Revisiting the Sociotechnical Principles for System Design (Clegg, 2000)

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Abstract. In this paper we reflect upon and re-examine the impact of one of the most influential papers in recent years in the field of sociotechnical systems design (Clegg, 2000). In particular, we look at the influence the paper has had upon a diverse range of researchers (e.g., citation patterns, the extent to which the ideas in the paper have been taken up by disciplines outside of human factors/ergonomics); carry out an evaluation of the extent to which the STS principles have stood the test of time and areas where they may need to be modified in the light of new developments within systems ergonomics (e.g., complexity theory, cybernetics), technology (e.g., the internet of things, automation and robotics) and wider society (e.g., globalization, climate change). The paper concludes with a section covering the future of STS and potential ways in which the principles could be taken forward and modified in order to cope with new developments in human factors/ergonomics and elsewhere.

Keywords: Sociotechnical systems · Complexity · System design

1 Introduction

One of the most influential papers in the area of systems ergonomics to appear in the journal *Applied Ergonomics* in the last few decades is Chris Clegg's 'Sociotechnical principles for system design' [1]. Alongside other well-known papers which argue the case for regarding the Sociotechnical Systems (STS) approach as one of the fundamental corner-stones of human factors and ergonomics (e.g., [2–4]), Clegg's paper extends earlier work in STS which can be traced back to the late 1940s and 1950s (e.g., [5]). The paper is widely cited (270+ citations in the Scopus database) and has gained a wide readership not only within the human factors/ergonomics community, but also amongst computer and information scientists, engineers and other branches of the social sciences. Chris died in 2015 and we would like to take the opportunity provided by the IEA session to partly pay tribute to his work, as well as revisiting the paper and reflecting on its influence and relevance almost two decades on from its original publication. In particular, we focus on the following aspects of the paper:

- An overview of the main content of the paper including a review of the sociotechnical (STS) principles and their origins in earlier sociotechnical work (e.g., [6, 7]), as well as influences on Clegg's work over the period 1980-2000;

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- The influence of the paper on other researchers (e.g., citation patterns, the extent to which the ideas in the paper have been taken up by disciplines outside of human factors/ergonomics);
- A re-evaluation of the extent to which the STS principles have stood the test of time and areas where they may need to be modified in the light of new developments within systems ergonomics (e.g., complexity theory, cybernetics - [8]), technology (e.g., the internet of things, automation and robotics – [9]) and wider society (e.g., globalization, climate change – [10]).

The paper concludes with a section covering the future of STS and potential ways in which the principles could be taken forward and 'recrafted' in order to cope with new developments in human factors/ergonomics and elsewhere.

2 The Original Sociotechnical Principles for System Design (Clegg, 2000)

2.1 Background and Earlier Influences

The nineteen principles as outlined in [1] represent the culmination of a body of work conducted by Chris at the Medical Research Council Social and Applied Psychology Unit (SAPU) in Sheffield which reaches back to the late 1970s on job and work design (e.g., autonomous work groups – [11]; job design models – Wall et al. 1978, the psychology of absenteeism and turnover – [12]). Later work, some of it conducted when SAPU became the Institute of Work Psychology (IWP) in the 1990s, focused on the implementation of new technologies into the workplace (e.g., CADCAM systems –; CASE tools – [11]), as well as methods for systems and organizational design [1, 11]. It is worthwhile noting that alongside some of this applied work, Clegg also managed to publish some important theoretical papers (e.g., the relationship between technology, structure and managerial control – [13]).

Throughout his career Clegg made use of earlier work from the Human Relations movement of the 1950s which first drew attention to the need to integrate the design of the social and technical components of work systems. Over the years there have many been attempts to create frameworks and processes for the design of sociotechnical systems. Some examples are the Nine Step Model [14], the ETHICS methodology created by Mumford [15] the ORDIT approach [16] and Multiview [17]. One of the most important contributions was made by the late Albert Cherns in two papers described the original and revised set of principles of sociotechnical design [6, 7]. These principles, *inter-alia*, included: 'minimal critical specification' (which states that while it may be necessary to be quite precise about what has to be done (e.g., a work task), it is rarely necessary to be precise about how it is to be done); 'information flow' (which states that information systems should be designed to provide information in the first place to the point where action on the basis of it will be needed; and, 'support congruence' (which states that the systems of social support should be designed so as to reinforce the behaviors that the organization structure is designed to elicit.

2.2 Clegg's Principles for STS and Systems Design

Clegg [1] explicitly acknowledges the earlier work of Cherns in the new set of principles for STS. Part of the motivation for their re-design is that the work of Cherns, alongside other examples of earlier pioneers of STS, has had little uptake within industry and wider practice. A similar concern appears to have been that Cherns' principles needed to be updated in order to be fit for purpose for the high-tech, early age of the internet world of the new millennium (Clegg [1], pp. 463–464). A summary of the 19 new principles is shown in Table 1.

