INTRODUCTION

This will be a personal essay on my thoughts about sociotechnology (or socio-technology if you will) and its current place in the study of technology in society. I will also be looking at some of the differing streams of thought concerning the sociotechnical principles that govern the way organisations and systems can be designed.

Technology is now pervasive in our society and workplace. It takes many forms but is essential to maintaining the way of life in Westernised societies. In developing nations we see that the use of mobile technology has transformed a number of their societal activities including medical care and communication possibilities.

Sociotechnology itself is a concept; a set of principles; and an underlying morality or philosophy. In Coakes and Coakes (2009) pages 1-53, I gave a short history of the movement but here I just want to reinforce some of the essential points that make sociotechnology such a unique field of study.

The principles of sociotechnology derive from the 19th century movements towards democracy and equality in society. Due to its origins it has been concerned specifically with the workplace but we now see that the concepts and principles apply much further – or could apply – to the way we design technology for the social environment whether it is in the workplace, or in the home, or in the external environment. The word sociotechnical is now used by some authors to refer to the interaction between society’s complex infrastructures and human behaviour. In this sense, society itself, and most of its substructures, are complex sociotechnical systems. Thus we now see papers being published that look at sociotechnology in this wider context – for instance, in the International Journal of Sociotechnology and Knowledge Development 1 (3) Dunckley et al (2009) look at participatory design in the developing world and say the technology is considered among the greatest enablers for the improved quality of life, but that is essential not to impose Western solutions to a situation where the context is not clear. “Local people will have their own concepts of knowledge and their own forms of ... communication so it is essential that they are able to shape their own use of ICT without the risk of losing their culture and identity” (p3).

A socio-technical system, is an action system that relies both on human and technical function carriers (Ropohl, 1999). Every invention Ropohl says, represents a novel acting function rather than solely a new artefact. There is no invention which would not constitute a novel pattern of human action at the same time. The use of sociotechnical principles in system design – system in the very broadest sense of the word - permit this to happen. It is also essential as Liebowitz says (2009) p56, not to force-fit the technology to the problem at hand. The ‘I have a hammer, therefore every solution is a nail’ philosophy must not be followed. It is essential to develop the user’s needs through participation in design and then
the appropriate technology will emerge. The international and developing nations theme was followed up by the special edition of the *IJSKD* (2009) where Gagliardone considered the shaping of technology for nation-building – technology morphs into techno-politics - where technology embodies and enacts political goals. The process of adoption of new technologies can be seen as “a socialization of artefacts to different cultural, economic and political context” (p24), and thus we see an extension of the traditional workplace or organisational design concepts being translated and expanded into the societal context.

In Coakes et al. (2008) a number of organisational drivers are identified that characterise organisations within the current global environment. These drivers are: an increasingly dispersed work environment; an increasingly complex environment; the need for efficient decision-making; the increased volume of knowledge available; problems related to knowledge attrition; and the continual development of new technologies.

These drivers are clearly also applicable to society at large as organisations disperse throughout society being pluri-located and containing multiple national cultures. The pluri-location increases complexity for the organisation and makes decision-making more difficult and yet the need for it to be more efficient is obvious – but will it be effective? The increased and ever increasing volume of data and information means that knowledge cannot stand still – it must be continually updated, expanded, developed, and discarded. And people are continually being required to utilise and understand an increasingly complex set of technologies and their interactions.

In Coakes et al, (2000) Enid Mumford, one of the best known practitioners of sociotechnical design for information systems highlighted the need to understand what is meant by the term technology in the sociotechnical domain. She said: “Technology can be described as both an artefact and a process. It consists of tools that help men and women extend their abilities and knowledge, but it is also the generic knowledge and skill required to design a specific product or process” (p30).

Sociotechnical thinking is therefore important to the design, development, implementation, and use of these information technology communication systems. It addresses vital issues in combining the use of powerful information and communication technologies with effective and humanistic use of people for the work environment (Coakes and Coakes, 2005), but also now we see has application in addressing the issues of the use of ICT in the wider societal context.

