

# Sociotechnical principles for system design

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## Abstract

This paper offers a set of sociotechnical principles to guide system design, and some consideration of the role of principles of this kind. The principles extend earlier formulations by Cherns (1976, *Human Relations*, 29, 783–792; 1987, *Human Relations*, 40, 153–162). They are intended to apply to the design of new systems, including those incorporating new information technologies and a range of modern management practices and ways of working. They attempt to provide a more integrated perspective than is apparent in existing formulations. The principles are of three broad types: meta, content and process, though they are highly interrelated. They are for use by system managers, users and designers, and by technologists and social scientists. They offer ideas for debate and provide devices through which detailed design discussions can be elaborated. The principles are most likely to be effective if they are relatively freestanding, but supported by relevant methods and tools. The principles are necessary but not sufficient to make a substantial contribution to design practice. © 2000 Elsevier Science Ltd. All rights reserved.

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## 1. Introduction

The aims of this paper are to offer a revised set of sociotechnical principles to guide system design, and to consider the potential roles and contributions of such principles. This is timely for a number of reasons. It is nearly 25 yr since Cherns (1976) published his landmark paper formulating for the first time a set of principles of sociotechnical design. A decade later he revisited them (Cherns, 1987).

It is apparent that industrial and commercial environments have changed enormously over this period. The rate of technological change has increased and has become dominated by new information and communication technologies. For example, the total spend on information technology in the USA in 1996 has been estimated at around \$500 billion (Gibbs, 1997). Furthermore, not only are the new technologies becoming more prevalent and powerful; they also offer opportunities to work in more interconnected ways, providing the scope and catalyst for new working arrangements. The organization of work is also changing at unprecedented rates,

partly as a result of the growth of a range of new management practices and techniques (Cairncross, 1998; Davenport, 1996; Dean and Snell, 1991; Hammer and Champy, 1993; Hanson et al., 1994; Oliver and Wilkinson, 1992; Storey, 1994). Teamworking, supply-chain partnering, empowerment, cell-based working, process-based working, just-in-time procedures, total quality management, and others, all constitute changes in work organization and working practices.

Inevitably many of these innovations are linked, for example as new management and working practices are accompanied, facilitated or enabled by the introduction of new technologies. Whilst these changes are usually not explicitly called as such by their designers and users, they can be interpreted as sociotechnical endeavours. Whether labelled as ‘sociotechnical’ or not, changes in sociotechnology continue at increasing rates. Given the scale and nature of these changes, it is timely to consider whether or not new or amended underlying design principles are required.

Whilst these changes in part reflect increased perceptions and levels of competition, there remains an underlying productivity paradox. For all the investments that have taken place and seem set to continue, and in spite of substantial reductions in the cost of computing power, it is apparent that many technical innovations are substantially less effective than intended (Blackler and Brown,

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1986; Clegg et al., 1997; Gibbs, 1997; Kearney, 1990; Landauer, 1995; Norman, 1998; Roach, 1985). Nor is disappointing performance restricted to new technology. Modern management practices also often fail to meet the objectives set for them (Davenport, 1996; Hackman and Wageman, 1995; Ingersoll Engineers, 1991, 1996; Waterston et al., 1997). Sociotechnical theory has at its core the notion that the design and performance of new systems can be improved, and indeed can only work satisfactorily, if the 'social' and the 'technical' are brought together and treated as interdependent aspects of a work system. Improvements in sociotechnical design principles and practice should contribute to enhanced levels of performance, where this can be taken to include operational measures such as effectiveness and productivity, along with psychological indicators concerned with well-being and attitudes.

It can also be argued that the application and diffusion of sociotechnical principles and practices have been disappointing, although one must recognize that there are international variations in this regard (van Eijnatten, 1993). Various interrelated criticisms can be levelled. The joint design and optimization of social and technical systems has been and remains rare (Matthews, 1997; Mumford, 1987; Pasmore et al., 1982). Most investments in IT are technology-led, reflecting too technical an emphasis. Many organizations lack an integrated approach to organizational and technical change, and, in most cases, users do not have substantial influence on system development (Clegg et al., 1997). Interventions often continue to take the technology as given, and the task becomes that of designing the social system around the technology. Criticisms have also been made that sociotechnical inputs are partial in their coverage and perspective. The core ideas and practices on which the sociotechnical contribution is based (the principles, the innovation of autonomous work groups, and the criteria for well-designed jobs) are largely social in their content and orientation (Klein, 1994; Czaja, 1997). There is little that is in widespread use, that helps guide the design and optimization of the technical aspects of the system, except by implication, or indeed that treats the social and the technical as an integrated whole (de Sitter et al., 1997). In sum, sociotechnical principles and ideas have not had the impact that their proponents might wish, especially given the changing context described above.

This is not to claim that the presentation of a revised set of principles will resolve all the above difficulties, in particular regarding levels of system performance and rates of diffusion. Rather these issues help illustrate the context within which such revisions are needed.

Before describing the principles, some further remarks help set the scene. The ideas are offered in the same spirit as were those in Cherns' earlier work, to offer ideas, to promote further debate and to encourage action. They are not offered as finished products; indeed their articula-

tion helps clarify where some of the gaps in our knowledge exist. Nor is their presentation intended to imply that design is thereby rendered non-problematic, that the principles alone are enough.

Nevertheless, a central assumption underlying this work is that social science has an interest in, commitment to, and contribution to, design (Simon, 1969). Too often in this domain, the contribution of social scientists is assumed to rest in a concern for the human and organizational *impacts* of new technologies, techniques or practices. The broad intent here is with making a contribution to design.

The principles have four main potential functions. They are intended to raise questions of design and designers that demand and merit attention. They advocate a series of interconnected perspectives on design, for example, arguing the need to include end-users in the design process, and identifying what makes for well-designed jobs, information systems and function allocations. These perspectives are concerned with content and process issues, but also with overall orientation (in the form of meta-principles). The principles also provide a potential framework for evaluation purposes. And finally here, they have some predictive value. Thus, for example, one can predict that failure to consider and resolve such issues (both at a general level and at the level of specific criteria) will result in designs that do not meet their objectives.

The principles are concerned with work system design and reflect a macro-ergonomic perspective (Hendrick, 1991). They reflect the author's experiences in undertaking a number of research and development projects over the past few years, focused both on new technologies and new management and working practices. They represent an attempt to synthesize personal experience in undertaking research and development with existing sociotechnical literatures.

The rest of this paper is organized in two main sections, involving the presentation of a revised set of sociotechnical principles, and consideration of the potential roles and contributions of principles of this kind.

