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The Social Shaping of Technology and Work: Human Centred CIM Systems

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ABSTRACT

This paper decribes the theoretical and methodological issues involved in the social shaping of technology and work, with particular reference to human centred computer integrated manufacturing (CIM) systems. Conventional approaches to the understanding and shaping of the relationship between technology, work and human development are criticised, and an alternative, human centred approach is outlined. The methods and processes whereby the design of human centred CIM systems may be shaped and evaluated are then described and appraised.

KEYWORDS

social shaping, human centred systems, computer integrated manufacturing, multidisciplinary design

INTRODUCTION

This paper describes the theoretical and methodological framework for the multinational, multidisciplinary research and development project, entitled 'Human centred CIM systems', which is currently being carried out as part of the Commission of European Communities' ESPRIT initiative.[1]
In the first part of the paper, the concept of 'social shaping' is introduced to describe the essential dynamic between the social purposes and technological possibilities which shape the development of technology in general. The concept of human centred

1 ESPRIT is an acronym for the European Strategic Programme of Research and Development in Information Technology. 'Human centred CIM systems' is ESPRIT Project 1217 (1199).

Computer Integrated Manufacturing (CIM) is then discussed as a particular example of this shaping process.

The second part focuses on the relationship between technology, work and human development in computer assisted work environments such as those associated with CIM. Conventional approaches to the understanding and shaping of this relationship are discussed and an alternative, human centred approach is described.

The final part of the paper describes methods and processes whereby the design of CIM systems may be shaped and evaluated from a human centred perspective. Difficulties experienced in applying these alternative shaping processes are discussed.

1.0 SOCIAL PURPOSE AND TECHNOLOGICAL POSSIBILITIES

1.1 Introduction

Technology is always a union of the technologically possible and the socially desirable. The relationship is dialectical in the sense that the technologically possible necessitates social purpose for it to become technology, and the translation of social purposes into technological artefacts is dependent upon what it is technologically possible to construct. Hence, the crossing of the boundaries between social and technological rationality is a precondition for the process of technology shaping (see figure 1).

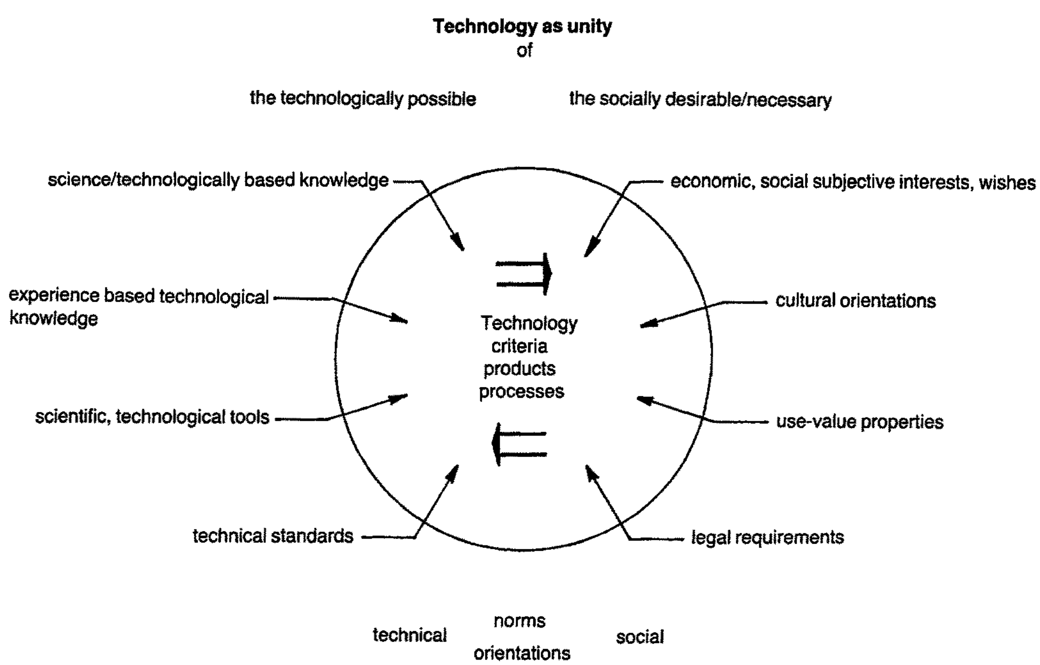

Figure 1 Technology as a unity of the technologically possible and the socially desirable.

In technology shaping processes, such as those associated with the shaping of human centred CIM systems, it is necessary to reflect upon this relationship:

What are the cultural, social and subjective orientations, wishes and interests governing the design and development of technology?
What are the technological possibilities, and in what form are they available in terms of knowledge, tools, methods and abilities?