Indeed Coakes (2002) stated that sociotechnical perspectives can be characterised as being holistic... “and take a more encompassing view of the organisation, its stakeholders in knowledge and the environment in which it operates ... the word sociotechnical...is a combination of two paradigms: the social and the technical. It was thus intended to describe a broader view of the role of technology in an organisation than either paradigm could offer on its own. Technology ... should be seen, discussed and developed not just as a technical artefact but in the light of the social environment in which it operated” (p4). So we see that a definition could also be: the study of the relationships and interrelationships between the social and technical parts of any system (Coakes, 2003). This latter definition is clearly applicable to sociotechnology in the societal context as well as in the organisational context. Indeed we would consider that sociotechnology is a holistic approach towards the totality of the world.

Looking now specifically at the organisational context and the principles that have been developed by key theorists we have a number of strands of development. The first is UK based through the work of the Tavistock Institute initially and then in relation to ICT, it is seen in the work of Enid Mumford; the second is European and is characterised by the work of Einjatten from the Netherlands but is in contrast to the Scandinavian view; and the third main strand is Australian and is developed from the work of Trist. A fourth more minor strand comes from application of the principles in the USA.
In the first strand Enid Mumford’s set of principles relate specifically to system development and are a set of principles about its design. Amongst these principles are the following (2000) – that there should be:

- **Participation**: in work and process design;
- **Representation**: all users should be represented in the design group;
- **Joint problem solving**: all are equal in decision-making and all should agree on the route to change and problem-solving;
- **Freedom of speech**: there should be face-to-face communication and honest exchange of views, solutions will be obtained through integration not compromise;
- **Gaining power**: groups should recognise that joint work increases their power in relation to other organisational groups;
- **Staying together**: groups should maintain their cohesiveness over long periods.

Beekun (1989) discussed the idea that when the social and technical systems of an organisation achieve consonance, the organisation is likely to achieve higher productivity and job satisfaction leading to lower absenteeism and staff turnover. He went on to say that workplace autonomy is closely related to the principle of minimum critical specification that was developed by Cherns in his seminal papers of 1976 and 1987 for the Tavistock Institute. Cherns, as discussed in the history of the movement referred to above, was one of the key Tavistock developers of sociotechnical thinking. Minimum critical specification is the idea that workgroups will operate more effectively without external supervision or control of processes and interference through boundary limitations of what they do, how and when. Wall et al., (1986) argue that most groups, if permitted, will make process, skill and method improvements for their own satisfaction and desire to improve skills and knowledge.

Munkvold (2000, p14) who is part of the Scandinavian European strand of thinking, said that the importance of mutual alignment of the social and technical systems in organisations, the structuring of work in self-autonomous teams and the participation of stakeholder groups in change activities is well acknowledged. Socio-technical principles can be seen as a foundation for much of the current practice related to organisational change and information systems development. Indeed as discussed later, Clegg (2000) has developed a set of 19 principles in relation to organisational design (see Appendix 1) that are sociotechnically based.

Eijnatten, whilst also from the European strand, looks at the Dutch strand of sociotechnical thinking and compares it to the American, Scandinavian, and Australian counterparts. He distinguishes it clearly in terms of its view of the underlying systems theory but concludes, in his paper with Zwaan (1998), that at a meta-level, they all share the ideal of participative democracy, while at the conceptual level, these distinctive approaches appear quite incompatible. Notwithstanding substantial diversity they say, these approaches can be seen as local manifestations of a single sociotechnical paradigm.

According to Kira & van Eijnatten (2008) - and also in Eijnatten and Hoogerwef, 2000 - sociotechnical systems theory and practice alone cannot achieve many of the great benefits to be expected from their own chaordic approach. The issue being related to the foundation of sociotechnical thinking which is the open systems approach and their chaordic approach being more complex but process based. Kira and van Eijnatten argue that traditional socio-technical systems approaches do not offer a foundation for achieving sustainability, and that to promote social sustainability, a work organisation has to be understood as a holonic system in which development can only take place when also its members grow in
their interior and exterior complexities. Complexity development is outlined as an emergent process. This critique is however, refuted by Merrelyn Emery (2010) as Emery states that there is abundant evidence to show that their claims and criticisms lack credibility.

It is important here to try and understand this criticism of sociotechnical thinking and its implications for the development of the field.