## 2. Sociotechnical principles for system design

The new principles are summarized in Table 1, along with comments on the main points of similarity and difference with Cherns' earlier work (1976, 1987). The principles are of three broad types. Some are labelled meta-principles since they are intended to capture a worldview of design, a 'Weltanschauung'. Some are focused on more specific aspects of the content of new designs, whilst the third group is more concerned with the process of design. It is important to stress at the outset that the principles are interconnected, indeed, given the explicit systems orientation, it would be bizarre

Table 1  
Principles of sociotechnical design and their relationship to those by Cherns

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*Meta-principles*

1. Design is systemic.  
This perspective is implicit in Cherns' principles and arguments.
2. Values and mindsets are central to design.  
This is similar to the views presented by Cherns.
3. Design involves making choices.  
Cherns very briefly considered social options under his principle of minimal critical specification.
4. Design should reflect the needs of the business, its users and their managers.  
This issue was not covered by Cherns.
5. Design is an extended social process.  
This issue was not covered by Cherns.
6. Design is socially shaped.  
This issue was not covered by Cherns.
7. Design is contingent.  
This issue was not covered by Cherns, but the idea was implicit in his writing.

*Content principles*

8. Core processes should be integrated.  
Processes were not explicitly included in Cherns' principles, but this principle subsumes his ideas on boundary location, information flow, and power and authority.
9. Design entails multiple task allocations between and amongst humans and machines.  
This principle includes Cherns' multifunctional principle and his criteria for job design, but extends to incorporate consideration of task allocation between humans and machines.
10. System components should be congruent.  
This is equivalent to Cherns' ideas on support congruence.
11. Systems should be simple in design and make problems visible.  
These ideas were not included in Cherns' principles.
12. Problems should be controlled at source.  
This is equivalent to Cherns' principle of variance control.
13. The means of undertaking tasks should be flexibly specified.  
This amends Cherns' ideas on minimal critical specification, in part to deal with the issue of technical design for complex systems.

*Process principles*

14. Design practice is itself a sociotechnical system.  
This subsumes Cherns' principles of transitional organization and incompleteness.
  15. Systems and their design should be owned by their managers and users.  
This amends Cherns' principle of compatibility and involves a change from his emphasis on user participation to user ownership.
  16. Evaluation is an essential aspect of design.  
This is mentioned briefly under Cherns' principle of incompleteness.
  17. Design involves multidisciplinary education.  
This is not included in Cherns' principles, but the notion of multidisciplinary is implicit in his ideas.
  18. Resources and support are required for design.  
This is not included in Cherns' principles, but is implicit in his arguments. Resources here are interpreted very broadly.
  19. System design involves political processes.  
This is not included in Cherns' principles, but was recognized by him.
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if they were not. Some of the main links are identified below.

*2.1. Principle 1: Design is systemic (meta-principle)*

A sociotechnical perspective explicitly embraces the idea that all aspects of a system are interconnected, that none should take logical precedence over the other, and that they should be designed jointly. Technical and social systems are interdependent (Klein, 1994). Exclusive emphasis on any one component during design, for example on technology, will be sub-optimal.

Unfortunately some of the interdependencies may not be apparent during system design. For example, the designers of some new technology, method of working or information system, may not be able to anticipate the impacts of their design efforts on other aspects of the system, and may experience difficulty planning changes that make their operation consistent. Put another way, there may be unintended consequences of various change initiatives. Some of these consequences may only become obvious when the system is in operation. Furthermore, some of the knock-on effects may have political consequences for others.

Consider the introduction of cell-based manufacturing that involves maintenance engineers becoming part of a shopfloor team, responsible to line managers for the conduct and priorities of their work. What impact will this have on their professional and career development, and on their skills and status? And how will they respond to such changes? Or consider the introduction of a national information system, which allows comparison of the apparent performance of secondary schools in the form of examination 'league tables'. What impact does this have on the policies and practices that schools use to 'select' their pupils and to enter them for public examinations? What impact does it have on student exclusions? What impact do such tables have on the morale and performance of the teachers and students in schools labelled as 'failing'?

There are a number of implications of such a perspective. In particular, system designers and others should make every effort to trace through the possible impacts of design choices, across as broad a range of system performance characteristics as is viable. This will certainly require additional resources and support, for example in the form of methods and tools (see principle 18)). Furthermore, as change will throw up some surprises, there should be some capability built into the process to review impacts (principle 16) and amend accordingly.

*2.2. Principle 2: Values and mindsets are central to design (meta-principle)*

Cherns included the notion of values in both of his essays, though dealing with them differently in each case.

Values and underlying mindsets are critical to a sociotechnical perspective. They can be articulated in a number of different ways but include a number of core ideas, for example that humans are assets (rather than costs), that technologies (and techniques) are tools to support humans in meeting their goals, and that different components (humans and machines) may bring complementary skills and abilities to meet the requirements of a system (Jordan, 1963).

A sociotechnical perspective encourages one to challenge two related sets of views: first, that human beings are error-prone, unreliable agents, resistant to change, that ideally should be designed out of systems as soon as this is technically feasible and can be afforded; and second, that when they cannot be designed out, humans need to be managed exclusively through Tayloristic systems of command and control. Of course, such views may not be articulated explicitly, but they do appear widespread. Thus, Clegg et al. (2000) bemoan what they term 'the charge of the Byte Brigade', the continuing over-emphasis on technological solutions to system design. They argue for the need to challenge existing practices and norms by asking questions such as: 'Why are we using technology to undertake this task?' 'What are the roles of the humans in this system?' 'What alternative ways are there of configuring the work?' 'What are the costs and benefits of the different design choices?'

Raising questions and challenges of this kind makes one open to criticisms of being anti-technology or Luddite. Such charges can be refuted on the basis that design should be seeking an appropriate balance of human and technological activity. An example of an approach to design, based on human-centred values, can be found in the work of Ainger (1990). With colleagues, he developed a shopfloor production scheduling system for use in small-batch manufacturing. Rather than have the computers work out the 'optimum' production schedule, the operators (with computer support) were responsible for making scheduling decisions (see principles 9 and 12). The reasoning was that the production system was highly variable and uncertain. As many automated scheduling systems are based on assumptions and data that quickly become out of date, the design philosophy was that the operators should draw on their local knowledge updated in real time. The underlying values were that the operators are the experts in the system and that they need computers as tools to support them in their work.

### *2.3. Principle 3: Design involves making choices (meta-principle)*

There are always choices, both in the design of sociotechnical arrangements, and in the processes through which they are designed (Klein, 1994). Although not included as a separate principle, this was one of the initial points made by Cherns in his essay in 1976. Choi-

ces exist on all dimensions. An example helps illustrate some of the issues. In this case a confectionery company wished to improve the quality and speed of information flow from its customers. The company manufactured and delivered a range of products for sale in a wide range of independent retail outlets. Unfortunately, it experienced significant delays and inaccuracies in the feedback of information from the shops via its drivers. The national sales manager thought a system involving the use of hand-held computers by the drivers would improve speed and accuracy. However, rather than simply select the apparent best option from a range of available technical products, he first considered how the whole system should work. Thus, he worked with drivers, depot managers, members of his area sales teams, IT specialists, and staff from accounts and sales administration at head office to design how the work would be organized. For example, his team considered whether the drivers would work in a delivery role only, or as salespeople, or as franchise holders. He wanted to make these choices before selecting the technical system he would purchase, in part because these organizational choices (for how the system would work) would affect what functionality should be built into the technical systems.