1.2 Fields of technology shaping

Rauner (1986) describes the numerous interlinking 'fields' of technology shaping which may need to be considered in answering such questions. These 'fields' constitute the whole spectrum of 'social sites' (e.g. societal, cultural, political, organisational and personal), 'technology sectors' (e.g. electro-mechanical, chemical and nuclear) and 'spheres of technology and their application' (e.g. work, communication and domestic technologies). A consideration of all such 'fields' in the shaping of human centred CIM system design and development within the confines of a single ESPRIT project is clearly impracticable, although a number of important considerations derive from this holistic perspective.

First, the capacity for technological and socially creative imagination on the part of project researchers and designers must be taken into account in any appraisal of possible historical ramifications – particularly for responsible participation in the shaping of technology for the future. This is essential if future development phases are to be anticipated and reflected upon.

Second, although the general recognition that technology is an expression of collective social purposes and interests is of fundamental significance to any insight into technology, this general awareness is not enough if one is to design a concept of technology shaping based on a specific technology such as CIM. Even if human centred CIM systems are created, the problem remains (as it does with every technology) that there will be a number of unintended effects and consequences: i.e. side effects. A solution to this problem, in the sense of technology shaping, is the abandonment of socially uncontrollable technology.

A third consideration, which derives from a holistic perspective of technology shaping, concerns the need to focus on a particular perspective or social purpose in order to shape and evaluate human centred CIM systems. The evaluation of a technology can lead to vastly different interpretations according to the perspective taken. It is therefore important to define the concept of human centred CIM.

1.3 Human centred CIM systems

Largely owing to these complexities and ramifications, human centredness is an allusive concept to define. Behind the concept of human centred CIM systems lies a questioning of the ways in which conventional manufacturing technology (as well as other spheres of technology and its application) has been shaped, and a redefinition of the 'socially desirable'. In so doing, both development criteria and technical requirement profiles are not available to the design team. In other words, although human centred CIM systems are technologically possible, tools and methods with which they may be constructed have themselves to be developed. Yet the human quality of CIM must be determined and operationalised, otherwise a human centred CIM system cannot be realised.

This confronts engineers and social scientists within the project design team with a dilemma. For although 'human centredness' can be substantiated and explicated in numerous ways within social science and the humanities, the concept does not lend itself to conventional empirical study and analysis.

Human centredness is ultimately a subjective concept which cannot easily be translated into operational criteria. However, in defining a human centred CIM system, the wishes and interests of those who are to work with that system must be taken into account if the system is to be shaped in a human sense: the immediately affected must have a voice in establishing what 'human centred' is. User participation, although necessary in the human centred shaping process, is not sufficient. A difficulty arises from the fact that the affected people and users do not often constitute a unity of interests. Rather, they constitute people of diverse, even conflicting, interests and abilities. Similarly, a multidisciplinary design team will have diverse cultural, social and subjective orientations and interests.

The development of technology, in practice, is also marked by an independent dynamic of the technology itself, fostered by abstract economic and secondary political interests divorced from immediate use-value orientated technical purposes. Indeed, this reversal of the purpose-means relationship into a means-purpose relationship is itself a compelling example of the uncontrollability of technology and its consequences.

The role of the social scientists in the development of human centred CIM systems therefore has three interrelated objectives.

i To establish the most relevant dimensions of work to facilitate the development of both the technological and organisational aspects of human centred work.

ii To aid the development of mutual and reciprocal understanding and readiness for dialogue between engineering and social scientists within the project design group.

iii To mediate between the ultimate users/affected persons and the system designers. Such a role is crucial if a catalogue of design criteria, reflecting a consensus of social purpose and technological possibility, is to be attained.

The success or failure of the project is to be evaluated not merely by the success or failure of the resultant CIM systems with regard to the 'fit' between the interests of the users and the designers. Human centredness is not 'user friendly' writ large. 'Human-centredness' therefore above all means possibilities for change and development in respect to:

1 The human centred CIM-System.
2 The shaping of the word processes and contents.
3 The qualification and development of employees.

A balance between the development dimensions is of utmost importance in this development process. A surplus of qualifications that cannot be applied can easily lead to demotivation among the employees.

Technical solutions that initially seem humane, but which do not correspond to the development of the personalities in their qualifications, as they prove to be too rigid and inflexible, must in the long run be perceived and experienced as inhumane technology. These three facets of human centred CIM development are inextricably interrelated and are the focus of the second part of the paper.