The arguments between Emery and van Eijnatten are based on the difference between what is called chaordic system thinking and open systems thinking. Chaordic thinking bases itself on chaos theory and the concept that systems arise and thrive on the edge of chaos with just enough order to give them pattern, but not so much to slow their adaptation and learning. Chaordic organisations therefore must be:

- based on clarity of shared purpose and principles;
- self-organizing and self-governing in whole and in part;
- durable in purpose and principle, malleable in form and function;
- equitable in the distribution of power, rights, responsibility and rewards;
- combining cooperation and competition;
- learning, adapt and innovating;
- amplifying ingenuity, initiative and judgment;
- compatible with and fostering diversity, complexity and change;
- utilizing and harmonizing conflict and paradox;
- and restraining and appropriately embedding command and control methods. (Chaordic Commons, 2010).

Chaordic principles according to the Chaordic Commons work to ensure that all people, by right of birth, have adequate necessities of life, including clean air, water, food and shelter; an equitable share of wealth and resources; and opportunity to develop their full physical, mental and spiritual potential. Additionally they work to ensure that human capacities, technologies and organisations sustain and support, not systemically alter, degrade or destroy, the Earth, its diversity of life or life support systems. According to Oscar Motomura of Amana-Key (2010) the traditional command and control organisation is no longer fit for new ways of working. Traditional organisational structures fragment work will, in principle limit space, and thereby reduce the area available for action. The assumption is that their employees are not capable of thinking, and that they are there to carry out what has been thought of by others, their “superiors.”

This idea that the command and control organisation is not longer fit for purpose though does not, in the opinion of many, mean that open systems are not suitable. Indeed, I argue (Coakes et al, 2002) that the sociotechnical principles as developed by Cherns are applicable to organisations in the knowledge management world. That if we apply those principles to current organisational design we can achieve a learning organisation which will permit chaordic systems. Using sociotechnical principles and with appropriate transformational leadership we can organise around competencies and expertise and permit creativity and experimentation. Allee (1997) also talks about a quantum worldview “where motivation comes from intrinsic creativity where knowledge is collective and life thrives on cooperation, with workers being multifaceted, always learning, and being managed through insight and participation” [Coakes et al, 2002] which aligns strongly to the UK sociotechnical principles.
In Fox (1995) we hear a different analysis of the origins of sociotechnical thinking (pp93-4) based on the work of Emery (1959) and Trist (1971; 1981); this is the third strand of thinking. He says that we should be concerned about the social system in terms of:

- “Whether work roles are organized so that workers are cooperative rather than competitive with each other;
- Whether work roles are organized so that workers view an end result as their responsibility or as someone else’s responsibility;
- Whether workers are made jointly responsible for how supportive services and implements are delivered or are provided separately and unilaterally to each worker;
- The extent to which key variances (those that significantly affect the quantity or quality or operating cost or social cost of production) are imported or exported across the social system boundary rather than being controlled by the workers, supervisors, and managers directly concerned;
- The possibilities for complex and simultaneous interdependencies among the workers to provide for task accomplishment in less time and for continuity in the face of individual failure;
- How each worker’s role is experienced; not only in terms of its inherent attractiveness but also in terms of perceptions of dependence, pay equity, subordination, self worth, trust, constraining factors, and isolation with regard to others;
- The extent to which task interdependencies are coordinated in terms of the social relations that are required by the task rather than the in terms of the social relations that develop for other reasons (such as friendship);
- The presence of personal worker goals and task interdependencies that are threatened by, or are not adequately handled by, formal organisational provisions. The presence of formal overspecification as well as underspecification.”

These key principles or concerns for work and related technology methods, and manner of undertaking, and organising, and changing, work and organisations, to meet new needs and requirements are clearly seen throughout the sociotechnical literature which also identifies a number of principles that are critical area in participative work and organisational design projects.

The final strand of sociotechnical thinking is that represented in North America by the STS Roundtable. They see it as:

“As a general approach to the analysis and design of organisational processes, systems and structures, it promotes principles of participation, an open systems conceptual framework embodying the joint optimization of the organisation’s social and technical subsystems, and an action-research methodology. Its key ideas are now embodied in a wide range of concepts and practices employed globally by practitioners as university researchers and teachers, consultants, and union and management leaders, who are working to develop organisations that are BOTH humane AND effective.” (Stsroundtable, 2010). For these members of this community there are 24 principles organised into Philosophical Premises and Values, Design Process, Structuring Work Groups, Work Design, and Continuity.

