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Olerup, Agneta

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SOCIO-TECHNICAL DESIGN OF COMPUTER-ASSISTED WORK:
A Discussion of the ETHICS and Tavistock Approaches

AGNETA OLERUP

Department of Information & Computer Science at Lund University
Sölvegatan 14a, S-223 62 Lund, Sweden

Abstract

In the paper the major sources of influence on the socio-technical perspective are identified and two socio-technical approaches are compared, namely the Tavistock approach and the ETHICS method developed by Mumford. The Tavistock approach has provided crucial contributions at the work system level, particularly principles for socio-technical design and models for job design (how to design jobs as well as criteria for job design). The ETHICS method aims to apply socio-technical thinking to the design of computer assisted work. ETHICS draws heavily on the Tavistock approach. In addition, the framework for job satisfaction is influenced by the Parsonian pattern variables. A series of detailed models of ETHICS has been put forward. In the early detailed versions of ETHICS participation was not considered. The method has, however, become increasingly participative. Finally, there are important differences in how the Tavistock approach and the ETHICS method conceputalizes the social and the technical parts of a socio-technical system. Also they differ in terms of integrating the social and technical parts into a socio-technical system.

Keywords: socio-technical system, Tavistock approach, ETHICS method, computer-assisted work, work design, information system design.

1 Introduction

There is general agreement that the quality of the relationships between people and the jobs they do is important. There is, however, little agreement on how to improve the quality of this relationship. Generally, it may be accomplished by either changing people or by changing the work itself. People-approaches include selection and training as well as payments and rewards. Among the work-oriented approaches are traditional approaches (e.g. scientific management), behavioural approaches (e.g. motivation, job description), and socio-technical approaches.

Traditional approaches to work design have been used extensively when designing computerized information systems. The outcome has typically been jobs that are highly fractionated, simplified, specialized and impoverished. In addition there has often been a high incidence of system failures with regard to computer systems, and the expected improvements in productivity and efficiency from introducing computer systems have not always been realized. Clearly, something needs to be done. Socio-technical approaches have been put forward, e.g. (Mumford, Bostrom & Heinen 1977, DeMaio 1980, Pava 1986) as a remedy. The earliest, and probably the best known, efforts to introduce socio-technical approaches into information system design are those of Mumford, e.g. (Mumford 1971, 1972a and 1983b). Furthermore, collective resource approaches have been proposed, which are founded on labour process theory (Ehn & Kyng 1987, Sandberg 1985). They will, however, not be discussed in this paper.

During the last thirty odd years an increasing number of empirical studies claiming to use a socio-technical perspective have been undertaken. The notion of socio-technical system has been generally accepted, but sometimes the meaning given to socio-technical systems is very wide and simplistic. There is not a single homogenous socio-technical school, instead socio-technical theory has developed in a number of directions (Gustavsen 1986, Kelly 1978). Furthermore, it appears that socio-technical system theory has become eclectic, drawing on a wide range of theories, models and techniques from the behavioural sciences (Pasmore *et al.* 1982).

This paper will be delimited to socio-technical systems of the *primary work system*, or the micro-organization. At the primary work system level issues concerning principles of work design, methods of work analysis, questions of motivation and design of autonomous groups are important. Socio-technical studies of the *whole organization*, or the macro-organization, e.g. (Hedberg 1977, Burns & Stalker 1966, Woodward 1965), and of *macro-social phenomena*, e.g. (DeGreene 1973) will not be considered.

The focus in this paper will be on the socio-technical perspective developed by the Tavistock Institute and the application of socio-technical systems to the design of computer systems by Mumford, the ETHICS approach (Mumford & Henshall 1979, Mumford & Weir 1979, Mumford 1983a). First work design and information system design are discussed, particularly socio-technical design is compared to other approaches for work design and contrasted with information system design. Then the Tavistock and ETHICS approaches are reviewed. The intention is to identify similarities and differences in the approaches. Finally, I shall indicate some areas where I believe further research is called for.

2 Work Design and Information System Design

The socio-technical perspective integrates a number of ideas, particularly from system theory and job design. Furthermore, socio-technical approaches have been influential in designing jobs and work systems. Other approaches to work design are available. Finally, socio-technical design complements and supplements information system design.

2.1 The Socio-technical Perspective—Sources of Influence

The socio-technical perspective introduced by the Tavistock Institute evolved gradually and has been used in a series of empirical studies in various industries and countries. Fortunately, a number of reviews are available. First, Trist (1981) explores exhaustively and in detail the evolution of the socio-technical perspective, and in a supplementary commentary Hackman (1981) identifies a number of problems in the socio-technical approach. Furthermore, Miller (1976) presents Rice's approach, and the main features of the Tavistock approach are outlined and appraised by Kelly (1978) and Mumford (1987).

Influence from a number of sources has been important in shaping theory and practice of the socio-technical perspective (Trist 1981, Miller 1976, Mumford 1987). I shall only briefly indicate these.

First, the seminal study on coal-mining (Trist & Bamforth 1951) introduced the concept of *socio-technical system*, which simply means that people produce products or services by using some techniques and tools.

Second, other sources are the work on *small groups* by Bion and Lewin. Bion's work involved leader-less groups and rotating leadership, as well as unconscious processes obstructing group purposiveness and group creativity; Bion drew on the psycho-analytic theories of Melanie Klein. Lewin argued that groups should be considered as dynamic wholes with a Gestalt of their own. Lewin's work included group climates and group decision making as well as studies of the commitment for action as a result of participation and found performance of the democratic mode superior (Trist 1981, Miller 1976, Mumford 1987, Faucheux *et al.* 1982).

Third, *system theory* has been important in developing the notion of socio-technical system. The concept of open system (von Bertalanffy 1950) was introduced at an early stage. Further, developments in system theory provided the basis for elaborating a theoretical socio-technical framework presenting a generalized model of the dimensions of social and technical systems (Emery 1959, Emery & Trist 1960). This version of socio-technical system theory[1] has influenced the socio-technical thinking applied in Scandinavia (Gustavsen 1987).

Developing and elaborating the socio-technical perspective involves ongoing efforts drawing on the evolution of system theory and system concepts. A broad range of concepts and ideas have been incorporated, among those are correlative system (Sommerhoff 1950 and 1969), and purposeful system (Ackoff & Emery 1972). Still other system concepts which can be found in recent socio-technical publications, e.g. (Trist 1981) are morphostasis and morphogenesis (Buckley 1967, Maruyama 1963), multifinality (Buckley 1967), appreciative system (Vickers 1968), and deutero-learning (Bateson 1972). Recent contributions to system theory, which are very likely to influence socio-technical system theory in the future are dissipative structures (Prigogine & Stengers 1985) and holographic systems (Pribram 1977, cf. Wilber 1988). These are just some samples!