2.0 WORK, TECHNOLOGY AND LEARNING

2.1 Introduction

The established way of perceiving the relationship between work, technology and learning is to determine both work and qualification requirements directly from the technological development, as illustrated in figure 2.

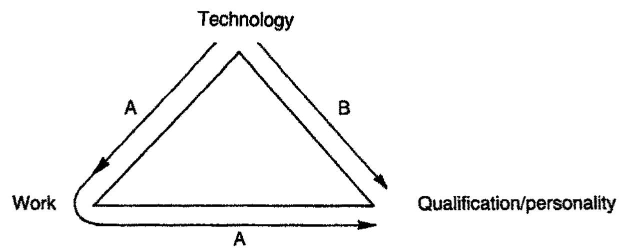

Figure 2 Conventional approaches to the study of work, technology and learning.

Two variants (A and B) exist of the (mis)understanding of technology as the historical subject. Following A, changes of technology determine changes of work which, on the other hand, determine qualification requirements. Following B, technological development directly determines the qualification requirements.

Studies of computer aided production technology demonstrate different lines of development in USA, UK, Germany and Japan due to the different cultural traditions of work and learning (e.g. Sorge *et al.*, 1981: Clegg, 1986). Therefore it is necessary to change the perspective as illustrated in figure 3.

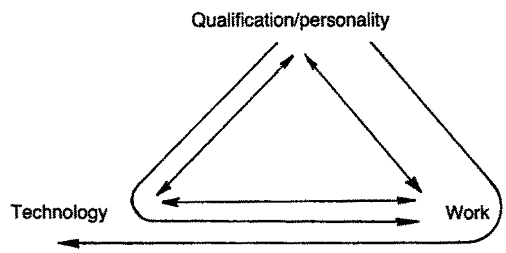

Figure 3 The social shaping of technology and work.

This illustrates the idea of beginning with the specific cultural tradition (qualification/ personality) and investigates how this influences the technological development and work process.

In accordance with this, the perspective of shaping technology and work must be revised, in order to help a less deterministic and more interaction-orientated perception of the relationship between work, technology and learning, stressing the communication-aspect as a fundamental human relation.

2.2 The relationship of work and technology

A number of historical and sociological investigations of the western industrial culture describe the connection between work and technology as a continuously increasing productivity of labour by improving the control over nature and over co-operating human beings.

A dramatic transformation in the relationship of work and technology has occurred during the course of the industrial revolution. This is characterised by the relationship of work to technology (as a measure in the work process) which was/is increasingly organised from the perspective of machines and 'restwork'.[2]

2 'Restwork' (from the German 'Restarbeit') refers to the process whereby as much of the work process as possible is automated, leaving humans to carry out those work tasks which remain.

This ongoing process of substitution and objectification of work presupposes a process of increasing regimentation and division of more complex work procedures that need to be carried out.

Thinking in terms of machines became the norm for the shaping of the work and technology relationship. In the resultant competitive situation of man versus machine, the machine usually proved to be superior in the work process.

This general perspective is presented by Braverman (1974) and others but, although it describes a dominant historical trend, such a perspective should not prevent industrial research from differentiating between industrial cultures as mentioned above. In fact, in our view, it becomes very important to understand how the technological development – besides the economical processes – are also dependent on the tradition of production culture, education and science.

The human development potential, as it is biologically and historically given, must become the point of departure in the shaping of work and technology. The potentialities of self-renewal and self-transcendence, both at the individual and organisational level, are given high priority from the human centred perspective. This includes the capacity for understanding and the instance of active participation in the shaping of one's own social conditions.

Where work is experienced as hardship, and generally regarded as burdensome, all forms of objectification of work appear as a reduction of stress, and a 'freeing' from work would ultimately correspond to a burden-free situation. 'Social work' is, however, not only objectively necessary for survival but, in the shape of humane work, is subjectively an intrinsic prerequisite for human existence. If one does not regard work, from the outset, as wage labour, in the relationship of work and technology, then it becomes apparent that cause enough exists for understanding *work as a primary form of human life expression*. Moreover, this awareness ought to lead to the shaping of work accordingly, and not to allow it to atrophy to a mere reflex of technological development that excludes the human being from (collective) productivity.

Therefore computer systems should be shaped as 'tool' assisting human-initiated activities. To realise this objective is more complex compared with the shaping of conventional tools, because computer systems represent a new quality of tools: they are able to 'explain' themselves, 'teach users', 'ask questions', 'give answers'. The substantive meaning of communication therefore seems to be of importance in order to understand the essential qualities of human centred orientation regarding the shaping of computer-assisted work.

