plans of the engineers' (Depla, 1988: 207), but to stimulate the discussion about possible alternatives, broadening the narrow techno-economic scope. Yet, this alternative plan proved to be rather modest in its consequences for work design, focusing on job enlargement and the elimination of unfavorable working conditions. Nevertheless, Depla was pessimistic about the chances of realizing this symbiotic project. He judges that full automation might be more economic depending on the market strategy followed, and is even desirable in case of unattractive tasks. Furthermore, there is a trade-off between making work more attractive by paying attention to the quality of working life versus elimination of this work by automation (cfr. the contemporary Japanese developments as described above). Finally, management's orientation to work design and automation and the union's power to influence this are essential factors for the chances to realize alternative plans.

DISCUSSION

Despite the brevity of the accounts of various approaches given above, a variety of often interrelated issues for discussion can be distilled, thereby we play occasionally the role of the devil's advocate.

1. Degree of workers participations. Some methods have a participative point of departure, i.e. opinions of workers are taken into account in system design. These methods stress the importance of job satisfaction, which is sought to be achieved by letting future users participate in system design. Other reasons for employee participation include system acceptance, input of employee knowledge and democratization. On the contrary, other methods have a more expert nature, i.e. experts in the field of symbiotic methods dominate system design. For instance, an objective standard is created by which to judge the quality of working life independen of the subjective account of employees.

Furthermore, how does democratization relate to symbiotic methods? Is user c.a. employee input in the design process necessary because of democratization as a value *per se*, or are aspects such as making available necessary user knowledge to incorporate into the design and increasing the likelihood that users will accept the system when implemented, more important? What choices have to be made when the opinions of design experts, for instance engineers and consultants, are incompatible with the demands of future users? To what extent does the possibility that such conflicts occur necessitate a structured design process such as ETHICS?

2. Economic aspects. As Herzog (1991) states, unsatisfactory economic performance is a killer argument for the development and implementation of symbiotic approaches, in his case WOP. Not surprisingly, especially the more recent symbiotic methods, are claimed to have superior economic results, thanks to positive changes in worker attitudes and behavior, and other things. However, a major problem in this respect concerns quantifying these 'soft' benefits. Whereas the costs of the implementation of symbiotic projects (or any other project for that matter) are generally easy to establish, the benefits of their functioning can often only be established retrospectively. Thus, it may be hard to justify symbiotic methods by capital budgeting techniques, which require an *ex ante* assessment of a project's financial prospects, a problem which is aggravated in case of extensive and thus expensive design projects. Furthermore, the recent closure of Volvo's symbiotic showcase, namely its

Swedish Uddevalla plant, has been criticized because of this plant's allegedly superior economic performance (Engström and Medbo, 1993). Although hard to accept for those who believe in rationalism, this would indicate that an adequate economic performance may not always be sufficient for symbiotic designs to last, and that deep lying resentments may play a role as well.

Finally, which organizations can afford the often long-lasting symbiotic design processes, which require substantial resources? Is this an impediment to the diffusion of symbiotic approaches in small- and medium-sized enterprises?

3. National environments. As Cole (1985) has shown for the case of small-group activities, the strands of employers' organizations, unions and (national) governments as well as labor market conditions play a vital role in the diffusion of organizational concepts. Most symbiotic approaches stem from countries in Western Europe with Scandinavian countries and Germany fulfilling leading roles in the development. The Southern countries of the EC (Wobbe, 1992), the United States and Japan have scarcely been involved (Rauner and Ruth, 1991), although the US sociotechnical tradition dates back from the 1950s. What are the major factors on the national level that respectively hinder or facilitate the development and diffusion of symbiotic methods? Consequently, is the competitiveness of symbiotic methods related to national environments? Is it a coincidence that Germany with its emphasis on skilled labor and strong system of vocational training fulfils a leading role in the development of symbiotic systems? Should this be interpreted from an institutional point of view (cfr. Maurice et al, 1980), or is a culture oriented view (cfr. Hofstede, 1980) to be preferred? Should they be seen as fitting in the specific West-European context characterized by small power distances and a tradition of participative and consensus-oriented relationships? Are symbiotic methods biased by Western values such as democratization\participation and autonomy?

4. The design process. Symbiotic methods stress the importance of simultaneous attention for technical, social and economic factors. System design has to take into account these factors simultaneously; neglecting this leads to sub-optimal designs. However, the common practice of muddling through, a term coined in 1959, does not seem to lead to large-scale bankruptcies, in other words: non-symbiotic approaches are often viable. Conventional sequential rather than symbiotic parallel decision-making with respect to technical, economic and social criteria has also led to acceptable results (De Haan, Peters and Giesberts, 1992). Complex symbiotic design projects may deter management from using it, especially because management generally has a preference for simple solutions or even panacea (Gill and Whistler, 1993).

This of course may be because management is used to treat organizational changes in a specific way and will only under extreme circumstances turn to new or innovative organizational practices. This behavior may turned to as bounded rationality or organizational inertia.

5. 'Wrong' use of symbiotic systems. Even industrialized countries are fairly dependent upon small- and medium sized enterprises (SMEs). Typically, affairs are handled in an incremental way in SMEs and they are characterized by low levels of knowledge concerning organizational affairs such as organization and job design. Symbiotic design projects are unlikely to be initiated by these firms; instead, they generally buy off-the-shelf systems. However, it is very well possible that a symbiotic system such as WOP is used in a traditional way, facilitating programming not for a worker, but for a specialist programmer (Benders, 1993).

6. Who stands accused? It is sometimes claimed that conventional technical systems seduce organizations to implement fragmented jobs or even that they are developed consciously to create such jobs (Noble, 1978; Scarbrough and Corbett, 1992). At the best, engineers are seen as being unaware of the social and organizational consequences of their technical designs. However, such claims are typically made by social scientists, accusing mechanical engineers. But these positions can be reversed: are social scientists sufficiently capable of specifying the technical requirements that symbiotic systems must meet? To what extent do social scientist need to have technical knowledge in order to communicate with technicians? Is it not too easy for social scientists to claim that engineers are insufficiently aware of social criteria while not possessing technical knowledge themselves?

If during the last decades descriptive studies repeatedly diagnosed that organizational and social aspects were neglected at considerable cost, why have prescriptive symbiotic approaches failed to be more effective? What factors impede the use of symbiotic methods, and is it possible to intervene?

7. Industrial setting. Frequently, symbiotic approaches are attributed best chances in case of unit and small batch production (Wobbe, 1992), indicating that symbiotic methods are primarily successful in particular market segments. In that case, mass production may retain a low quality of working life, whereas this sector needs improvements most from the perspective of the quality of working life. To what extent do chances for symbiotic approaches vary depending on market segments and output characteristics (Sorge, 1989)? What if economic assessments prove that conventional designs are superior? Are social and organizational needs always compatible?

Obviously, this list of questions and discussion points is by no means exhaustive. Its main function is to elucidate some of the more vital issues to be raised and discussed during the workshop.

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BIOGRAPHICAL DATA

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