Tables 1-5 below detail these 24 principles as explained on the website and divided into the five sets of principles. Note that these words and pages are taken from Some Principles of Sociotechnical Systems Analysis and Design which was originally published in 1992 by Dr. Eli Berniker for the School of Business Administration, Pacific Lutheran University
**Table 1. Philosophical Premises and Values**

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<th>Principle</th>
<th>Value Clarification</th>
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<tr>
<td>1</td>
<td>The Design Philosophy</td>
<td>Guide and test design decisions against explicit values and assumptions which may be codified in a philosophy statement.</td>
<td>Value clarification is a process of deliberation about and sharing of the tacit assumptions and values embedded in traditional modes of organizing. Participants share hopes and expectations and work to achieve agreement on the goals and objectives of the design team. The outcome is a set of shared values and assumptions that reflect the process.</td>
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<td>2</td>
<td>Uncertainty</td>
<td>Uncertainty is a necessary condition of organisations and their technical systems.</td>
<td>Uncertainty and equivocality are necessary attributes of organisational life. All problems and uncertainties cannot be eliminated. As problems are solved, competition, standards of quality, economies of scale and scope (Jelinek and Goldhar, 1984) and increasingly ambitious technical endeavours drive systems design towards increasing complexity until limited by emergent problems and technological deficiencies. Effective management of uncertainties instead of efficient performance of routines is critical to the long term survival of organisations in 'turbulent environments' and, therefore, should be the primary focus of work design.</td>
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<td>3</td>
<td>Technological and Organisational Choice T</td>
<td>Technology does not determine work organisation or design. There are choices in the design of technical systems and the organisations that operate them.</td>
<td>Competent design and the discovery of technical system disturbances and challenges require careful analysis of technical systems and the technologies that inform them (Davis, 1982; Engelstad, 1979; Berniker, 1986). This is the key to improved effectiveness by work groups, to expanded work roles, and the justification for their autonomy.</td>
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<td>4</td>
<td>Work as Problem-Solving Action and Motivated Behaviour</td>
<td>Work is a purposeful causal interaction between a person and an environment that produces changes valued by that person. (Berniker, 1985) and Work is motivated behaviour conditioned by individual needs, expectations and opportunities.</td>
<td>Therefore we have contradictory views: work may be understood as determining action or as determined behaviour. In STS we see people as solutions to problems rather than the problems themselves. There is a deep belief that groups of skilled workers, organized cooperatively with the responsibility, autonomy, and knowledge to deal with challenges, and motivated by the opportunity to meet their own goals at work, are the most effective organisational means to deal with emergent challenges to their productive performance (Emery, 1979; Susman, 1990). This belief in the capacities of individuals and groups has explicit work design implications that can lead to practical opportunities to improve both Quality of Working Life and organisational performance.</td>
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<td>5</td>
<td>Participation</td>
<td>People have the right to participate in the design of their own work lives and in the decisions that guide their work activities.</td>
<td>Participation is held an intrinsic good, and is both means and end. Participation enables a proactive and conscious process of deciding about the design and functioning of a work group.</td>
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<td>6</td>
<td>Open Sociotechnical Systems</td>
<td>The organisation is conceived as a sociotechnical system; i.e. an integration of a social system, organisational members enacting their roles, and a technical system, the means they use to accomplish organisational goals, into a coherent open system in commerce with a relevant environment.</td>
<td>The organisation is seen as a system that interacts purposefully with its transactional and contextual (Trist, 1981) environments. The transactional environment involves specific stakeholders whose interactions with and expectations from organisations impose objectives on them. The contextual environment involves developments in society and the economy relevant to the organisation but not specifically directed to it (Davis, 1982).</td>
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<td>7</td>
<td>Human Values</td>
<td>The objective of organisational design should be to provide high quality work. (Cherns, 1976)</td>
<td>Not everyone has the same needs, goals, and expectations. Therefore, options should be provided for individuals to realize that measure of involvement, responsibility, growth, and variety that suits them. It may not be possible to achieve everyone’s objectives simultaneously (Cherns, 1976).</td>
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Table 2. Design Process, *The design process is inseparable from its outcomes* (Churchmen, 1971)