Key choices then include how the overall system will operate, how the work will be managed and organized, what form of technology will be required to support this work, and what other organizational systems are required (see also principles 9 and 10). In addition, there are choices in how the design and implementation processes are managed. (see principle 15).

A further point is important here. Design choices are not independent; they do influence one another (see principle 1). But, at the other extreme, they are not usually deterministic, such that a choice in one area fully determines a choice in another. There always remain degrees of freedom. For example, even the decision to manufacture using an assembly line, leaves some social choices for how the work will be organized. Will operators work as individuals specializing in a particular workstation? Or will they operate as teams allocating work flexibly amongst themselves? The point is that choices constrain (but do not determine) other choices, and this opens up the possibilities of extended design. Unfortunately technologists and social scientists understand relatively little about the ways in which these constraints and interdependencies work.

### *2.4. Principle 4: Design should reflect the needs of the business, its users and their managers (meta-principle)*

A system needs to be useful, to meet some articulated purpose, to meet the needs of the business, its users, and their managers. Such pragmatic concerns may be based on current or future needs. Within companies this concern surfaces in the form of a variety of questions, such as:

Are the plans for the new system driven by the business strategy? Is the investment appropriate for the business? Does the system contribute effectively to the core goals of the business?

In one sense such notions are obvious but nevertheless they are worth stating explicitly. All too often systems are designed which do not meet the needs of the business, or of the users. There may be several reasons for this. For example, the needs of the business may change over time, perhaps as a result of changes in the market place or alterations in strategic direction. Users and their managers may not know quite what they want, and they too may develop new needs over time. There are dangers that the organization becomes subject to the latest fad or fashion (see also principle 6). Senior managers may allow technologists to determine the agenda for change, and this may then reflect a rather partial, perhaps technology-led, view of future possibilities (principle 15).

These are some of the major reasons why modern computer-based systems achieve relatively disappointing levels of performance against their initial objectives. Nevertheless, there are success stories. For example, the Production Director of one engineering company was motivated to reduce lead times and inventory levels, and to improve quality and responsiveness to customers. He introduced a system involving cell-based working within which teams of employees manufactured complete products and sub-assemblies to meet customer orders (see principle 8). One key element included the introduction of a shopfloor computerized scheduling system that allowed the operators to manage their own workflows. The results were dramatic: increased output, quality and customer satisfaction, along with reduced inventory, lead times and costs. The company focused on business needs and goals, redesigned their system of working, and used computerization as one important aspect of a sociotechnical change.

#### *2.5. Principle 5: Design is an extended social process (meta-principle)*

There are several important considerations embedded in this principle. The first is that design is extended over lengthy periods of time. It is not a one-off that has a clear end. Design continues beyond implementation and throughout use, for example, as the people using the new system interpret it, amend it, massage it and make such adjustments as they see fit and/or are able to undertake. In part this reflects the attempts by people to take ownership of, and control over, the systems they manage and use. Whilst designers are clearly involved, so too are the people involved in implementation, use, management, evaluation, maintenance and upgrade. Thus the system gets (re-)configured as it goes along. Such changes may be formally negotiated in, or may just happen in practice as

people start to use and tailor a system in a way that suits them.

In addition, this principle points to the social nature of design, in which various stakeholders help shape and moderate design choices over time. Most obviously, users may choose to use a technology in a certain way. They may tailor the technology to meet their particular needs. They may implement certain social practices (such as teamworking) in a variety of ways and amend its operation as they go along. Stakeholders who influence system design may include those who design, implement, manage, use, evaluate, maintain, measure or bargain and negotiate over the system.

It also follows that such stakeholders will interpret designs and their meanings in different ways (McLoughlin and Harris, 1997). For example, the introduction of a computer-based system that is used to book time against various projects may be seen as a means of achieving financial control by accountants, as a way of monitoring the work of its users by their line managers, and as a constraint on their autonomy and behaviour by the users themselves. Different people will interpret systems in different ways, and there need to be structures and mechanisms through which views can be aired, recognized and understood.

#### *2.6. Principle 6: Design is socially shaped (meta-principle)*

Implicit in principle 5 is the notion that design is shaped by a range of social partners over time. This principle goes further and argues that wider social factors help influence the sorts of design problem that are addressed, and the kinds of design solution that are attended to and invested in. Put a different way, design is subject to social movements and trends. These themselves may be manifest in various fads and fashions.

Some of these movements may be driven by technologists pursuing innovations that interest them. Others may arise from the activities of consultants and others developing their own new products and services; whilst some may reflect the interests of companies and users trying to lead, or respond to, market and competitive pressures. Outside agencies may also try to promote particular innovations, as in the case of the UK Department of Trade and Industry in the 1980s encouraging manufacturing companies to 'Automate or Liquidate'. Furthermore, all of these processes may be happening in parallel, mixing supply-push and demand-pull in a variety of ways. This top-down and rather macroscopic perspective can be applied to the uptake of various practices, techniques and technologies, including, for example, just-in-time working, lean manufacturing, business process re-engineering, teamworking, empowerment, flexible manufacturing systems, computer-supported collaborative work, and, most recently, the internet and world wide web.

The general point is that design choices are, in part at least, social phenomena and subject to social shaping. Design thus is subject to fashion. This perspective carries with it some negative connotations; it implies that designers and others need to take care that their attentions and efforts are not driven by, and caught up in, the latest fads to emerge (see principle 4).

### *2.7. Principle 7: Design is contingent (meta-principle)*

This principle acknowledges that design choices are contingent and do not necessarily have universal applicability. There is no 'one best way'. Thus for example, a Flexible Manufacturing System may represent a good design choice when producing a range of similar (but not identical) products, in batches of various sizes, and where quality demands are at a premium. Similarly, teamworking may be a good form of work organization when the tasks are interdependent, when people need to interact to resolve problems as they arise, where a range of skills is needed, and where the work can be organized such that the team is responsible for the provision of a complete product or service.

One of the difficulties is that the nature of these contingencies is not well understood. Thus, under what circumstances are the following design choices likely to improve organizational performance: just-in-time working; lean manufacturing; business process re-engineering; teamworking; empowerment; flexible manufacturing systems; computer-supported collaborative work; and the internet and world wide web? What sorts of contingencies are involved in these equations? Thus, for example, does it depend on the nature of the market, the product mix, the sector, the size of the company, the organization culture, the local labour market, the skills and capabilities of existing staff, the style of the senior manager, the levels of uncertainty, national variations in culture and expectations, or what? And if multiple contingencies are involved, how do they interact with one another?