A fourth source of influence is ideas on *job design*, put forward by Louis Davis in USA (Trist 1981, Kelly 1978). The first empirical studies using a socio-technical perspective had only considered work organization, but not job design, and autonomous groups, for example in the textile industries in India (Rice 1958), and in a coal-mining district in Britain (Trist *et al.* 1963). The job design principles were applied, for example, in the Norwegian Industrial Democracy Project (Thorsrud & Emery 1970), which was a cooperation project between the Norwegian Federation of Trade Unions and the Norwegian Employers' Confederation and also included independent researchers (Trist 1981, Ehn & Kyng 1987, Mumford 1987). This branch on the tree of socio-technical theory influenced the socio-technical ideas adopted by the Swedish Confederation of Employers, who initiated and controlled a series of experiments without neither any cooperation from the Swedish Federation of Trade Unions nor any involvement of independent researchers (Ehn & Kyng 1987). Other working-life researchers, not only from the Center for Working Life, were at the same time working collaboratively with unions (Dahlström 1987) attempting to improve and humanize working conditions through increased worker participation in decision-making on work and organization of work.

In summary, the major sources of influences on the socio-technical perspective are (1) the concept of socio-technical system, (2) research on small groups, (3) system theory, which continues to provide a rich source of concepts and ideas, and (4) principles of job design.

2.2 Socio-technical Design Compared to Other Approaches to Work Design

In contrast to traditional and behavioural approaches *socio-technical* approaches are more comprehensive. Changes in a work system involve simultaneous modifications of technical and social systems to create work designs which are improvements in terms of both productivity as well as social and psychological requirements. Further, the focus in socio-technical design is on clusters of strongly connected jobs forming a work group and contributing towards a common task which forms a whole distinguishable from other tasks in the production system.

Traditional appproaches (e.g. scientific management) tend to concentrate on the efficiency of the technical system, while *behavioural* approaches concentrate on people and the social system.

The outcome of *traditional* approaches are the creation of a number of clearly defined jobs of limited scope and a management structure arranged to provide close and helpful supervision to the people performing the jobs. It is the common goal of *behavioural* approaches to design work in such a way that high work productivity is achieved without incurring the human and social costs associated with traditional approaches. The most important behavioural approaches include concern with satisfaction and motivation, as well as those concerned with job characteristics. While *behavioural* approaches tend to pay insufficient attention to the operation of the technical system, *traditional* approaches ignore both the personal needs of the people who do the work as well as critical aspects of the social system (Hackman & Oldham 1980).

Job design has been improved by the introduction of job enlargement and job rotation, which has reduced specialization and increased discretion. However, they did not substantially increase the intrinsic quality of a person's job. Hence, job enrichment was later introduced, involving an enlarged work cycle, incorporation of both support and production tasks, as well as including decision-making. Job rotation, job enlargement and job enrichment all focus exclusively on individual jobs, i.e. on jobs performed by one worker. In contrast, the focus in socio-technical design is on the work system, i.e. on distinguishable clusters of interrelated jobs performed by groups of workers (Child 1984).

2.3 Socio-technical Design Compared to Information System Design

System concepts and theories are utilized both in information system design and in socio-technical design, ranging from simple and mechanistic system concepts to complex and sophisticated ones. First, I shall outline the basic system theoretic ideas of the socio-technical perspective. Second, as a contrast, I shall outline the main features of the system theory currently applied in information system design.

First, the *socio-technical perspective* has been influenced by the evolution of system theory and the development of a large number of system concepts. The basic idea refers to open socio-technical systems, open meaning that organizations have external transactions and dependencies, and socio-technical meaning that organizations are places of work for individuals and groups. Briefly, a socio-technical system is open, it is systemic and has positive feedback, it is characterized by joint optimization and equifinality.

The concept of *open system*, introduced by von Bertalanffy (1950) has been particularly important in directing attention to the fact that open systems must interact with their environments in order to survive. External relationships and transactions are necessary for maintaining the structure of a system and for acquiring production inputs and exporting the production outputs to some other system.

In an open system structure is created from the patterned activities performed by individuals and groups. The pattern of activities has a cyclic character, i.e. an interrelated set of activities or events return upon themselves to complete and renew a cycle. Cycles of activities are repeated, bounded in space and time, relatively enduring and interrelated. Thus the structure of a system is ongoing, it is constantly being created and recreated. The whole system is not equivalent to the sum of activities and cycles, instead it is created through interactions among activities and cycles. It is *systemic.*

In an open system external relationships and dependencies need to be reflected in the structure. Open systems may be more or less dependent on their environment, thus openness is not an absolute concept but a relative one, it is a matter of degree of openness. In addition to negative feedback, open systems have *positive feedback* when deviations amplify (Maruyama 1963), so changes in external relationships require internal changes.

The concept of *socio-technical system* recognizes that work organizations exist in order to do work. In work organizations people use technological artifacts (hard as well as soft) to perform sets of tasks contributing to some specified overall purposes. Thus a social and a technical system can be identified. The original conceptualization of social and technical relations had been in terms of obtaining the best match or "goodness of fit" between the two (Trist 1981). This was later reformulated (Emery 1959, Trist 1981) as the *joint optimization* of the social and technical systems. The two systems are independent in the sense that the social system follows the laws of the human sciences and is purposeful, while the technical system follows the laws of the natural sciences. They are mutually interacting since one requires the other for transformation of an input into an output. They are both necessary to accomplish a task, thus their relationship represents a coupling of dissimilars that can only be optimized jointly.

According to the principle of *equifinality* (von Bertalanffy 1950) an open system can reach the same final state from differing initial conditions and by a variety of routes. In the context of socio-technical systems this means that there are alternative ways of coupling a social and a technical system, and a choice must be made. The principle of organizational choice (Trist *et al.* 1963) is in agreement with the system-theoretic principle of equifinality.

System theories and concepts, particularly as found in the socio-technical perspective, are general, abstract and elusive. They can be adapted to almost any organizational situation, but it is difficult to pin down meanings and identify empirical counterparts. This is also aggravated by the fact that meanings are themselves interrelated and systemic. Even the concept of open system, which is relatively simple, is not an easy one.

Second, in *information system design* it is crucial to define the task of designing an information system and to find ways of making it manageable. The first is concerned with the role of an information system in an organization, and the latter requires defining smaller design tasks. There is a large number of methodologies for tackling each of the two problems, as well as a great variety in the concrete methods and techniques put forward. The approaches proposed by Langefors (1966/73, 1970) are representative, and they have had considerable influence on a number of methodologies for information system design.

The task of designing an information system is an imperceivable system, which must be handled with formal methods. According to the theory of imperceivable systems (Langefors 1966/73) the original system is partitioned into a set of subsystems, which are disjoint and exhaustive. A check is made that the partition corresponds to the original system. Each subsystem is then partitioned, and checked. When no further subsystems can be defined, final checks are made all the way up to the original system. In this way subsystems are identified which can be tackled and implemented independently, as well as replaced independently without affecting other subsystems. The system theory implies an analytical and systematic procedure resulting in a hierarchical system.