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<td>8</td>
<td>Compatibility</td>
<td>The process of design should be compatible with its objectives. If adaptive competence is a design objective, then a process self-design is appropriate</td>
<td>The people who own the problem should own the solutions. Ownership of problems and opportunities links design decisions with responsibility for successful implementation. Participative design develops adaptive capacity so the work team can creatively respond to emergent challenges by reassigning tasks, reorganizing itself, and inventing responses</td>
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<td>9</td>
<td>Minimum Critical Specification</td>
<td>This principle has two aspects, negative and positive. The negative simply states that no more should be specified than is absolutely essential; the positive requires that we identify what is essential. (Cherns, 1976)</td>
<td>Minimum critical specification means that we design as little as possible and only specify what is essential (Cherns, 1976). But the essential must be specified. A technical system must be sufficiently well specified to be built and operated. A good specification strategy is to choose those alternatives that keep the most adaptive options open. Another is to locate decision authority in the design team instead of delegating that responsibility to technical specialists.</td>
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<td>10</td>
<td>Constraint-Free Design</td>
<td>Create ideal alternative designs. Avoid premature “realism”.</td>
<td>Ideal designs should be sought without reference to assumed or real organisational or technical constraints. The point of the principle is to be innovative, not to produce impractical designs. Constraint free design establishes an ideal standard; an optimal vision enabling the team to gain a perspective on its efforts.</td>
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Table 3. Structuring work Groups

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<td>11</td>
<td>Self-Regulating Work Groups</td>
<td>The self-regulating work group is the building block of the organisation. Design work groups rather than individual jobs.</td>
<td>The object of the design process is a self-regulating work group with the capability to achieve organisational objectives under a variety of conditions while maintaining its internal structure and adapting to changing demands (Davis, 1982).</td>
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<td>12</td>
<td>Work Group Responsible Autonomy</td>
<td>The work group takes responsibility for its productive outcomes. Work group autonomy is constrained by the requirement that it be used to improve organisational performance and effectiveness.</td>
<td>The unit of performance control is the work group rather than the individual and this also means that it must be possible for each individual worker to be held responsible by an external supervisor for his individual performance. (Emery, 1979 p.88) but there is work group rather than individual measures of performance. Organisational coordination is to be achieved by outcome standards rather than direct supervision or work standards (Mintzberg, 1983).</td>
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<td>13</td>
<td>Inducements to Work</td>
<td>The primary inducements to work are necessity and pay.</td>
<td>When organisational performance improves as an outcome of STS designs and participative management, there arises an expectation that employees will benefit accordingly.</td>
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<td>14</td>
<td>Boundary Location</td>
<td>Boundaries should be drawn to permit a self-regulatory decision making within the work group.</td>
<td>Organisation charts and technical system designs may reflect boundary assumptions that inhibit effective team functioning and problem solving. Boundaries should enable members to develop face-to-face relationships necessary for effective group functioning. The boundaries should define a group of sufficient size to have the requisite response variety needed to execute the work, to control and maintain the technical and social systems within the boundary, and to incorporate administrative functions in the group’s role. External controls should be minimized as the group increasingly coordinates its own activities.</td>
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<td>15</td>
<td>Boundary Management</td>
<td>The regulation of the interface between work teams and their organisational environments is a crucial role of management and the work group.</td>
<td>The focus of managerial attention should be shifted from internal activities to external relations. These relations may be with a variety of organisational stakeholders including upper management, other departments, staff functions, and external bodies. The goal of management is to assure access to those resources needed by work teams to achieve organisational goals.</td>
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<td>17</td>
<td>Organisational Unique-ness</td>
<td>Honour each organisation’s uniqueness. Each organisation should invent itself.</td>
<td>Each organisation is sufficiently unique that it should design itself, its component units, and their functioning rather than attempt to copy what others have done (Davis, 1982). However, exploration and observation of other innovative organisations extends design horizons and broadens the scope of creative design.</td>
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<td>18</td>
<td>Support Congruence - Reinforcement</td>
<td>Organisational systems of social support should be designed to reinforce the behaviours that the innovation is designed to elicit. (Cherns, 1976)</td>
<td>Each organisational practice should be reviewed to see whether it reinforces or contradicts the intended functioning of work teams. Pay for knowledge reward systems (Gupta, Jenkins, Curington, 1986; Lawler, 1988; Pasmore, 1988) are an example of congruence. Increased knowledge and competence enhance a team’s adaptive capacity. Career paths based on skill acquisition support learning and cooperation within teams (Davis and Sullivan, 1980) are to be preferred.</td>
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Table 4. Work Design