2.3 Work and communication

Communication is a fundamental human relation (Holzkamp, 1973). In the speech act theory developed by Habermas the *act* of language and communication is emphasised rather than its descriptive or representational role. Communication through language or non-verbal gesticulation is an *act* of commitment and interpretation based on a more or less common social and historical background. The act of communication is directed towards the creation of mutual orientation (Maturana). As pointed out by Winograd and Flores (1986), this orientation is not grounded in a correspondence between language and the world, but exists as a consensual domain – as interlinked patterns of activity.

Communication, as defined here, influences the work process more deeply than is reflected in the perception of the mechanistic approach, which emphasises the role of transmitting information and symbols. Through the communicative act the actors are not only giving or obeying orders in the work process. Moreover, they confront or share interpretations of experiences regarding the social and functional aspects of the common worklife.

As pointed out by Leithauser (1986), there exists a 'hidden situation' in every firm under and beside the formal organisation of the firm, which is largely unrecognised by the management or the external system-experts. The centre of the 'hidden situation' may shift or take different shapes dependent on how extensive and advanced the technology, but we may anticipate that even the most integrated and complex system is still dependent on the interactions taking place in 'hidden situations'.

In the context of computer-systems, the predominant emphasis is on formalised information and pre-planned communication. The significance of non-formalised information and communication is often neglected, perhaps due to the difficulties of making it visible. Many systems designed by computer professionals are intended to facilitate the activity of an individual working alone, and thereby leave out the essential dimension of collective work. The introduction of integrated systems with time-sharing terminals has often radically cut off natural face-to-face communication channels. From both a functional and human perspective such tendencies should be counteracted. An holistic technology shaping may deliberate how to widen informal and face-to-face communication as possibilities both in the single work-group and between different departments.

Communication mediated by computer applications may constitute a supplement to face-to-face communication but not substitute for it. Thus formalised and pre-planned communication may readily be interpreted as a part of the overall communication. If there are any problems in the technical communication, it may be shifted to personal face-to-face communication. Furthermore, if the objectives of co-ordination between two or more collaborating persons are known, it may be their own decision how to find an appropriate medium of communication.

2.4 Work and learning

Work, from an anthropological perspective, is always an acquisition or earning process. During the work process, the expenditure and acquisition of abilities always take place as two dimensions of the same process. Hence the volume of learning opportunities within the work process is a measure for humane work and technology. However, in a work environment characterised by extensive division of labour between planning and task execution and between production functions, the opportunities for learning and skill development are considerably restricted.

In the search for new production concepts in the area of computer assisted work and technology, this insight, as well as the recognition that a phasing out of the acquisition aspect of work is counter-productive, is beginning to find acceptance. The reintegration of previously fragmented work and the extension of performance flexibility as instances of rehumanisation of work, combined with a strengthening of the quality of acquisition (learning opportunities) motivation, and identification with the work, are becoming sought after productive forces in computer integrated production.

For example 'production islands', with their homogeneous qualification structures, can, from a manufacturing as well as a time perspective, react better to the varying requirements of the market than centralised and hierarchical forms of organisation (Brodner, 1985).

The dynamic productivity model proposed by Rosenbrock (1981) and developed further by Seliger (1984), demonstrates that productivity gains, if directly transformed into short term rationalisation gains, can lead to unfavourable economic consequences in the long term. In this view more humane computer integrated manufacturing which enables greater performance flexibility (autonomy), more opportunities for learning (qualification), and the realisation of less stress can, when coupled with the dismantling of 'indirect' skills in separate planning and steering spheres, lead to increases in productivity in the long term (Moll, 1983, 1986).

Besides the utilisation of opportunities for learning in the work process, the anticipated growth in productivity is translated into further industrial qualification measures. This further education/training is, above all, directed towards the transmission of creativity and shaping, as well as social and reflective abilities (i.e. abilities related to the personality of the working individual).

Therefore, the established view of qualification as a requirement relatively external to the personality of the working individual needs to be revised.

Qualification is an economic category. 'Cultivation' (from the German 'Bildung'), on the other hand, refers to personality in the relationship of work and personality. From the 'cultivation' perspective, the question is raised about the *'cultivation' value of work content*. The unfolding of the personality on the basis of an intellect capable of self-determination is the starting-point of the education concept, as well as of practical 'cultivation' efforts.

This means that besides the procuring of *instrumental qualifications* (trade, craft, intellectual, emotional), the opportunity to comprehend the work process must be available, both in its technical-economic connections (shopfloor and external), and from an ecological and humane, as well as social-historical, perspective.

The discrepancy between 'cultivation' and qualification also includes the discrepant relationship between individual and collective interest in education/training of the employees on the one hand, and the interest of the management in the utilisation of qualifications on the other.