The role of an information system is as an instrument for controlling and managing another system (the operative system) towards some goals, for example manufacturing certain quantities of specific goods (Langefors 1966/73, 1970). This is clearly based on simple cybernetic models (of the first order) similar to mechanical systems and machines. In such a system, deviations from desired behaviour is corrected by using *negative feedback*. Further, it is assumed, that relationships between a system and its environment are well-known and not likely to change. This means that a system can be regarded as sufficiently independent of its environment, which allows most problems occuring in the system to be solved with reference only to its internal structure, disregarding external relationships.

Both with regard to the design task and the role of an information system, the structure of a system is equivalent to connections between components (human beings, machines, etc). A system is analytic, systematic, reductionistic and hierarchic.

Finally, the major differences between information system design and socio-technical design may briefly be *summarized*. Socio-technical design is concerned with work and accomplishing work, while the concern in information system design is with formal design methods. In information system design organizations are assumed to require negative feedback in order to correct for deviations from desired behaviour and to be fairly independent of their environments. In the socio-technical perspective organizations are characterized by negative as well as positive feedback, and they are open systems, i.e. interacting with their environments.

3 Socio-technical Design at the Primary Work System Level (The Tavistock Approach)

The core of socio-technical design is the concept of an open socio-technical system, accordingly modelling the social and technical systems is crucial. This can be assisted by approaches for socio-technical design. An approach for practical socio-technical design in actual work-situations has gradually been developed. It includes several elements: (1) principles of socio-technical design, (2) model for work analysis, (3) criteria for work design, (4) democracy and autonomous groups, and finally (5) action research. These elements are interdependent and interacting, and they need to be adjusted in order to be mutually supporting and coacting, in an actual design situation.

3.1 Principles for Socio-technical Design

The *socio-technical design principles* are intended to serve as a checklist or guideline. The most comprehensive list has been compiled by Cherns (1976), also quoted in (Mumford 1987).

The first principle of *compatibility* means that the process of design must be compatible with the objectives of design. The second principle of *minimal critical specification* (Herbst 1974) means that no more should be specified than is absolutely essential, when stated negatively, or that we identify only what is essential, when stated positively. A third principle refers to *controlling variances* (the socio-technical criterion), when impacts of variances are reduced either by attempting to eliminate them or by controlling them as near to their point of origin as possible. (A variance is the occurrence of an unforeseen event.) A fourth principle refers to *multifunction.* When work is organized based on the redundancy of parts, highly specified and fractionated tasks are assigned to people who are treated as replaceable parts. On the other hand when work organization is based on the *redundancy of functions* means assigning a range of tasks. The fifth principle of *boundary location* refers to the fact that all complex organizations require division of work, i.e. the work of the total system needs to be broken up into smaller groups of tasks, which can be readily coordinated and controlled. Boundaries are usually established on the basis of technology, territory or time. According to the sixth principle of *information flow* information systems should in the first place provide information to the point where required action is decided. A seventh principle deals with *support congruence*, which means that systems for social support (e.g. payment, reward, selection and training systems) should reinforce desired behaviour. Furthermore, in the eighth principle of *design and human values* emphasizes that the objective of organizational design is to provide a high *quality of work.* Finally, the last principle of *incompletion* suggests that consequences, which occur after implementation, indicate needs for redesign. Changes in the environment indicate needs for redesign. Design is ongoing, it implies monitoring and revision. Design means continual learning and evolution.

Additional socio-technical design principles which have been introduced (Trist 1981) are, for example, considering the *work system* as the basic unit of design, in favour of one-man-one-job, thus focussing on the work group rather than the individual. Further, the principle of *complementarity* (Jordan 1963) suggests that human and machine are not comparable, instead they are complementary.

3.2 Work Analysis and Work Design

Models for work analysis have been put forward. The first model was developed in connection with the Norwegian Industrial Democracy Project (Thorsrud & Emery 1970). This has since been expanded into a nine-step model for socio-technical inquiry (Trist 1973 and 1981), and it also exists in a number of versions.

In general the models for work analysis[2] start with an *initial scanning* in order to obtain a general idea of the target system. The *technical system* is examined, in order to identify *unit operations* and *variances*, and next the *social system* is studied. Then the inquiry expands to *neighbouring* systems, for example support and maintenance systems, including also an analysis of the organizational environment.[3] The process is a *recycling* one, and suggestions for change may arise at any point in the analysis, but only after all steps have been performed is it possible to formulate redesign proposals for the target system. The models for work analysis are not intended as a guiding procedure to be used solely by research workers. They are also intended for people in client-organizations.[4]

Work analysis includes an identification of unit operations and variances, which were originally used in the Norwegian Industrial Democracy Project. Unit operations and variances are useful concepts when analyzing the technical system (Engelstad 1969, Taylor 1975). *Unit operation*[5] refers to a set of integrated activities in the technical process, and it is separate from other unit operations by an identifiable state of change in the inputs or materials (Taylor 1975). *Variances* are deviations from some standard or norm (breakdowns in the technical system are excluded), a *variance matrix* shows the dependencies among variances (Engelstad 1969, Taylor 1975).

3.3 Criteria for Work Design

A model for work analysis also needs to be supplemented with a set of *criteria for work design.* Such criteria are needed to improve work design so that the ideal of joint optimization, which is a fundamental idea in socio-technical design, can be approached. Obviously these criteria must consider what individuals require from their jobs, in terms of both extrinsic and intrinsic requirements. The extrinsic requirements refer to pay, job security, benefits and other conditions of payment. Intrinsic requirements are only satisfied by characteristics of the jobs themselves and of the work organization in which the jobs are embedded (Trist 1981).

Drawing among other things on research on groups, six intrinsic characteristics have been identified (Thorsrud & Emery 1970, Trist 1973 and 1981), based on contributions from several researchers, for example Davis, Emery, Engelstad and Thorsrud (according to Kelly 1978).

The intrinsic characteristics have become known as the *socio-technical work requirements.* Six characteristics are particularly important. There is a need for variety and challenge in the content of the job. Possibilities for on the job learning, i.e. to learn and go on learning, are important. A job need to have a distinct area of decision-making, i.e. some discretion and autonomy. It also should give recognition and support. Essential are the meaning of work and its role in a larger context. Finally, a job should lead to a desirable future.

The socio-technical requirements are too general to serve as operational guides for work redesign. They need to be linked to objective characteristics of industrial jobs. Similar sets of job characteristics and core dimensions of jobs can be found in the socio-technical approach (Thorsrud & Emery 1970, Trist 1973 and 1981) and in behavioural approaches (Hackman & Oldham 1980, Schein 1980).

3.4 Autonomous Groups

In the classical studies in coal-mines (Trist & Bamforth 1951, cf. Emery & Trist 1960) it was found that autonomous groups had been introduced into some mines. These groups regulated their operations with a minimum of supervision. The contrasts in terms of absenteeism, accidents and productivity were considerable between mines using autonomous groups and mines using a conventional one-man-one-job form of work organization.

These and other studies suggested that the small self-regulating group held the clue to a great deal of improvements in work organizations. *Autonomous groups* became an important feature of socio-technical design. Such groups involve the formation of groups of employees who share responsibility for carrying out a significant piece of work, designed so that it is a whole and meaningful piece of work. Autonomous groups have several important features (Hackman & Oldham 1980, Trist 1981).