A major problem facing organizations is that they may be receiving messages from their environment that teamworking will improve effectiveness, or that the internet has the capacity to revolutionize their business, but be unsure whether or not this holds true for them in their particular situation (see principle 6). The sheer volume of competing claims and messages may compound the problem. Even if teamworking (say) is appropriate for parts of a business, given limited resources is it sensible to invest effort in teamworking rather than in something else? It is not solely a matter of appropriateness for context; competing demands and their opportunity costs are also important. Such choices, given current levels of knowledge and understanding, are extraordinarily difficult. Indeed, in many cases, it is unlikely to be clear what represents an optimal design choice (Simon, 1960).

### *2.8. Principle 8: Core processes should be integrated (content principle)*

Organizations can be viewed as comprising a number of core processes that typically cut laterally across different functions. This contrasts with the more traditional view that organizations comprise sets of expertise-based specialisms that are organized vertically. There is much to be said for such a process perspective and indeed sociotechnical practitioners have used it. Unfortunately, the perspective has been somewhat tarnished in recent practice, by its application in the form of Business Process Re-engineering (BPR) (Mumford and Hendricks, 1996). Comments here are concerned with a process perspective, rather than with the practice of BPR.

The process perspective on design is a powerful one that holds many implications. It is important to design integrated processes, i.e., to avoid splitting a core process across artificial organizational boundaries. People should be responsible for supervising and managing complete processes. They should have the authority and resources to do it. A job should incorporate a whole task, rather than a fragmented part (Hackman and Oldham, 1976) (see principle 9). The information systems should be designed to match this perspective (principle 10). (See also de Sitter et al., 1997). Processes should be simplified to take out unnecessary activities, repetitions and delays. The logical processes should be designed first, before consideration of how they will be managed, controlled and supported (i.e., the structure fits the process, not vice versa).

Unfortunately, many organizations fragment core processes, for example by splitting production and packing, assembly and testing, and design and manufacture. Indeed, look no further than the fragmentation that typically exists between the design of new computer-based systems and their use. Such fragmentation can lead to problems of responsibility, accountability and understanding, and to difficulties of coordinated effort. Quality and lead times typically suffer.

A process perspective is more holistic and can lead to dramatic improvements in performance. For example, Leicester Royal Infirmary redesigned the ways in which patients were examined, tested and treated to cut down delays and the number of required visits to the hospital. The process orientation meant that patients in certain departments (for example, neurology and hearing) are examined, have a number of tests, receive the results, receive consultation and begin treatment all within one visit to the hospital, rather than involving several visits spread over several months (Bevan, 1996).

### *2.9. Principle 9: Design entails multiple task allocations between and amongst humans and machines (content principle)*

Sociotechnical systems involve the allocation of tasks amongst and between humans and machines. System

design is concerned with allocating tasks amongst humans (usually called ‘job design’ or ‘work organization’), between hardware and software (traditionally the domain of the engineering communities), and between humans and machines (usually called ‘allocation of function’). Multiple task allocations are the core of sociotechnical design. Unfortunately many of these choices are often not explicitly addressed in a systemic way.

Well-established criteria exist for the design of jobs in systems. These criteria can take a variety of forms but Cherns’ formulation in 1976 (based on Emery, 1964) was that: jobs should be reasonably demanding; there should be opportunities to learn; there should be an area of decision-making the individual can own; there should be a degree of social support and recognition; it should be possible to relate what one does to wider life; and, the work should have some desirable future. (For similar, more recent, formulations, see Hackman and Oldham, 1976; Medsker and Campion, 1997; Warr, 1987).

Surprisingly however, there has been relatively little work to establish the contingencies under which particular forms of work organization are optimal (Wall and Jackson, 1995). (See also principle 7). Thus, for example: are more complex jobs always ‘better’ than simplified ones? are there cultural differences? Are more complex jobs especially beneficial under conditions of uncertainty? Under what conditions is teamworking a better solution than individual working? What forms of teamworking are optimal under what circumstances? How should teams be configured?

By way of exception, Medsker and Campion (1997) have identified the circumstances under which they believe teamworking represents an appropriate organizational design choice, and this is reproduced in Table 2. It should be noted, however, that their listing does not help make choices about the most appropriate form of teamworking.

Once a decision to adopt teamworking has been made, some evidence is available to help design how it operates (West, 1996). As an example, some advice on organizing for teamwork is presented in Table 3.

Criteria also exist to help allocate tasks between humans and machines (Fitts, 1951; Grote et al., 1995; Older et al., 1999; Sharit, 1997; Beevis and Essens, 1997). These criteria include the feasibility and cost of automation, the health and safety implications of allocation decisions, the operational requirements of the system, and the characteristics of the task itself. Thus, if a task is critical to system performance but highly unpredictable and requiring judgement, then it should be allocated to a human (rather than a computer). It was for these reasons that local production scheduling decisions were allocated to the operators in the example described under principle 2.

Unfortunately many new system design projects do not get explicitly involved in the complexities of these allocation choices, focusing more heavily on technical

Table 2

Circumstances under which teamworking is an effective choice (from Medsker and Campion, 1997)

When to design jobs around work teams:

1. Are workers’ tasks highly interdependent, or could they be made to be so? Would this interdependence enhance efficiency or quality?
2. Do the tasks require a variety of knowledge, skills, and abilities such that combining individuals with different backgrounds would make a difference in performance?
3. Is cross-training desired? Would breadth of skills and work force flexibility be essential to the organization?
4. Could increased arousal, motivation, and effort to perform make a difference in effectiveness?
5. Can social support help workers deal with job stresses?
6. Could increased communication and information exchange improve performance rather than interfere?
7. Could increased cooperation aid performance?
8. Are individual evaluation and rewards difficult or impossible to make or are they mistrusted by workers?
9. Could common measures of performance be developed and used?
10. Is it technically possible to group tasks in a meaningful, efficient way?
11. Would individuals be willing to work in teams?
12. Does the labour force have the interpersonal skills needed to work in teams?
13. Would team members have the capacity and willingness to be trained in interpersonal and technical skills required for teamwork?
14. Would team work be compatible with cultural norms, organizational policies, and leadership styles?
15. Would labour–management relations be favourable to team job design?
16. Would the amount of time taken to reach decisions, consensus, and coordination not be detrimental to performance?
17. Can turnover be kept to a minimum?
18. Can teams be defined as a meaningful unit of the organization with identifiable inputs, outputs, and buffer areas, which give them a separate identity from other teams?
19. Would members share common resources, facilities, or equipment?
20. Would top management support team job design?

Affirmative answers support the use of team-based work organization.

issues. This is not to imply that these allocations are easy. In part, this is because the criteria and guidelines, along with the knowledge underpinning them, are incomplete. To take one example, the criteria for well-designed jobs do not specify how much, or what kind of, decision-making is optimal. Furthermore, craft knowledge and expertise of this kind require careful interpretation and application in any particular context.