Therefore, it would be of fundamental value to shape the concept of further education/training in such a way that the right of education and interest in education of the employees, and the qualification interest of the firm, are sufficiently taken into consideration.

In conclusion we see that the computer-assisted work process has a new quality owing to the specific tool-character of computer systems. Learning does not happen only by doing, but also with the assistance of specific software (computer aided learning).

A human centred perspective is contradictory to solutions in which the computer becomes the teaching system (the subject of the learning process) and the user becomes the learning system (the object of the learning process). A tool-oriented computer-based learning facility gives the initiative to the learner concerning both what and how to learn.

3.0 SHAPING THE DESIGN OF HUMAN CENTRED CIM SYSTEMS

3.1 The normative perspective of the shaping process

Every shaping process involves the anticipation of products and processes. Moreover, the shaping of the future always creates new conditions and opportunities for the development of individuals in terms of the interaction between the development of society and of subjective experience. Therefore it is necessary to establish normative concepts of technology and work.

The global orientation of values in the process of designing human centred CIM is such that the subjective potential for autonomous action develops as comprehensively as possible and the ability to shape one's own working and living conditions can be achieved as extensively as possible through computer-aided work.

3.1 Shaping the design process

Conventional approaches to the design of CIM systems do not incorporate any explicit consideration of the human aspects of technological design. Typically, technical aspects of a work environment are considered first, and wider human and organisational aspects are not considered until the system is implemented. The technical system is thereby shaped by the mechanistic science-ideal, producing a work environment for the users which fragments and simplifies the work process. Such environments have harmful consequences for the psychological well-being of users, well documented in the industrial psychology and sociology literature (e.g. Kornhauser, 1965; Braverman, 1974; Wall, 1987).

A human centred approach to the design of CIM systems involves the consideration of technical and human/organisational aspects from the onset of design. Amongst engineering designers the design of production technology and work is viewed almost solely as a technical concern and it is therefore important that some means, whereby human centred considerations can reshape conventional methods, are available to designers if this trend is to be redirected.

A number of alternative design methods have been developed in the social sciences in recent years. One particular method involves the development of human factors design criteria for use by engineers as an aid to decision-making during design. However, with very few exceptions (e.g. Corbett, Ravden and Clegg, 1987), such criteria relate to detailed aspects of hardware and software ergonomics and do not consider wider aspects of system architecture and organisational structure.

3.3 Dimensions of work

There is a growing consensus amongst work scientists concerning key work dimensions which contribute to the development of psychological well-being, personality development and learning of employees. These dimensions differ from human factors design criteria in terms of their qualitative nature and by virtue of their wider frame of reference. Based on the work of Brater (1984), but particularly on Hoff, Lappe and Lempert (1983) and Jahoda (1983), it is possible to differentiate six, interrelated work dimensions which may be used to evaluate and shape the design of human centred CIM technology and work. Each of these dimensions may be characterised by their degree of restrictiveness or flexibility in a given work environment. The extent to which a work environment can be regarded as human centred is governed by the extent to which flexibility and discretion are available to an individual worker or group of workers to shape these dimensions to suit their own working behaviour and objectives. These dimensions are briefly described below.

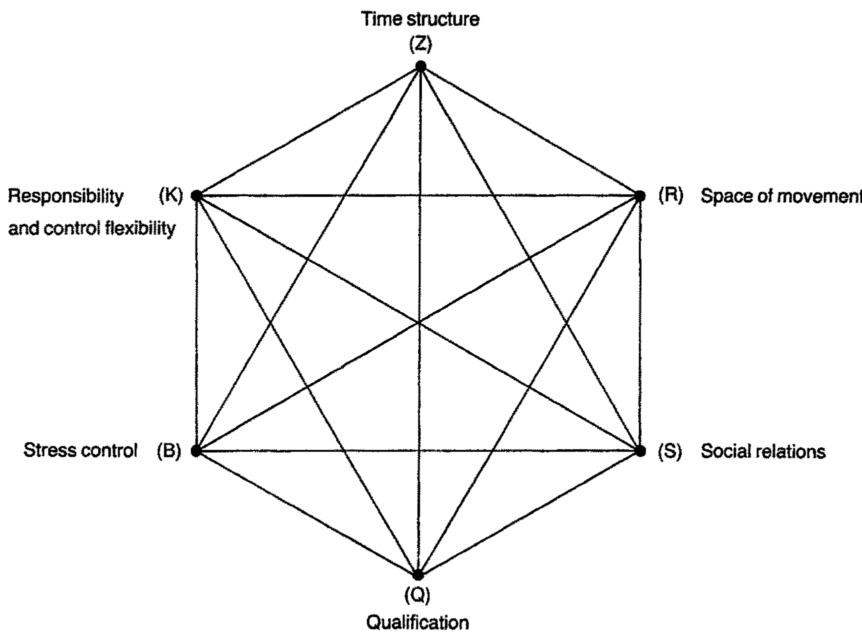

Figure 4 The interrelation of dimensions of experiencing and shaping of work.