First, autonomous groups are *self-regulating*, they control key variances within their area of work. Members make the decisions about how the group and work should be planned and executed. The role of supervisors changes. The function of supervision is to manage the boundary conditions in the group's environment, thus freeing the group to manage its own activities. The supervisor no longer exercises direct control.

Second, an autonomous group is *homogenous*. Every member has acquired the skills to perform all the tasks necessary for the group to accomplish its work, thus an autonomous group is *multifunctional* and multiskilled.

Third, autonomous groups are *face-to-face groups*. Typically such groups are relatively small. There is, however, disagreement on the number of members suitable in such groups. Studies have reported findings of groups beyond the limits of the face-to-face range.

Finally, autonomous groups are often perceived as meaning increased democracy for workers. The socio-technical perspective has been particularly interested in *work-linked democracy* (Trist 1981), emphasizing that those workers, who are directly involved, should be encouraged to participate in decisions about how work shall be done at their own level.

3.5 Action Research

A final component in socio-technical design is *action research* (Trist 1981) meaning research leading to social action. Important influences came from psychoanalysis and Lewin's work on action research (Miller 1976). The guiding idea in Lewin's model of action research is that a process may be studied by introducing changes and observing their effects on it (Clark 1976). An intervention should be based on a theoretical model of how the organization or system works, and this model should, ideally, assist in predicting the consequences of the intervention. This suggests that a research process consists of recurring cycles of theorizing, intervening, gathering data on the effects of the intervention and then checking the theory prior to designing the next intervention.

Action research has both practical and theoretical goals. It aims to contribute towards the practical concerns of people in a problematic situation, this is the action part and encompasses introducing interventions from a social or behavioural science perspective in the ongoing process of a social system. In addition it aims to contribute towards the goals of social science, by generating new knowledge that can be incorporated into the body of social scientific theory, method and practice (Clark 1976).

Action research requires active involvement in changes both of research workers from the behavioural and social sciences and of clients. This requires developing a collaborative relationship between researcher and client, in order to assist the client in solving problems (Clark 1976). A common strategy in relating to a client is to seek to relate to the top executive level, assuming that change is more likely to follow if it has top-level support. For this reason the Tavistock approach has often been labelled as being managerial in orientation (Eldridge 1986).

3.6 Some Final Comments

The five elements of the Tavistock approach are closely related. First, the nine principles for socio-technical design provide the guidelines, which are then practically implemented in terms of analysis and design of work, criteria for work design and autonomous groups. Second, action research is crucial, since socio-technical design needs to be both used in practice and theoretically assessed. The Tavistock approach is an evolving one, which is applied in actual situations attempting to contribute to the concerns of people in work-organizations, and it is also contributing towards theoretical development of the socio-technical perspective.

4 Socio-technical Design of Computer-assisted Work (ETHICS)

The ETHICS method—Effective Technical and Human Implementation of Computer-based Systems (e.g. Mumford & Henshall 1979, Mumford & Weir 1979, Mumford 1983a)—has been developed to tackle design situations when computers are introduced into office-work. It is a basic belief that in such situations there are changes both in the technology of the office work and in the jobs of clerks and secretaries. The aim is "to help system designers, managers and other interested groups" to take advantage of the flexibility of computer systems and achieve good organizational as well as good technical design (Mumford 1983a). The ETHICS method, which has been developed by Mumford[6] and her research colleagues, is still being improved (Mumford 1983a).

The ETHICS method is based on a number of fundamental assumptions. There is a need to improve job satisfaction and quality of working life in addition to technical and operational factors. Further, it is necessary to ensure that a technical system is surrounded by a compatible and well functioning organization and work system. Finally, users need to play a major part in the design of computer systems, to enable them to influence the design of their own work situations (Mumford 1983a).

ETHICS consists of a set of logical, sequential, analytical steps, guiding the design of a computer-based work system (Mumford 1983a). This detailed method has been developed based on a *framework for design of computer-based work systems*, which provides a comprehensive summary of the major stages involved. It is also supported by a *framework for job satisfaction*, by concepts and techniques for job and work design, and by a *model for socio-technical design*. Finally, a *participative approach* is recommended.

4.1 ETHICS: Sources, Applications and Diffusion

Publications on ETHICS are almost exclusively aimed towards system designers and job designers (users). The purpose is to guide and train designers and users in designing computer-based work systems. A step-by-step procedure is introduced and each step is described in detail in terms of what to do and how to do it. Accordingly discussions of the scientific reasonings underlying the method are kept to a minimum.

In an early study[7] of the effects of computer systems it was found that the jobs of clerks became fractionated and specialized when computers were introduced (Mumford & Banks 1967). This provided the original stimulus for developing a design method. The idea of a *socio-technical system* was taken from the early Tavistock publications (i.e. Trist & Bamforth 1951, Trist *et al.* 1963) and a model for arriving at a socio-technical solution when designing computer systems was put forward (Mumford 1971). Another source of influence is the *pattern-variables* formulated by Parsons (Parson & Shils 1951). These were used in developing a comprehensive framework for job satisfaction (Mumford 1970, 1972b and 1973).

The socio-technical model and the job satisfaction model have been incorporated into the framework for design of computer-based work systems, which provides a "comprehensive method for handling the human problems of computer introduction" (Mumford 1972a). Concepts and techniques for work analysis, in particular *unit operations* and *variance analysis*[8], were introduced after Mumford visited UCLA during the first half of the 1970's and worked with Professor L. Davis (Mumford & Henshall 1979, Mumford 1983a).

During a ten-year period, 1972-82, ETHICS has been applied in seven UK-companies (Mumford *et al.* 1983). The first case was an order-processing system in a UK-company in 1973. This was followed by a visit to UCLA. The outcome of this visit was an introduction of the concepts of unit operations and variances into the ETHICS method (Mumford 1983a). Since then a number of versions has been introduced of the ETHICS method incorporating unit operations and variances at different points in the design process (cf. section 6.5), the latest is presented by Mumford (1983a). In parallell, during the period 1974-82, ETHICS was used in six UK-companies (Mumford *et al.* 1983). There are exhaustive accounts of two of these cases. One case concerns a computer system used by purchasing clerks in an aerospace firm, the initiative for socio-technical design came from the systems analysts (Mumford & Henshall 1979, cf. Mumford 1981). The other case is a study of word processing in a large chemical firm (Mumford 1983b). Both case descriptions provide detailed chronological accounts of the processes of design.

In six of the UK-cases the users are clerks and secretaries. The computer systems introduced in these companies include: an order-processing system, a system for buying and selling currency, a system for purchasing supplies and paying suppliers, a word processing system, a system for purchasing supplies, and a personnel information system. The remaining system is a total information system for academic and administrative staff in a Government Agency concerned with education. The other six cases concern *clerical and secretarial work*, and the computer systems are primarily *operational* and task-oriented systems, which are used in performing certain tasks.