### 2.10. Principle 10: System components should be congruent (content principle)

The notion of congruence is central to a systems perspective. A new design involves a set of working arrangements and these need to be congruent with surrounding systems and practices (van Assen and den Hertog, 1984),

Table 3  
Preconditions for successful teamworking

1. The team should be a 'logical' task grouping: it should be an intact group with clear boundaries; it should have interdependent members and differentiated roles, and it should be congruent with employees' mental models about how work should be done.
2. Employees should be involved in the design of the work organization.
3. The size of the team will vary according to the exact nature of the work, but it should always be of a manageable size. As a guide, there should not be more than 10 or 12 members.
4. The team should be empowered as far as possible to plan and manage all aspects of its own work. This includes taking responsibility for planning and scheduling the work, organizing rest breaks, and ensuring that quality standards are achieved.
5. The team should have clear, specific and challenging performance goals, in order to foster maximum motivation. These goals should cover the full range of required outcomes, rather than just one measure such as short-term output.
6. The actual methods by which the work is done should be minimally specified, allowing team members to choose the particular working methods they feel most comfortable with. The only constraints should be the need to meet performance targets, and the need to adhere to codes of conduct regarding discipline, health and safety.
7. The team needs to have all the basic skills necessary to perform each task. To facilitate the rotation of unpopular tasks, it is necessary to ensure that each team member is capable of a number of different tasks.
8. Significant training will be required in new skills. A common pitfall in implementing teams is the assumption that employees will be competent in the new way of working. Training will be required in technical skills, planning skills, and team/ interpersonal skills.
9. The transition from traditional working methods to teamworking should be carefully planned and designed in its own right.
10. A vital support for teamworking is the provision of an effective information system, as team members should have access to relevant information to enable them to make decisions. Separate principles exist for the design of information and control systems.
11. If employees are working as a team, they should receive feedback at the team performance level. However, individual team members may at times face problems with which they need help, and the feedback system should include a way of identifying such occasions in a way that is not threatening to individuals.
12. First-line supervision will require major restructuring to support teamworking. Since the team takes on many of the responsibilities traditionally allocated to supervisors, the role of first-line supervisors will change quite radically, moving from a controlling role to one facilitating effective team performance.
13. This will involve 'boundary management', such as liaising with other teams or other parts of the organization and procuring resources from the organization for the team. This means that supervisors will need extensive training in these skills, which will be quite different from the skills used in a traditional supervisory role.  
Supervisors may feel that their authority is being removed, or that their jobs are under threat, and they may find their new role quite stressful or frustrating. This can lead to resistance or inappropriate actions, which may adversely affect team performance.
14. Other groups may also feel threatened by expanded operator roles. For example, engineers and quality inspectors may feel that their jobs are being taken away.  
However, they may be reassured by the fact that the new work organization may help them to be more proactive in their work. For instance, engineers could spend more time on planned projects and preventative work, rather than routine maintenance and cleaning.
15. Wider organizational structures and systems also need to be congruent with a team-based work organization, and failure to take these into account is a frequent reason for a lack of success of teamworking. For example, many team-based organizations find it necessary to change the payment structure from seniority-based to skill-based and team-based pay, which will motivate employees to become multi-skilled and counteract the de-motivating effects of 'topping out' of careers.

including, for example, systems for payment, selection, work measurement, performance assessment, and so on. All these were described in Cherns' essays. This may act as a force for conservatism, for example if the new sociotechnical systems are designed to fit with the old systems and their underlying values. It may be exceedingly hard to change surrounding systems and this is one reason why some sociotechnical innovations may be undertaken on 'greenfield' sites. However, the notion of congruence should not be taken to mean that influence extends only in one direction. Certainly, new systems do become assimilated into existing ones. But, it may be that a new system requires some accommodation by the systems into which it is being placed. It may prove to be a catalyst for change. For example, in the engineering company described under principle 4, the move towards cell-based working led to changes in the relationships between production operators and those in production and quality control.

Cherns singled out the design of information and control systems as a separate principle. Whilst it is clear that all interrelated systems should be consistent with one another, the design of information and control systems is especially important. For example, the introduction of teamworking will require the support of an information system that allows the team to understand the goals and targets pursued, to monitor progress against their achievement, and to manage itself in real time. Thus the information system should be designed after the goals of a system have been determined, and in parallel with the work organization. The system components should be consistent with one another. The information should support those who need to take action (for example, those who control key variances — see principle 12). The information should be available to the appropriate person at the right time and in a usable format. It should be comprehensive enough to allow decision-making. The level of technological support for the information system

is itself a sociotechnical design. Basic systems may be satisfactory (see principle 3).

Some sample criteria to help design and select information systems in a sociotechnical context are presented in Table 4. Whilst it may not always be possible to apply these criteria in all cases, it is important not just to select an available information system on technical grounds, around which the work must then fit. Minimally, some tailorability is required. Information and control systems are not neutral entities — they shape and influence the way work is managed and undertaken.

#### 2.11. Principle 11: Systems should be simple and make problems visible (content principle)

This requirement for design simplicity includes a range of more detailed concerns such as ease of use, ease of understanding, and learnability. The proposition is that sociotechnical systems should be simple and that this will promote their ease of use. This principle applies to the detail of design (including, for example the design of human–computer interfaces and interactions), but also to the broad concept.

For example, Canon, the Japanese manufacturing company, uses a common set of manufacturing systems and techniques throughout all its factories. These include systems for total productive maintenance, just-in-time inventory, ‘stop and fix it’ repairs, production planning, and for communicating targets and giving feedback. All these systems are very simple to explain and communicate, and very powerful in their effects. They are well designed. A related design issue is focused on making problems visible. For example, Canon use a ‘stop and fix it’ system on their assembly lines. When an operator experiences problems s/he pulls a chime and a roving ‘trouble-shooter’ has 30 s to solve the problem. If the problem is not solved, the whole line stops. The faulty product is *never* passed on to the next stage, and *never* pulled off the line for rework later. The system makes problems visible (and measurable in impact). This visibility (and measurability) means that resources get allocated to problem solution and this helps ensure that difficulties are addressed (Clegg, 1986; Dankbaar, 1997).