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<td>19</td>
<td>Variance Control</td>
<td>If variances cannot be eliminated, they should be controlled as near to their point of origin as possible.</td>
<td>A variance is any disturbance, deviation or unplanned event that can have a negative effect on the throughput of a productive organisation (Berniker, 1983). Design for effective variance control requires (1) that variances occur or are observed within the group’s boundary; (2) that the work group has the resources to measure and control the variance (Davis and Wacker, 1982); (3) that the work group has the requisite response variety and information to control the variance; and (4) that the group has the authority and responsibility to take the required actions for control.</td>
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<td>20</td>
<td>Multi-Functionalism and Requisite Response Variety</td>
<td>Design work groups with flexible work roles enabling members to increase their competence, master multiple skills and gain the requisite response variety to solve problems.</td>
<td>Work groups need both social and technical skills to function effectively. Social system skills, including communication, listening, teamwork and organisational skills and technical system skills are developed through appropriate training. Work groups should be developed so individuals have the opportunity and motivation to master multiple roles and increasing response repertoires. Workers can master each other’s roles and maintenance, administrative, and social system tasks. Groups, with multi-skilled members, would have many possible deployments of their skills exhibiting ‘equifinality’, the flexibility and adaptability that is an important characteristic of living organisms (Bertalanffy, 1980).</td>
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<td>21</td>
<td>Information Flow</td>
<td>Information should flow to people who can take effective action. Information used to control performance cannot be used for self-regulation.</td>
<td>Design information flows so that employees have immediate access to information needed for effective action. Effective action takes precedence over administrative control.</td>
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Table 5. Continuity

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<td>22</td>
<td>Learning</td>
<td>Successful designs will allow for many kinds of learning by the group</td>
<td>Learning proceeds at both the individual and the organisational levels. The work group should learn about its own learning processes, deutero learning (Bateson, 1972) enabling it to examine and change its frame of reference and values or norms (Cummings and Mohrman, 1987) and sustain its learning capacities in the face of emergent challenges.</td>
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<td>23</td>
<td>Experimentation</td>
<td>Design decisions are to be taken as experiments to be modified in the light of the evaluation of outcomes.</td>
<td>Develop commitment to an evolutionary process of work group experimentation than to particular aspects of work group functioning.</td>
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<td>24</td>
<td>Self-Design</td>
<td>Design is an ongoing participative activity of the work group as it responds to changing environmental demands and stakeholder objectives.</td>
<td>As the environment of a work system evolves and presents new challenges, so must the work group adapt. Immediate adaptations may involve a simple redeployment of individuals between tasks. The succession of adaptations results in irreversible changes. Over time, the environment and the work group functioning may become uncorrelated. Periodically, the work group should re-examine its roles and practices and engage in an explicit process of redesign.</td>
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Berniker however says: “Principles do not constitute a design process. Design as a craft involves exploration, experiment, elaboration and elimination, trial and error, all with the intention of making the most coherent and expressive use of an opportunity framed by a set of outcome goals and constraints. Principles give direction to the process, suggest innovative premises and provide an anchor for what is necessarily a creative sensemaking process. A design team enacts the organisation-to-be as a vision of the future, an initial set of reasonable organisational prescriptions and specifications for a technical system to be built. The principles of sociotechnical systems design are intended to provide an intelligible basis for such a process of workplace innovation.” (STS Roundtable)
When considering organisational design projects Clegg, as mentioned above, [2000] gives us 19 principles that should govern our design (Appendix 1), and clearly are linked through to the principles discussed above.