Socio-technical thinking has been introduced into the information system field in Scandinavia by two groups. The *first group*, in the early 1970's, included researchers at a number of Business Schools (or equivalent) in Denmark, Norway and Sweden, who have a solid background in organizational behaviour and also publishes on organizational behaviour, e.g. (Bjørn-Andersen 1984, Borum 1977, Hedberg 1973, Høyer 1971 and 1974). The influence came not only from Enid Mumford's early work on developing a method for socio-technical design of computer systems, but also from other socio-technical, job design and industrial democracy efforts in Scandinavia, e.g. Høyer in Norway had contacts with Thorsrud (Bansler 1987). The *second group*, in the late 1970's and early 1980's, includes researchers at Departments of Information Processing or Information and Computer Science (or equivalent) whose major background is in information systems development and design ("systemeering"), information analysis, information retrieval, data processing etc. By that time the ETHICS method had been formulated as a step-by-step procedure in much the same way as ISD-methodologies. The ETHICS method thus provided a pragmatic approach, which made it very acceptable to information system analysts and designers. This group was influenced by Mumford's work, and to some extent by some members of the first wave, particularly by Niels Bjørn-Andersen, but there was little acquaintance with other socio-technical design, job or work design and industrial democracy efforts in Scandinavia or elsewhere.[9]

4.2 A Framework for the Design of Computer-based Systems

Arguing that a common defect in planning, designing and implementing computer systems is an overconcentration on technical variables and a neglect of human problems, Mumford (1972a) outlined a framework for handling the human problems of computer introduction.

The rudimentary framework included (1) *diagnosis* of the needs of the social system (in terms of job satisfaction), (2) development of *planning strategies*, (3) *socio-technical systems design*, and (4) post-change *evaluation* of the effectiveness of planning strategies and the systems design approach (Mumford 1972a and 1973, Mumford & Weir 1979).

The framework was put forward as "a method which can be used by computer specialists, personnel managers and line managers to assist them in systematically thinking through the human aspects of any computer based change and to enable them to plan and design systems which will meet human and technical needs at one and the same time" (Mumford 1972a).

Later versions of ETHICS are based on a slightly modified framework. This includes (1) *diagnosing* business and social needs and problem, focussing on both short and long term efficiency and job satisfaction needs, (2) setting efficiency and social *objectives*, (3) developing a number of alternative *design strategies* which will fit efficiency and social objectives, (4) *choosing* the strategy which best achieves both sets of objectives, (5) *designing* this in detail, (6) *implementing* the new system, and finally (7) *evaluating* it once it is operational (Mumford 1983a).

Today's computer systems are mostly flexible in terms of work organization, and most computer systems can accept a variety of task structures (Mumford 1983a). The ETHICS method was developed to "help system designers, managers and other interested groups to take advantages of this flexibility and achieve good organizational as well as technical desig" (Mumford 1983a). Users are apparently among other interested groups.

4.3 A Framework for Job Satisfaction

The basic definition of job satisfaction defines *job satisfaction* as a *good fit* between what employees are seeking from their work, i.e. *job expectations*, and what they are required to do in their work, i.e. the *organizational job requirements* (Mumford 1970 and 1973, Mumford & Henshall 1979, Mumford & Weir 1979, Mumford 1983a). In order to be able to measure job satisfaction it was necessary to identify the factors leading to a good fit.

The first phase in the development of a job satisfaction model utilized the five *pattern variables* of Parsons: (1) affectivity—affective neutrality, (2) self orientation—collectivity orientation, (3) universalism—particularism, (4) ascription—achievement, and (5) specificity and diffuseness (Parsons & Shils 1951).

These were translated into five pairs of characteristics referring to *a firm's role expectations* and *an individual's need dispositions:* (1) company job requirements—personal job requirements, (2) company interest—self interest, (3) uniformity—individuality, (4) performance—personal quality, and (5) work specificity—work flexibility (Mumford 1970 and 1973)

In the second phase job satisfaction was further elaborated by bringing together Parsons's pattern variables and a number of schools on job satisfaction. These schools included (1) psychological needs, (2) leadership, (3) effect-reward bargain, (4) management ideology and values, and (5) job description and work structure (Mumford 1973). The outcome is an identification of *five contracts:* (1) the knowledge contract, (2) the psychological contract, (3) the efficiency/reward contract, (4) the ethical contract, and (5) the task structure contract (Mumford 1973, Mumford & Weir 1979).

In a third phase a grouping of the contracts is introduced: (I) needs associated with *personality*, including knowledge and psychological fits, (II) needs associated with *competence and efficiency* in the work role, including support/control and task fits, and finally (III) needs associated with *employee values*, including ethical fit (Mumford & Henshall 1979, Mumford 1983a).

4.4 Socio-technical Design

Socio-technical design of computer systems aims to design systems which are based on explicit social and technical objectives and which are only accepted as viable if a degree of harmony between these technical and social ends is achieved. Mumford (1971) proposes a method for arriving at a socio-technical solution. Separate analyses are made of the technical and social systems. Technical and social solutions are formulated independently and then merged, eliminating incompatible combined solutions. The remaining combined solutions are evaluated with regard to resources, cost/benefits and objectives; and finally they are ranked. Social objectives include job design principles.

This model for socio-technical design then recurs as an integral part of the ETHICS method (e.g. in Mumford & Henshall 1979, Mumford & Weir 1979, Mumford 1983a). There is only a minor terminological change, technical objectives are replaced with efficiency objectives (Mumford 1983a).

4.5 Participation

A participative approach is advocated as crucial when using ETHICS, e.g. (Mumford 1981 and 1983a). Participation of users in design is recommended from a moral standpoint: "people have a moral right to control their own destinies and that this applies as much in the work situation as elsewhere" (Mumford 1983, cf. Mumford 1981).

Experiences from some early cases of using a socio-technical approach to computer design were decisive in introducing the participative ideas (Mumford &

Henshall 1979). These early cases illustrated three approaches to participation (in chronological order): (1) in ***consultative*** participation staff in user departments are consulted but the bulk of decisions are made by managers and system designers, (2) in *representative* participation a design-group is formed consisting of users representing different categories and systems designers, and (3) in *consensus* participation, it is attempted to involve all staff of the user department throughout to design process (Mumford & Henshall 1979, Mumford 1981 and 1983a, Mumford *et al.* 1978).

The three approaches differ in terms of the structure, content and process of participation. *Structure* includes mechanisms for enabling participation to take place, *content* refers to the nature of decision issues and decision-boundaries, and *process* refers to acquiring knowledge for taking informed and well-founded decisions (Mumford 1983a and 1984).

A consensus approach is recommended as being the most democratic approach (Mumford & Henshall 1979, Mumford 1983a). In order to ensure the proper structure, content and process of participation a project organization is instituted, composed of a steering committee and one or several design groups. The *steering committee* includes managers, and union officials, and it sets the guidelines, among other things. A *design group* (with 8-10 members) is composed of representatives of major user groups, and in addition includes the professional systems analysts engaged on the project. The design group will design the new system, including organizing work and allocating tasks and responsibilities, as well as deciding on hardware, software and man-machine interface (Mumford 1983a).