#### 2.12. Principle 12: Problems should be controlled at source (content principle)

One of Cherns’ principles specified that variances (unprogrammed events) should be controlled at source. This is a powerful and enduring design principle that has clear benefits. The advantages are: motivational (people like to have control over the problems they face); cognitive (people learn to perform better through exerting control and by anticipating and solving problems); logistical (it is

Table 4  
Criteria to guide the design and selection of information systems

- |     |  |
|-----|--|
| 1.  | The information system should be designed and selected after the goals of the system have been established, and in parallel with the ways in which the work will be organized.   |
| 2.  | The level of technological support should be chosen after the information system is designed. Information and control system can be quite basic. For example, whether or not the system is computerized should be decided at the end.  |
| 3.  | The information should be consistent with the chosen method of working; thus it should support an empowered method of working, or teamworking, or whatever the chosen way of working. For example, if teamworking is in place, information on individual performance is not appropriate. (Separate principles and criteria exist to help design the work organization.)                      |
| 4.  | The information should fit the mental model used by the decision-maker (i.e., his/her views of the work). For example, if the decision-maker thinks in terms of machine utilization (or whatever), then the information should be available in these terms.  |
| 4.  | If there is any discrepancy between the method of working, the information system and the operator mental models, then this must be addressed and resolved, and changes made so that there is congruency.  |
| 5.  | Information should support those who need to take action. Put another way, the information should get to the right person, i.e., the person who is making the decision (this could be a group of people). For example, the person/group making the decision should not have to go to someone else to get the necessary data.   |
| 6.  | The information should be available at the right time (i.e., in real time). For example, the person/group should not have to wait for hours or days to receive the information needed to control the work.   |
| 7.  | The information should be in the appropriate format and level of detail to enable the receiver, its user, to make the decision/take necessary action. This is partly a matter of usability. Can it be understood? Can it easily be assimilated? etc.   |
| 8.  | The information should be comprehensive enough to support appropriate decision-making, but not unnecessarily complex.  |
| 10. | The users of the information system should be involved in its design.  |
| 11. | The information system should include a target and feedback system. Thus people should know what is expected of them in advance, know how well they are doing in real time (so that they can change their behaviour if necessary), and know how well they did soon afterwards.   |
| 12. | The levels of target should be discussed with the operators to ensure they are regarded as fair and reasonable. In particular, targets are not motivating if people think they are unfair and unreasonable.  |
| 13. | The design of the information system can be evolutionary. For example, the work can be started with very rudimentary information systems in place, and then developed as the ‘needs’ of the operators become clear, and as their responsibilities develop. If this evolutionary design is adopted, then the operators must understand from the outset what are the objectives of the system. |
| 14. | The information system for operators should be nested within, and consistent with, the wider management information systems.   |
| 15. | The information system should not be prohibitively expensive to administer and support.  |

quicker to solve a problem locally than to wait for an 'expert' to visit); and, resource-based (the company can use the 'experts' elsewhere). The notion of variance control at source can take a variety of forms. Historically it has been manifest in schemes for job enrichment, and in the practice of semi-autonomous work groups; more recently it has become popularized in the idea and rhetoric of empowerment.

However, as discussed under principle 7, there are emerging debates over the extent to which this principle is universally applicable. For example, Wall et al. (1999) argue that this principle is best enacted under conditions of operational uncertainty. When work systems are more certain, then problems, because they are relatively predictable, may be handled through other organizational mechanisms. This may mean that resolving problems at source, as an organizational design strategy, will be no more effective (but no worse either) under conditions of relative certainty, than are other design strategies. From a psychological perspective, however, the variance at source approach may be preferable for the operators. Interestingly too, this logic may also be applicable to allocation of function choices (see principle 9); it may be preferable to allocate to humans, decision areas which are both uncertain (unpredictable) and critical to performance. When operating conditions are more certain, the decision areas become more programmable and this increases the likelihood that automation represents a good design choice.

*2.13. Principle 13: The means of undertaking tasks should be flexibly specified (content principle)*

This attempts to extend another of Cherns' powerful principles, that one should not over-specify how a system will work (minimal critical specification). Whilst the ends should be agreed and specified, the means should not. This incorporates the idea that users, as local experts, should be allowed to solve their own problems (see principle 12) and develop their own methods of working, thereby incorporating scope for learning and innovation. This may be difficult in relatively bureaucratic organizations where notions of standardized and common working practices may be the norm.

The notion of 'minimal critical specification' for technology may also be difficult to envisage, especially for complex systems, in part because their operation is usually tightly specified and prescribed at least in the intent of system designers. In practice there is likely to be more variability. As such this principle is that systems should allow for some flexibility in their operation, for example through local tailorability or by affording different modes of operation, perhaps depending on the situation at the time, or variability in the skill and expertise of the operator (see also principle 9). For example, in the case of the shopfloor production scheduling system described

earlier (under principle 2), the users had the option of letting the computer system suggest an 'optimal' schedule if they so wished. They could use this facility when they were too busy to work out their own schedules, when new people joined the group, or when they had prepared their own plan and wanted to check it against the computer's solution.

Substantial conflicts can arise here. For example, local tailorability of a computer-based system may be desirable for operators (see also principle 10), but may be very costly from a technical perspective, especially when system revisions are implemented.

*2.14. Principle 14: Design practice is itself a sociotechnical system (process principle)*

Design processes can themselves be highly complex systems. Consider a project team that develops software, or one that designs a complex aerospace product. Think also of a group that designs the systems and processes (such as concurrent engineering) that will be used to develop such products, or that introduces new technologies and techniques into the process. They are design groups, designing complex products and/or processes. And they are all sociotechnical systems in their own right, involving an interdependent mix of social and technical sub-systems.

This principle simply states that systems that undertake design also need designing, and that sociotechnical thinking, ideas and principles are applicable to such systems. This is especially important as design processes are becoming increasingly subject to the introduction of computer-based methods and tools (such as structured methods and CASE tools), to new forms of working (such as concurrent engineering, business process re-engineering and virtual teamworking) and to new metaphors (e.g., the idea that software is 'manufactured in a factory'). Design processes are increasingly subject to sociotechnical change (see Clegg et al., 1996).

*2.15. Principle 15: Systems and their design should be owned by their managers and their users (process principle)*

Cherns in both his essays emphasized the need for compatibility between process and outcome, and this highlighted the need to involve users in design. The emphasis here is on the related notions of ownership and appropriation, that is with who owns the new system and the processes through which it is designed and implemented. Currently, investments in new technology face massive problems in this area. Many different forms of expertise are involved at different stages, undertaking different activities (including some combination of strategy, feasibility, conceptual design, detailed design, programming, implementation, use, and maintenance).

These activities are typically poorly integrated and coordinated and their ownership rests with different groups of people.

This principle states that ownership of the new system and of its design, should be appropriated by the people who will be responsible for its management, use and support. Furthermore, principle 8 applies in this context — this process should not be split. Why split the ownership of, and responsibility for, design, implementation and use? And yet this is commonplace. A change in mindset is required, away from the notion of ‘user participation’. Too often the implicit argument is that ‘we, the designers of a new system, are trying to find ways of getting you, the users, to participate in its design’. A reversal is required, for example, that ‘we, the managers and users of a new system, need to find ways of getting you, the experts in various forms of design (including technology, business processes and work organization), to help us design how we are going to work’.