Time structure. This dimension includes both the pressure of time imposed on a worker from another, and the degree to which it is possible for the individual or group to plan the use of time themselves.

Space for movement. This includes the degree of explicit formalisation governing the movement of workers from one place to another as part of the job function. It further includes the implicit possibilities for individual or group choice in this regard.

Social relations. This dimension refers to the degree of explicit formalisation regarding a worker's interactions with others, as well as the informal possibilities to communicate within the formal organisational structure.

Responsibility and control flexbility. This concerns the scope and degree of responsibility available to workers. It also includes the possibilities and actual practice of controlling how this responsibility is managed by the individual or group.

Qualification. This concerns the functional abilities relating to the individual work task and/or the work process as a whole. It also includes the more comprehensive aspects of personality development and learning as essential human abilities ('cultivation').

Stress-control. This includes the degree to which the individual and/or group is able to control the physical and psychological pressures resulting from work organisation and human-machine interaction factors.

It is important to realise that each of these dimensions must be developed from the perspective of the others (see figure 4). For example, the relationship between space for movement and time structure is the first aspect that enables a more precise determination of the quality of the restrictiveness of an existing time structure. In the same way, social relations, work methods and the perception of responsibility are also subject to a time structure. Time structures are also reflected in the stresses, learning and overtaxing of abilities. In general, therefore, the question of time structure is always linked to the other five dimensions. This relationship holds for all six dimensions, although it should be noted that the dimension of qualification ('cultivation') is better suited than any other dimension as a main indicator of the degree of performance flexibility or restriction.

If one regards the relationship between work and personality as static, a wide variety of forms of work and work organisation can be found which permit 'humane' work. However, if one considers the personality to be developing at work, then it is of particular importance to create a work environment which enables workers with different qualifications and abilities to carry out their work, and which enables them to establish and change the levels of flexibility within which they work. The stress on the flexibility inherent in the design of these six dimensions of work make it possible to respect individual differences. It is important to avoid imposing job design techniques which impose standard solutions on a heterogeneous workforce. In this respect, the concept of the 'production island' (Brödner, 1985), with its emphasis on autonomous group working, represents a form of work and work organisation of particular merit.

3.4 The use of work dimensions in the shaping process

If the work dimensions are to be constructively used by designers and others, both for shaping and evaluating CIM system design, it is important to develop methods to enhance their usability. In published reports of interdisciplinary design (e.g. Corbett, 1987) it seems clear that one of the problems associated with the use of non-technical criteria and dimensions is the difficulty experienced by designers, who are usually unfamiliar with the knowledge base from which they are derived, in visualising the end product, i.e. a system design based on such criteria or dimensions.

One way in which this problem may be alleviated is through the development of concrete examples of CIM work environments which illustrate different degrees of flexibility along each work dimension. The matrix presented in figure 5 is an example of a classification of work on differentiated levels of flexibility. The examples within this matrix refer to computer aided production environments: for other areas of CIM (e.g. computer aided design) it is necessary to change the descriptions with more relevant details.

Note that it is also necessary to work out a specific perspective of a human centred environment (level 0 in figure 5) through the drawing up of a scenario. This scenario, or vision, illustrates how the system would look if maximum flexibility is achieved across all six dimensions. By placing the dimensions in an overall context, such a scenario makes the interrelationships between the work dimensions more explicit and serves as an aid to usability of the dimensions, more generally, by exposing the ultimate goal of human centred design. Alternative scenarios may be drawn up to illustrate other levels of flexibility – the most restrictive level corresponding to level five in figure 5. Given the quantitative bias of technically-led systems, the use of such scenarios enables the essentially qualitative nature of such dimensions to take on a more concrete, usable form, in the shaping process.

3.5 The shaping and evaluation of computer-aided production systems

Conventional, technically-led methods of system design and development presuppose the possibility to formalise the description of any work process as a set of functions and

Figure 5 Differentiation or the dimensions of experiencing, shaping and evaluating the work situation according to degrees of restriction/performance flexibility, for computer assisted production work.