Much attention is paid to the benefits of participation, for example resolving conflicts, improved design, easier implementation (Mumford 1983a). Little attention is devoted to what conditions must be present in order for participation to allow real user influence and not just result in manipulation. In order to obtain influence participation is necessary but not sufficient, the power bases (e.g. knowledge, positional power, external assistance) available to users are crucial. Another important factor in participation is *respect* (Lawrence 1954), particularly the respect of management and system designers towards users. Participation in the ETHICS method refers to designing the work system, no attention is paid to the need for user influence in designing the computer system.

4.6 Different Versions of the Method

The ETHICS method—Effective Technical and Human Implementation of Computer-based Systems—now exists in a number of versions. The ETHICS acronym appears to have been used first by Mumford and Henshall (1979) and Mumford and Weir (1979). Subsequent versions are found in Mumford (1981), which uses the same case as Mumford and Henshall (1979), and Mumford (1983a). The method is presented as a participative approach by Mumford *et al.* (1978) and Land *et al.* (1980), without using the ETHICS acronym. The framework for work system design provides an outline for developing the detailed ETHICS method, which also incorporates the model for socio-technical design and the job satisfaction model. The ETHICS method also attempts to integrate the notions of unit operations and variances.

The versions of ETHICS differ in terms of number of steps. An early version includes four steps (Mumford & Henshall 1979), while the latest consists of 15 steps (Mumford 1983a). This is, however, only superficial, since substeps have become steps in later versions (two versions, i.e. Land *et al.* 1980 and Mumford 1983a are presented in the appendix).

Important changes in the ETHICS method can be traced by examining definitions of technical and social systems, and further by examining how unit operations and variances are handled. By analyzing the different versions in a chronological order a number of phases in the evolution of ETHICS may be identified.

In the first phase, the technical system is implicitly defined as the computer system (Mumford 1971 and 1973). The social system is defined as organizing work (Mumford 1971) or in terms of job satisfaction (Mumford 1973).

Next, in the second phase, analysis of the technical part of the system consists of a logical analysis of the *technical components* of the work system (i.e. machines, procedures, information) and the grouping of these into *unit operations* (Mumford *et al.* 1978, p. 250). Tendencies for the work system to deviate from a desired standard are called *variances*[10] (Mumford *et al.* 1978, p. 242). The analysis of the *social* part of the work system consists of analysing the *role relationships* within the system, and in addition an analysis is made of the *job satisfaction needs* of individuals (Mumford *et al.* 1978, p. 250).

The third phase differs from the second phase. The socio-technical method (developed by the Tavistock Institute) incorporates a logical analysis of the *technical components* of the work system and the grouping of these into 'unit operations' (Mumford & Henshall 1979, p. 8). The socio-technical method has a second important objective, this is the improvement of the efficiency of a work system through identifying and analysing system *variances* (Mumford & Henshall 1979, p. 8). Implicitly, however, the computer system is considered as the technical system, and the *social* system is analyzed and designed in terms of *work system* and *job satisfaction.*

In the fourth phase the computer system is implicitly considered as the technical system, and the social system is analysed in terms of job satisfaction (Mumford & Weir 1979). There is no identification of unit operations and variances.

Similary, in the fifth phase, the computer system is implicitly considered as the technical system (Land *et al.* 1980, Mumford 1981). The social system involves describing (1) the *essential organizational system*, i.e. boundaries, objectives, unit operations, and variance analysis (Land *et al.* 1980, Mumford 1981), and (2) the *essential human system*, i.e. roles and relationships as well as job satisfaction needs (Land *et al.* 1980), or just job satisfaction needs (Mumford 1981).

Finally, in the last phase, *technical* options considered during the design process include hardware, software and the design of the man-machine interface (Mumford 1983a), thus the technical system is defined as the computer system. The social system includes diagnosis of *efficiency* needs (step 7), i.e. looking for variances, and diagnosing *job satisfaction* needs (step 8), during the detailed work design (step 13) unit operations are identified (Mumford 1983a).

The computer system is consistently considered as the *technical system*, with one notable exception. In the second phase, technical system is defined as "machines, procedures, information" (Mumford *et al.* 1978) which obviously includes not only the computer system, but unit operations and variances are as well included as part of the analysis of the technical system, this is an exception, however. Analysis of job satisfaction needs is consistently a part of the diagnosis of the *social system.*

Unit operations and *variances* are considered as part of the technical system, when first introduced (Mumford *et al.* 1978) in accordance with the original definition (Engelstad 1969, Taylor 1975). Later versions of ETHICS (Land *et al.* 1980, Mumford 1981, Mumford 1983a) all consider the computer system as the technical system and accordingly include identifying unit operations and analysing variances in the analysis of the social system. The case in Mumford and Henshall (1979) is somewhat confused, but the application of ETHICS agrees with later versions. Mumford (1983a) does not identify unit operations as a basis for variance analysis, instead unit operations are first identified in the step of detailed work design.

Some changes and variations in the detailed ETHICS method can probably be explained by the need to adjust the procedure to the conditions prevailing in specific cases. They may also be explained by referring to experiences gained, for example certain techniques may be more comprehensible if used in another phase. Such discussions are however missing.

4.7 Some Final Comments

There is a very strong impression of remarkable stability in the ETHICS method. It has not changed in any significant way, those changes which have occurred have only been of minor scope. Also, the ETHICS method is a very structured and pragmatic approach.

The ETHICS method is oriented towards supplementing methodologies for information system development and design (ISD), either by supplementing ISD with a parallell process for work system design or by including ISD as a subprocess within work system design. ETHICS has adopted a detailed step-by-step procedure analogous to the step-by-step procedures of ISD-methodologies.

The empirical studies (Mumford & Henshall 1979, Mumford 1983b) give very detailed accounts of the work design process, but next to nothing on the process of designing the computer system, nor on the situation some time after having finished the design. Furthermore, they provide very scanty data on the computer system, for example with regard to the characteristics of a computer system in an organization introducing a work organization based on autonomous groups.

A further issue concerns the extent to which the structure and content of the ETHICS method depends on the types of computer systems studied (i.e. operational systems for routine office work) and to what extent it has been affected by the sequential characters of life-cycle and milestone approaches to ISD. The life-cycle and milestone approaches view ISD as a detailed sequence of steps which after a finite number of steps results in a computer system.

5 Discussion of the ETHICS Approach

The previous two sections reviewing the Tavistock and the ETHICS approaches provide the basis for a comparison. In particular three issues are important in such a comparison. These are (1) the detailed approaches, i.e. the detailed step-by-step procedure of ETHICS and the Tavistock model for work analysis, (2) defining the social and technical parts of a socio-technical system, and (3) integration of the social and the technical systems, i.e. whether joint optimization or matching and merging of social and technical systems. The characteristics of the ETHICS method and the Tavistock approach are briefly presented and discussed for each issue. An evaluation of some socio-technical approaches for information system design can be found in Fok *et al.* (1987).