For example, one large manufacturing company which made regular and substantial investments in new manufacturing technologies, changed the ways in which it project managed their design. Previously a technical project manager would be responsible for the design, development and implementation of the new system, at the end of which the new system would be handed over to the line manager and the end-users. Results were often disappointing. The company changed its way of working. In the new way, either the project manager during design became the line manager responsible for the new system once it was operational, or alternatively, the existing line manager was given responsibility of project managing design. Thus, the same person became responsible for the design, implementation and use of the new system. Improvements in performance were substantial.

#### *2.16. Principle 16: Evaluation is an essential aspect of design (process principle)*

Earlier, reference was made to the disappointing levels of performance of many new systems, in particular to the common failures of investments in new technology and new working practices. A surprising feature of this area is that organizations so rarely undertake systematic evaluations of their investments against their original goals. There may be many reasons for this. The original estimates of performance may have been over-optimistic. The estimates may have been political statements to persuade senior managers to release capital for investment. There may have been little expectation that the goals would actually be met. Project champions and managers may not want to have subsequent evaluation since they do not wish to have any failures exposed. In any case, circumstances will have changed. What can be

gained from such work? Key people may also have moved on. Furthermore, it may be more exciting to plan new projects and new ideas than to get buried in the detail of past hopes and intents. In other words, there are many good human, political and organizational reasons why evaluation appears not worth the effort.

Nevertheless, evaluation is a requirement for learning. This applies both within particular projects, and also across projects over time. Furthermore, such evaluations need to be pluralistic, considering a wide range of criteria and from different viewpoints. A sociotechnical perspective explicitly assumes a commitment to evaluating the performance of new systems against the goals of the organization and the people in it, and includes the explicit inclusion of social, technical, operational and financial criteria. The emphasis is on pluralistic evaluation.

#### *2.17. Principle 17: Design involves multidisciplinary education (process principle)*

Many design processes are dominated by people with partial forms of expertise and views of the world. In the case of new technology investments, for example, design processes are often dominated by people with expertise in technology, technical design methods and project management. Knowledge of how the organization works, of how it could work in the future, and of the range of organization and job design choices that may be possible, are typically under-represented in design projects. The real danger is that systems designed by people and processes which incorporate partial knowledge can only be partially effective.

A key feature of sociotechnical design involves bringing together people from different roles and disciplinary backgrounds who have different skills, experience and expertise to offer the design process. Pluralism is the norm, and this implies that they share their views and expertise. They need to educate one another in the opportunities that may exist for the design of a new system and what they have to offer the design process. The intent here is not to argue that the holders of one perspective should try to educate others in the correctness of one view (and thereby the inappropriateness of others). Rather, views of the kind articulated in these principles need to be incorporated into design thinking and design practice as worthy of debate. The goal is to educate one another in the complexities of design, and in the need for a more multi-disciplinary understanding. A further potential benefit exists: a multidisciplinary approach to design is more likely to foster creative and innovative solutions. Whilst this may seem obvious, a sociotechnical approach explicitly assumes that design needs to draw upon the expertise of both social and technical domains. This requires considerable resources and support (see principle 18).

### 2.18. *Principle 18: Resources and support are required for design (process principle)*

Organizations undertaking the design of new systems need to invest resources. Resources and support, here are taken to include a number of interrelated elements: money, time, and effort; knowledge, expertise and skill (including, for example, knowledge of the social issues); methods, tools and techniques which designers can draw upon to practise sociotechnical design; and, structures and mechanisms that allow these principles to be enacted (for example, that bring groups of people together to make design choices, to design jobs, to allocate functions, etc.).

Expertise in how to adopt a more holistic and systemic view is critical. For example, technical change projects (as they are often regarded) can be highly complex but at the same time subject to tight timescales and budgets. People responsible for managing such projects may not be expected to consider their social aspects, may not be rewarded for doing so, and may not be trained in this domain. People need to have the time to consider the social aspects of system design, and need inputs of the necessary knowledge and expertise for it to be done successfully. Time and expertise are critical. Resources of this kind are more likely to be invested if a new system and its development are owned and appropriated by the people who will manage and use it, and who will be responsible for its performance (see principle 15).

Resources are also required to undertake some of the complex tasks identified in this paper, for example, to help in planning new work organizations, information and control systems, core processes, and allocations of function. All of these choices and issues require considerable investments of expertise and skill. But they also need to be supported by methods and tools, working principles, and theoretical understanding and frameworks. The sociotechnical community has a great deal of work to do in this area.

Structures and mechanisms are also needed to enable and foster this work. These resources are not trivial. In the light of the tendency that technological issues command the vast majority of resources, this perspective implies more of an equalization of the relative investment in technical and social concerns. Furthermore, the view that design is an extended social process (principle 5), implies that resources continue to be required after a new system becomes operational.

### 2.19. *Principle 19: System design involves political processes (process principle)*

The above principles highlight the need to recognize the political nature of change. Design debates concerning values, choices, ownership, processes, task allocation, evaluation, and resources inevitably raise political issues in organizations. Put another way — the design, imple-

mentation, management, use and evaluation of new sociotechnical systems are not trivial matters for the various stakeholders concerned.

A number of practical implications follow, for example, that: senior managers need to commit themselves to changes of this kind; senior managers cannot abrogate their responsibilities, for example by leaving technological choices to the ‘experts’; bottom-up commitment to change is necessary but not sufficient; different perspectives on changes of this kind are inevitable, should be respected, and need to be addressed; and, there need to be mechanisms in place to handle these political debates and discussions in ways acceptable to those affected by the designs.

## 3. Discussion

### 3.1. *What are the roles of sociotechnical principles?*

Principles of this kind are not offered as blueprints for strict adherence. They are not intended as design rules for mechanistic application. Rather, they provide inputs to people working in different roles and from different disciplines who are engaged collaboratively in design. They offer ideas for debate, providing rhetorical devices through which detailed design discussions can be opened up and elaborated. Heuristic, rather than algorithmic, thinking is required.

It is important to consider the extent to which principles of this kind are integrated with existing design methods, or are relatively freestanding. One argument is that principles of this kind need close coupling and integration with articulated design methods and approaches. This is the approach espoused by de Sitter et al. (1997) and, in a more general human factors context, by Lim et al. (1992). The potential benefits of such an integrated approach lie in their comprehensiveness and in their commitment to the incorporation of important issues, which are built into the design process. Unfortunately three major problems are encountered in this approach. First, it does not fit well with how system developers work. The evidence is that they are pragmatists drawing on methods and tools as they see fit (Hornby et al., 1992). The fact that a method prescribes a certain approach does not ensure its use in the way intended. Second, a related point, such an approach also assumes that a method will be used in its entirety. This may be unrealistic. And third, such an approach would require that all design methods in use have built into them a set of prescribed sub-routines through which human and organizational issues are addressed. This would represent a massive investment, one that is probably beyond the capability of the existing sociotechnical community.