These 19 principles can also be seen implicitly in the work of Carvalho (2006) who says that the co-evolution of technology and organisations brings with it an expanding array of new possibilities for novel interaction. The permitting of autonomous teams and the destruction of stove-piped departments and the removal of traditional command and control procedures means organisational flexibility and rapid response to changing circumstances are easily achieved. Uncertainty or complexity are also often related, according to Carvajal (1983), more to internal process or system organisation than external ambiguities. In the traditional command and control organisations problems with moving and shifting or ambiguous targets often become magnified through a much larger social space, one in which there is a far greater extent of hierarchical task interdependence – see also Trist & K. Bamforth (1951). The technology that forces processes to be rigid and controlled such as ERP systems magnify this effect. The semi-autonomous group, and its ability to make a much more fine grained response to the shifting target situation, and so can be regarded as ‘agile’. Local problems additionally, do not ripple throughout the entire system or process, affecting the workload and work quality of many others. Agility means rapid response and the capability to respond to the chaordic environment. A complex organisation doing simple tasks has been replaced through sociotechnical design, by a simpler organisation doing more complex tasks. In this simple organisation, the outcomes of the tasks are specified but not the manner in which the outcomes are achieved. Managers are facilitators rather than controllers. For each participant in the task, the “task has total significance and dynamic closure”, [Trist & Bamforth, 1951 pp7-9], as well as the requirement to deploy a multiplicity of skills and have responsible autonomy to select what, when and how.

From the above we can conclude that chaordic and open systems are learning systems and are clearly sociotechnical systems, and that the arguments, when looked at closely between the strands are not substantive. Thus, whichever set of principles we follow, the result of the design of our new system, whether technical or organisational, will be a more flexible system that is better fit to cope with shifting external realities and is also thus a sustainable system.

Elayne Coakes  
University of Westminster, UK

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APPENDIX

Table 1. Clegg’s 19 Principles

<table>
<thead>
<tr>
<th>Clegg’s Principle</th>
<th>Meta principles</th>
<th>Content principles</th>
<th>Process principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design is systemic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Values and mindsets are central to design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Design involves making choices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Design should reflect the needs of the business, it users and their managers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Design is an extended social process</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6 Design is socially shaped</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7 Design is contingent</td>
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<td></td>
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<tr>
<td>8 Core processes should be integrated</td>
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<td></td>
<td></td>
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<tr>
<td>9 Design entails multiple task allocations between and amongst humans and machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 System components should be congruent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Systems should be simple in design and make problems visible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Problems should be controlled at source</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 The means of undertaking tasks should be flexibly specified</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Design practice is itself a sociotechnical system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Systems and their designers should be owned by their managers and users</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Evaluation is an essential aspect of design</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>17 Design involves multidisciplinary education.</td>
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<td></td>
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<tr>
<td>18 Resources and support are required for design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 System design involves political processes</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

These 19 principles are closely related to, and build on, the principles that Cherns advocated. The table below compares the two sets.

Table 2.

<table>
<thead>
<tr>
<th>Clegg Principle</th>
<th>Relationship to Cherns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta principles</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Implicit</td>
</tr>
<tr>
<td>2</td>
<td>Similar</td>
</tr>
<tr>
<td>3</td>
<td>Considered briefly in minimal critical specification.</td>
</tr>
<tr>
<td>4</td>
<td>Not covered.</td>
</tr>
<tr>
<td>5</td>
<td>Not covered.</td>
</tr>
<tr>
<td>6</td>
<td>No covered.</td>
</tr>
<tr>
<td>7</td>
<td>Implicit in his writing.</td>
</tr>
<tr>
<td>Content principles</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Implicit. Subsumes boundary location, information flow and power and authority.</td>
</tr>
</tbody>
</table>
| Clegg Principle | Relationship to Cherno  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Includes multifunction/job design criteria extended to include task allocations between humans and machines.</td>
</tr>
<tr>
<td>10</td>
<td>Supporting congruence.</td>
</tr>
<tr>
<td>11</td>
<td>Not covered.</td>
</tr>
<tr>
<td>12</td>
<td>Variance control.</td>
</tr>
<tr>
<td>13</td>
<td>Modifies minimal critical specification to deal with technical design for complex systems.</td>
</tr>
</tbody>
</table>

**Process principles**

| Process principle | Relationship to Cherno  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Subsumes transitional organisation and incompletion.</td>
</tr>
<tr>
<td>15</td>
<td>Modifies principle of compatibility with a shift in emphasis from user participation to user ownership of new system and processes from design through to implementation.</td>
</tr>
<tr>
<td>16</td>
<td>Modifies compatibility and with emphasis on user ownership from user participation.</td>
</tr>
<tr>
<td>17</td>
<td>Multi-disciplinarity implicit</td>
</tr>
<tr>
<td>18</td>
<td>Implicit.</td>
</tr>
<tr>
<td>11</td>
<td>Recognised but not in principles.</td>
</tr>
</tbody>
</table>