	Grade of restriction/ performance flexibility	Dimensions of discovering/experiencing, and shaping of the work situation: Time Structure (Z)	Space of movement (R)	Social Relations (S)	Responsibility and control flexibility (K)	Qualification level (Q)	Stress-control (B)
5 (↑ maximum restriction (technocentric))	**Centralised hierarchical manufacturing concept CAD centred, precision planning objectification of factory work**	Time-rhythm bound programme Time schedule	Strictly bound to one place, without possibility of place change, or change in movements	No minimum work related social connexions, maximum control (technically facilitated)	Total control via higher factory department; technologically transmitted	Senso-motoric abilities	Stress completely steered externally (technologically transmitted)
4	**Operator orientated manufacturing with a large degree of AV in CAD and work preparation, separate skilled work (machine operators, qualification control, secondary skilled workers)**	Not time-rhythm bound, but definite handling times for definite processes	Largely bound to one spot, with markedly reduced freedom of movement, e.g. machine oriented	Formal hierarchical work related minimum cooperation, no informal contacts possible during work; extensive control (technically transmitted)	Broad control, technologically and socially (personnel) transmitted	Routine fulfilment of job requirements according to a given work programme/rhythm; narrow variation span	Stress largely externally steered (technologically transmitted) little variation in the work speed
3	**Classical skilled worker orientated manufacturing with advanced AV and the separation between machines and secondary skilled workers**	Variable time organisation within the AV blueprints (e.g. optimising of CNC programme and varying of technology input data)	Largely bound to one spot (machine group) and occasional shift in space, dependent on cooperation	Cooperation via work based communication technology, minimal informal cooperation possible; social and technological control	Broad control due to planning structures, and personal control	Controlled, understood and self-optimised work (e.g. skilled machine work)	Stress largely externally controlled (technologically and socially transmitted), variation of the work speed possible within defined borders
2	**Classical skilled worker based manufacturing with limited workshop orientated work planning and centralised material-tool economy, also AV orientation in programming of tool machines**	Variable time organisation (e.g. in relation to the variation of lots to be handled)	Workshop orientated possibilities for movement (subject to cooperation and work diversity, e.g. by means of secondary skilled work)	Technologically and socially transmitted cooperation on the workshop level necessary, informal social cooperation possible to a limited extent (social + technological control)	Limited control (reduced to more complex work situations)	Self programmed, planned manufacturing on diverse manufacturing installations; experimental abilities (above all, in secondary skilled work)	Work speed externally and self controlled by work breaks and a combination of work activities (primary and secondary skilled work)
1	**Integration of primary and secondary skilled workers. Broad decentralisation of manufacturing, with partly autonomous manufacturing islands, largely autonomous workplan, and geometrically based construction (CAD)**	Open time organisation on workshop level in the framework of definite time sectors (e.g. 14 days) for the lots to be handled, including maintenance, servicing, repair	Good possibilities for movement (necessary because of broad responsibility on the shop floor level)	Social and technologically induced cooperation and communication with relevant informal components; social control	Largely (cooperative) collective social control	Planning in the frame of part goals within a broader given goal; carrying out of diverse duties/tasks in the workshop	Participation in decisions about stress/burden largely possible; decentralised work planning
0 (↓ maximum performance flexibility (anthropocentric))	**Completely decentralised workshop orientated production, with autonomous production islands, (partly) integrated construction and work planning**	Open time organisation of the workshop, and participation in production planning, autonomous workplace orientated work planning	Good possibilities for movement on the shop floor level and beyond	Social and technologically induced cooperation and communication (horizontal structure), with well developed informal components; great degree of self-control	Largely self-responsibility and self-control in a work collective	Planning of complex work relationships; carrying out of complex tasks (in manufacturing and production)	Maximum involvement in the decision making process concerning stress, possible via decentralised work shaping

data exchange. Given such a formal model, it is then possible to design a work process based on the technological rationality of 'optimum' solutions. The design is therefore shaped by the mechanistic science-ideal.

The human centred perspective rejects such a shaping process owing to the rejection of traditional production skills inherent in these methods. Furthermore, human centred design methods rely fundamentally on the influence and knowledge of the system users. These users have particular needs and job specific knowledge which should be included in the system specification and design itself.

Human-centred design comprises three complementary shaping methods. Namely, the use of work dimensions and other related design criteria, (see, for example, the human-machine interaction criteria developed by Corbett, 1985), the use of design scenarios, and the incorporation of users in the design process. Work dimensions and their related scenarios are primarily intended to act as a focus for debate and discussion amongst the members of a multidisciplinary design team, which contains representatives from the user population. Such a framework is particularly important given the different perspectives of users and specialist design engineers (Briefs, Ciborra and Schneider, 1983; Perrow, 1983).