Another view prevails, one to which this author subscribes. In this view, design principles are more likely to

be effective if they are relatively free-standing, for use as appropriate by system managers, users and developers, providing they are supported by various methods and tools which allow them to address relevant issues. For example, the principles become more useful when they are used alongside specific methods and tools to help with the identification of design choices (principle 3), with the design of jobs and allocations between humans and machines (principle 9), and with evaluation (principle 16). In this perspective, there is no single ‘all-singing all-dancing’ methodology through which its users must work. Rather, the need is for relevant sociotechnical principles supported by portfolios of tools that help put these into design practice. Success, evident in the improved performance of new systems, will be most likely achieved by the continuing development and application of new principles, supported by new methods and tools.

A further related issue concerns the extent to which these principles may be universal. Do they imply there is a single best way to undertake design? or is design contingent, and if so, upon what? or alternatively, is each design problem and process unique? The view here is that principles for sociotechnical design should encapsulate some generic properties and ideas that have the potential for widespread application, but that the way in which they become enacted and articulated in a particular design solution will vary across, and be grounded in, particular situations (Klein, 1994). For example, the principle of choice is generic. But, how choices are made, and what form they take, will vary depending on the situation. In a similar way, this paper presents some criteria for, *inter alia*, information system design. The criteria are intended to be generic, and to help design and evaluation, whilst recognising that the actual form of a particular information system will be unique. One potential benefit of generic principles and criteria is that they enable their users to build on the experiences of others and to extend learning from one situation to another.

It is interesting that the examples to illustrate the principles have all involved change within individual companies, rather than across companies (the author is grateful to one of the referees for this observation). There would seem, however, to be no reason why sociotechnical thinking should not be extended to supply chains, partnerships and other networked ways of working that cross company boundaries. This applies to the meta principles (e.g., that design is systemic), to content principles (e.g., concerning the integration of core processes) and to process principles (e.g., that evaluation is required). The logic remains the same; what changes is the ‘system’ as a unit of analysis.

These principles are targeted at people who become involved in the (re-)design of systems, rather than at an identifiable professional group that might be labelled as

‘designers’. Thus the principles (and any associated methods, tools and other forms of support for design) are for use by anyone involved in the design process, including end-users, their managers, technologists, human factors specialists, trade unionists, or whoever. Furthermore, the principles are for use at any stage of the design process. Whilst this should ideally be from the very beginning, i.e., before constraints get built into the process, recall the argument that design continues through implementation and use. Thus principles 5 (that design is an extended social process) and 15 (that systems and their design should be owned by their managers and users) imply that these principles are for use by any relevant stakeholders and at any time during (re-)design.

Of course, this does *not* imply that the principles themselves are enough to enable sociotechnical design. There are three main interrelated reasons for this. First, there remain many gaps in our knowledge. *For example*, as elaborated earlier in this paper, the interdependencies and constraints between design choices are not fully understood (see principle 3); nor are the contingencies affecting design (principle 7). Similarly, job design, work organization and allocation of function (principle 9) are not well understood and defined activities. Second, design always takes place in context, and involves considerable complexity. And third, in part for these reasons, these aspects of design require considerable expertise and skill. There is no suggestion in the presentation of the above principles, that once articulated, they can be applied in some straightforward and linear manner. Considerable craft knowledge and expertise is required to interpret and apply such principles in context.

Principles of this kind aim to be relevant to the design of any new work system, including those which have traditionally been seen as primarily technical in emphasis, as well as those seen as predominantly social and organizational. They should be applicable to the design, implementation, use and evaluation of both new technologies and new management practices. Interdependent consideration of sociotechnology should lead to improvements in performance. As described earlier, changes in sociotechnology continue at increasing rates. One goal here is to develop generic sets of principles such that research and development is not inevitably 3–5 yr behind leading practice, struggling to keep up with new sociotechnical innovations, and unable to comment usefully until particular research has been conducted. Principles should allow one to generalize from earlier experiences and understanding, and to make predictive accounts of likely outcomes and consequences for subsequent evaluation. For example, the initial design and use of sociotechnical innovations such as Call Centres, extended enterprises, teleworking, dispersed teamworking, e-business, and others, should have benefited from the application of design principles. Furthermore, the principles would almost certainly have been improved

in the process. Prospective design represents a major challenge for proponents of sociotechnical thinking.

### 3.2. *What claims are made for these principles?*

It is important to be clear about the claims made concerning the above principles and propositions.

It is clear that these principles are massively interrelated, and some of the interconnections have been identified in their descriptions earlier. The author believes this is a strength rather than a weakness. One would expect principles focused on a systemic perspective to be consistent with one another and to overlap. This helps promote the view that good design has a 'net-like', rather than linear, quality.

One important question concerns the extent to which this formulation offers an improvement on those by Cherns (1976, 1987), in particular concerning the criticisms that Cherns' principles were too partial, too focused on social aspects (to the relative exclusion of technical and/or more integrated concerns). Does this new formulation offer improvements in this broad area? Whilst this question can best be answered through detailed application, the author believes that the principles do offer the scope for a relatively integrated approach. For example, the meta-principles concerned with adopting a systemic view (principle 1), focusing on values (2), identifying choices (3), reflecting business needs (4), design as an extended social process (5), being socially shaped (6), and being contingent (7), all apply to the social and technical aspects of system design. The same argument applies to both content and process principles. Thus, the content principles that core processes should be integral (8) and that design entails multiple allocations between and amongst humans and machines (9) are concerned with both social and technical design. Similarly, process principles that design practice is itself a sociotechnical system (14) and that systems and their design should be owned by their managers and users (15) are both concerned with an integrated approach to sociotechnical design.

No claim is made that the development of a set of principles of this kind is enough in its own right to increase the application of more integrated design. Principles have a role: they should be seen as necessary, but not sufficient, to make a substantial contribution to practice. The claim is that their continued development and improvement will make them more usable and useful, but that other changes are also needed. This is not an essay on how to integrate fully the social and the technical, except to say that if it were easy, it would already have been achieved. A wider analysis is required and improvement will almost certainly involve a number of changes (see Clegg (1993) and Perrow (1983), for a discussion of some of these wider issues). But whilst some of these changes are wider, some actions are within the control of

those engaged in sociotechnical work. As argued above, practical design methods and tools are required, for example in helping designers identify and make choices. More work is required in establishing the relationships between principles, design methods and tools, and more specific design criteria, each of which has a role in promoting and undertaking sociotechnical design.

One concern is that some of these principles may state the obvious. Thus it may come as no surprise (to some) that design is concerned with systems thinking, that values are important, that there are always choices, and so on. But such ideas are not shared by all (it is surely a mistake to assume that these views are universally agreed), and certainly are not observed by all in daily practice. In this logic, such ideas are worth making explicit; in this way they can be debated and challenged, but also defended and improved.

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