First, with regard to the *detailed approaches* the ETHICS method and the Tavistock approach both introduce detailed stepwise procedures. These procedures follow a similar order, starting with an initial scanning and analysis, and ending with detailed work and job design. The ETHICS method is strongly analytical and systematic in orientation. ETHICS presents a step-by-step procedure wich is very detailed, specific and sequential. The detailed Tavistock models for work analysis are defined on a less detailed level and emphasize the need for recycling (Trist 1973 and 1981), thus making them more adaptable to varying conditions. There are variations in the number of steps between versions of ETHICS and between the ETHICS method and the Tavistock approach reflecting that a group of tasks may form a step or each task may be a seperate step. It may thus be concluded that the ETHICS method is quite in keeping with the Tavistock approach, in particular it agrees with the version proposed by Emery.[2]

Second, analyzing the *social and technical systems* are crucial tasks. Drawing the boundary between them affects what is included in the social or in the technical sytstem. In the mining studies (e.g. Trist & Bamforth 1951, Trist *et al.* 1964) the analysis of the technical system involved not only an examination of tools and machinery but also of tasks and work-operations. Neither was Rice's (1958) analysis of the technical systems in the Indian textile industry limited to the different types of looms.

In the ETHICS method the computer system is considered as the technical system, while tasks and work-operations are analyzed as part of the social system. Unit operations and variances are considered as important in the technical analysis in the Tavistock approach (Engelstad 1969, Taylor 1975) while they are part of the analysis of the social system in ETHICS.

The initial empirical studies using the Tavistock socio-technical approach (e.g. Trist & Bamforth 1951, Trist *et al.* 1963, Rice 1958, cf. Trist 1981, cf. Kelly 1978) were orientated towards production and manufacturing and were based in industries such as mining, textiles and refineries among others, which utilize process and massproduction technologies. On the other hand ETHICS has been applied to the introduction of computers into routine office work.

Introducing computer technology (e.g. robots, CNC) into the process of production means a change in the production technology, though it may still be of the massproduction variety. It is extremely unlikely that a socio-technical study of a firm (or a department within a firm) which has introduced a computerized production technology would constrain the technical system to computers, rather it would look at a technical system using a new computerized production technology and producing certain products. A *technical system* is not concerned with machinery only, but far more with the throughput or the transformation of energy or information (Katz & Kahn 1966).

Similarly, introducing computers into office work means a change in office technology. The old technology may only have involved using pen and paper, typewriters and calculators, while the new computerized office technology replaces some of the old tools and machinery used in an office, thus changing not only the technology but also tasks and operations.

The conceptual problem depends to a large extent on the fact that computer technology is different in nature from other technologies—such as production, office, administrative, sales technologies—which deal with specific task or problem areas. Computer technology is a general technology which can be used as an *auxiliary* technology in production, office etc technologies.

In order to grasp the role of computer technology in socio-technical systems the notions of primary and secondary socio-technical systems have been proposed (Damodaran *et al.* 1974). The *primary* socio-technical system actually produces work, and its technical subsystem consists of the techniques by which its work objectives is accomplished. This technical system frequently operates by virtue of a *secondary* socio-technical system. The secondary system is socio-technical because in addition to its own technical system it normally contains people who operate, maintain and develop it. The secondary socio-technical system supports the work of the primary system.

Third, in a socio-technical system the social and the technical system must operate jointly. The coupling may be accomplished either by *joint optimization* or by *matching and merging.* It is a characteristic feature of ETHICS that the social system and the computer or technical system are considered separately before they are matched and merged. On the other hand the Tavistock approach argues for joint optimization of the social and technical system (Trist 1981). Such joint optimization requires a close and ongoing interaction between the social system design and the technical system design, which implies a recycling procedure.

Mumford (1983a, cf. Mumford & Weir 1979) discourages from using joint optimization on the grounds that it is more difficult to use than the matching and merging procedure unless the design group has a very good knowledge of the technology they are concerned with as well as work design. At the same time, unit operations and variances are included in the technical system in the Tavistock approach. In the ETHICS method they are, however, considered to belong to the social system.

There is clearly a risk that the matching and merging procedure may be less successful than the joint procedure. A socio-technical system designed by matching and merging may be less than optimal, though still an improvement over the old one. A compatible socio-technical system is not necessarily a cooperative, interacting socio-technical design.

The character of information system design (ISD) methodologies provide a likely and plausible reason for the preference of the matching and merging procedure in ETHICS. An ISD-methodology typically consists of a detailed sequence of steps, broadly reflecting that requirements are analyzed before designing a solution and finally implementing this solution. Such ISD-methodologies are labelled life- cycle or milestone approaches. A number of recent methodologies for ISD are, however, based on prototyping or experimental approaches. Designing work systems and computer systems jointly requires an experimental approach to computer system design to be able to check the fit between the computer system and the work system. The joint design approach is not compatible with milestone approaches to ISD, but the matching and merging approach is.

Finally, in summary, the ETHICS method is quite compatible with the Tavistock approach, the differences are hardly consequential with regard to the design process and its outcome. Some of the differences may be explained by referring to the strict sequential character of milestone methodologies for ISD. It is however, quite possible to modify the ETHICS method and make it compatible with experimental ISD-approaches. There are no concepts and techniques in ETHICS which are not part of other socio-technical approaches as well. Thus the ETHICS method is not exclusively oriented towards the introduction of computers into office- work. The method does, however, demonstrate that a socio-technical approach is both feasible and useful in such situations.

Socio-technical approaches are among those approaches to developing information systems which argue that introducing computers into the work of people is not only a problem of designing a computer system. It is much more, it requires both organizational and work redesign to capture the full benefits in addition to information systems design.

6 Conclusion

This paper has examined socio-technical approaches, particularly the Tavistock approach and the ETHICS method. The ETHICS method has been put forward as a method for handling work design when designing computer systems. The differences between the two approaches have been found to be negligible, with regard to models for work analysis, design principles and techniques. There are, however, important differences in terms of comceptualizing and integrating social and technical systems. Thus some central concepts need to be clarified in ETHICS.

Based on the analysis in this paper, there are no grounds for concluding, that the ETHICS method is superior to other socio-technical approaches, or to other approaches to work design (particularly collective resources approaches and behavioural approaches).

Computer systems are characterized by increasing versatility and flexibility. There is a growth in facilities and services provided. Applications are expanding into areas where tasks are characterized by high levels of uncertainty and equivocality. Organizations utilize technologies and operate in environments that are increasingly becoming turbulent. Jointly, these trends suggest a need for both empirical studies and ongoing theoretical development, improving our understanding of methods and processes of design as well as increasing our comprehension of the interaction between work design and information or computer system design. It is equally important to investigate which computerized information systems are appropriate with specific work organizations and which are not, i.e. matching qualities of computerized information systems and qualities of work organizations.

It is practically impossible to assess methods for design only from their definition and description. There is a need for *rich case studies*, providing not only chronological accounts on the design-process, but also descriptions of the company (mission, technologies, structure etc) and department, as well as of the computerized information system in relation to the work organization.