The six dimensions of work described above are to be considered as guidelines regarding the shaping process of technological design. They are not fixed in a deterministic way, however, as their influence must be mediated by the skills and knowledge possessed by users.

Human-centred design should therefore include methods to involve users in the process of system development. As pointed out by Rosenbrock (1983), such methods meet a number of obvious difficulties. He argues that workers involved in the R & D process could be placed at a disadvantage through lack of knowledge of these specifications. He also mentioned the risk that many aspects of the real situation will not be represented in laboratory conditions (e.g. pay systems and realistic pressure of work). Furthermore, a 'Hawthorne effect' may be expected. Moreover, different workers will have different abilities, and may need to use the system in different ways. Different management situations may require different ways of using the system, and so on.

The above mentioned difficulties are serious constraints for user-involvement in system development. It may be important to reflect very carefully on how the interests and practical knowledge of the users in the field are to be communicated to the specialists in order to influence the system development.

Firstly, it may be important to plan user involvement as a long-term process, such as continuous involvement over several years, and not limit it to one or two discussion-meetings or test-procedures.

Secondly, it may be necessary to use some time, particularly at the early stages of design, to discuss the human centred idea with the users of the field and have their response to the idea. In this phase of the process the specialists and users have to be quite open regarding different social-psychological barriers which may obstruct the communication. The specialists may learn to understand some of the valuable aspects of the design and craft tradition without romanticising it. The users in the field may be open to looking at new possibilities of carrying out or organising the jobs stimulated by methods such as 'future-creating' workshops. It is also important to be quite open regarding potential conflicts of interests.

Although the human centred perspective may serve the interests of the users in principle, the concrete suggestions from the specialists may turn out to be a compromise between conventional and human centred intentions, and thus may run the risk of generating other, unexpected, consequences which may be in opposition to the interests of the users in the field.

Thirdly, it is important to make a *flexible* plan for the process-oriented approach. The users may have more or less relevant knowledge, ideas or motivation to participate than expected from the beginning. New problems may appear. If so, it is important to be able to adapt the co-operation between specialists and users during the process as soon as new, more or less unforeseen, problems emerge.

Although user involvement will face difficulties, the consequence is not to avoid user involvement, but to find ways to overcome these difficulties. The realisation of the human centred perspective may depend on how well and to what extent the above mentioned constraints are overcome.

4.0 CONCLUSION

The project 'Human Centred CIM-Systems' represents a new direction in technological development, which is not grounded in a list of operationalized criteria – the so-called requirement profile. Instead, basic ideas of a general nature and social orientations, such as a humane, ecological and socially compatible technology, assume tangible, technical shape only in a dialogue which transcends – and indeed does so necessarily – the bounds of academic departments and of science itself.

From the point of view of compartmentalized science, the assignment to develop human-centred CIM-systems inevitably leads into a dilemma. For any given technology to prove humane it has to have assumed tangible shape. Assessing any given technology as in/humane presupposes its physical existence which, by implication, results from operationalizing the desired requirements and clearly defined purposes it has to meet. It holds equally true that there is no scientific way of deriving from the basic idea of human-centredness a list of operationalized criteria for the development of humane technology. Human-centredness is a quality that varies with the individuals concerned and is thus subject to individual judgement.

A way out of this dilemma can only be found provided that all parties involved in the development of any given technology engage in a dialogue. This would include the academics of the different departments relevant to the project in question as well as those people variously affected by the technology to be developed. The former would, by transcending the bounds of their departments, find a technological solution in co-operation with the latter. In the course of this dialogue, both the people affected and the scientists would transcend their usual practice.

Any technological solution that meets the criteria of humaneness or social compatibility as outlined above is necessarily hypothetical and can always represent but one step on the way towards a more humane and socially compatible technology. This is also why we can conceive of products whose development has been guided by the basic idea of human-centredness as elements in a process characterized, in part, by the fact that both the individual and social meanings of humaneness and social compatibility change along with the scientifico-technological preconditions of the shaping of technology.

On the way towards the shaping of 'Human Centred CIM-Systems' the six dimensions of evaluating and shaping work and technology which we have suggested are intended to help gear the shaping of technology – more adequately than has hitherto been the case – towards more humane work and technology. Hence also the scope for a maximum of possible alterations inherent in a human-centred CIM-system. These allow adapting computer-aided work and technology to personal development, integrating in the work process opportunities for learning graded according to people's prior skill and knowledge, as well as reducing work loads in the course of such development.

The shaping of technology is an important dimension in the shaping of society's future and is too important to be left to engineers and scientists to grapple with on their own.

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