Notes

1. The framework also introduces a notion of *alienation* (Emery 1959), which has been heavily criticized (Bansler 1987, Kelly 1978). Lennerlöf (1987) points out the existence of two traditions on alienation, one relating alienation to concrete conditions of production, the other oriented towards subjective perceptions of alienation.

2. A nine-step model for socio-technical inquiry (Trist 1973 and 1981) can briefly be presented as follows:
(1) An *initial scanning* of all the main aspects, both technical and social, of the selected target system. Then (2) the *unit operations* are identified, i.e. transformations (changes of state) of the material or product that take place in the target system. Next (3) an attempt is made to discover the *key process variances* and their interrelations. A variance is any deviation from a standard or specification. A variance is key if it significantly affects (i) either the quantity of production or its quality, (ii) either its operating or social costs. This makes it possible to (4) construct a *table of variance control* ascertaining how far the key variances are controlled by the social system—the workers, superiors and managers concerned. Next (5) a separate inquiry is made into the perceptions of *roles*, role possibilities and constraining factors by social system members. Then (6) attention shifts from the target system to the *neighbouring systems*, beginning with the support or maintenance systems, and (7) attention continues to the *boundary-crossing systems* on

the input and output sides. Furthermore (8) the target system and its immediate neighbours are then considered in the context of the *general management system* of the organization. Finally (9) suggestions for change may arise at any point in the analysis. The process proceeds by *recycling* rather than by a strictly sequential procedure, but only when all steps have been compared does it become possible to formulate redesign proposals for the target system.

A slightly different version contains the following steps (Emery *et al.* 1978, according to Mumford 1987):
(1) Initial scanning and briefing, (2) identification of unit operations, (3) identification of variances, (4) analysis of the social system (i.e. organizational structure, variance-table, ancillary activities, relationships between workers, flexibility, pay relationships, workers' psychological needs), (5) workers' perceptions of their roles, (6) the maintenance system, (7) the supply and user system, (8) the corporate environment and development plans, and finally (9) proposals for action.

3. The model approaches a social organization in terms of a number of *generic* types of subsystems or processes, similar to those identified by Katz & Kahn (1966): i.e. production or technical systems, supportive systems, maintenace systems, adaptive systems, managerial systems.

4. The procedure has been incorporated into a course on quality of working life, which is held by Louis Davis at UCLA (Trist 1973 and 1981).

5. The concept of unit operation has been taken from chemical engineering (Taylor 1975).

6. Enid Mumford was the first recipient of the J-D Warnier Prize, which was presented in October 1983. The grounds for awarding the prize states that the ETHICS method is unique for three characteristics: it has a high level of user involvement; it makes increased user job satisfaction a specific objective; and it places as much emphasis on good organizational design as on good technical design (according to a circular letter from Ken Orr & Ass).

7. The study by Mumford & Banks (1967) was one of a series of studies initiated by the OEEC/OECD in the late 1950's and early 1960's. A Swedish study was made by Eliaesson (1966).

8. The idea of a socio-technical system as well as the concepts of unit operations and variances have been incorporated into the ETHICS method and acknowledgements made. Despite the considerable influence of system theory on the Tavistock approach, there are hardly any references to system theory in the ETHICS method. An article (Mumford 1987) reviews Tavistock and the evolution of socio-technical design, but without mentioning the role of Davis in the socio-technical perspective, cf. (Trist 1981). The review briefly mentions system theory, referring to the ideas of von Bertalanffy, and pointing out that the appropriateness of system concepts and system theory for describing industrial organizations has never been completely demonstrated (Mumford 1987). There is no discussion in this article of the connections between ETHICS and the socio-technical concepts and principles reviewed. It is a plausible and reasonable explanation that it was not part of the task given.

9. In the late 1960's I started looking for studies on the consequences and implications of computers. Among the publications I discovered were some by Enid Mumford, among those (Mumford 1971 and 1972). I did not meet any members of the first wave until 1973 and 1974, though of course I knew about them and some of their publications. Having a background in business administration (as well as information and computer science) I decided to learn organizational behaviour and to study computerized information systems on a macro-organizational level using a contingency framework (Olerup 1982).

10. According to Mumford *et al.* (1978) variance analysis was developed by Louis Davis, a reference is made to an article by Davis (1971), which does not contain any discussion of variance analysis, nor of variance matrices, reference is also made to Taylor (1975). Mumford & Henshall (1979) also attribute variance analysis to Louis Davis, making a reference only to Taylor (1975). Mumford (1983?) states that variance analysis was developed in connection with the early socio-technical experiments in Norway, and that she became familiar with variance analysis through working with Prof. L. Davis and his team at UCLA (in the first half of the 1970's).

Appendix: Two versions of ETHICS

There are a number of versions of ETHICS, among those Land *et al.* (1980), Mumford (1981), Mumford (1983a), Mumford *et al.* (1983), Mumford & Henshall (1979), Mumford & Weir (1979). I found no significant differences among the various versions when examining and comparing them (with regard to steps and substeps, concepts and techniques etc). Only two versions of ETHICS are included, a recent one (i.e. Mumford 1983a) and one which is most different from this (i.e. Land *et al.* 1980).

ETHICS-1980

Land, Mumford and Hawgood (1980) present four analytical procedures (cf. Mumford, Land & Hawgood 1978):

1. The social system
   (a) Describing the Essential Organizational System: the nature of the problem, the boundaries of the system, objectives, unit operations, and variance analysis.
   (b) Describing the Essential Human System: (i) roles and relationships, i.e. operational roles, problem avoidance or correction roles, co-ordination roles, development roles, and control roles; as well as (ii) job satisfaction needs.
2. Discrepancy analysis, in order to establish the extent to which existing organizational arrangements are meeting or failing to meet efficiency and job satisfaction objectives and needs.
3. Future Analysis.
4. Setting Objectives and Evaluating Strategies.

ETHICS-1983

Mumford (1983a) presents a 15-step version of ETHICS:

Preparations before ETHICS proper starts include:

- setting up a project organization with steering committee and design groups (participative),
- determine roles of system analysts, facilitator, and departmental managers,
- training.

1. Why change?
2. System boundaries.
3. Description of existing system : (i) an input- output-analysis, and (ii) an analysis of different levels of work complexity and importance, i.e. operating activites, problem prevention and solution activities, co-ordination activities, development activities, and control activities.
4. Definition of key objectives (of an ideal/minimal organization)
5. Definition of key tasks.
6. Key information needs.
7. Diagnosis of efficiency needs (i.e. looking for key variancesand operating variances)
8. Diagnosis of job satisfaction needs.
9. Future analysis, e.g. changes in technology, legal requirements, economic factors, employee or customer attitudes, and company organization.
10. Specifying and weighting efficiency and job satisfaction needs and objectives, incl. translating broad objectives into specific and measurable targets.
11. The organizational design of the new system, organizational options.
12. (done in parallell with 11) Technical options.
13. Preparation of detailed work design (incl. identifying unit operations).
14. Implementation.
15. Evaluation.

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