Table 1. Clegg's 19 principles of STS for systems design (Clegg [1])

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

2.3 Impact and Outreach

Figure 1 shows the steady growth of citations of Clegg [1]. In the last decade citations and other indicators of influence (e.g., downloads from the Applied Ergonomics website – Dempsey, *personal communication*) clearly demonstrate its steady influence and relevance amongst researchers.

Whilst the majority of citations in the Scopus database (May, 2018) indicate that the paper has been mostly cited by researchers in human factors/ergonomics (37% of total citations), the paper has also gained a wide readership in other disciplines:

computer science/information systems (24%); human resource management (9%); industrial engineering (9%); and, medicine and healthcare (8%).

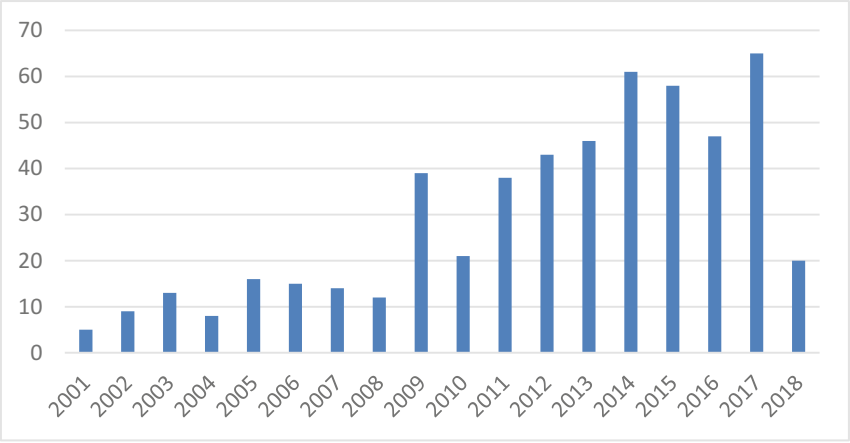

Fig. 1. Citations of Clegg [1] 2001-2018

3 Applying the Principles – Health Information Technologies in the UK NHS

In what follows we reflect on the nineteen STS principles using a set of example case studies that the authors have been involved with over the last few years. These are drawn from research on the introduction of large-scale information technologies within the UK National Health Service (NHS, [4, 18]).

3.1 Top-Down Design in the UK National Health Service: The Story of the National Programme for Information Technology (NPfIT)

Across the 241 healthcare trusts in England (and other contributors to healthcare) there are many electronic patient information systems. These systems are supplied by many different companies and, unfortunately, in many cases it is not possible for the records in one location to be shared with other locations. As a result when patients go from one part of the health service to another, as they often do, their records do not travel with them. This can lead at best to much extra effort, for example, undertaking tests yet again, and at worst to dangerous situations where, because the new healthcare agency is unaware of important elements of the patient's medical history, they may embark on inappropriate treatments. To combat this widely acknowledged problem, the Department of Health launched a National Programme for Information Technology (NPfIT) in 2002. A large part of this programme was to introduce a standard fully detailed electronic patient record system into every healthcare agency on the basis that if they all used the same system they could share records and an up-to-date patient record

would be available wherever the patient appeared for treatment. Contracts were issued to supplier consortia who offered a small number of 'best of breed' existing patient record systems and who began a major 'roll out' in 2004 to install them in all the healthcare trusts and other agencies across England. The new systems were thus the most up-to-date, already proven record systems and they were offered free to all the healthcare agencies.

Despite this tempting offering the programme quickly ran into difficulties. When the healthcare agencies looked at the systems they were being offered and the work they would have to do to install them they either refused the offer or ran into problems as they tried to implement them. New examples of problems appeared in the national media every week. As examples, the Marsden, a leading cancer hospital in London found that the system they were offered had no way of storing the family histories of its patients. They already had an electronic patient record system, geared to treating cancer patients that could store important details of the cancer histories in families. They declined to accept the new system they were offered. The mental health trusts in the London area have to keep special records when patients are 'sectioned' because they may be a danger to themselves or others. When they examined the new system on offer to them they found that, because it had been created to deal with people with physical ailments, it had no facilities for recording the procedures when patients were sectioned. The Trusts would have been in breach of the law not to hold such records and they too declined to take the system that was offered. The General Practitioners (GPs) in England had a long history of developing and using electronic patient records and 75% of them used a particular system created especially for general practice. They found that this system was not one that NPfIT could offer them and that what was on offer was not well suited to the needs of general practice. Many of them declined to change from the system they already used. But many health trusts did accept the new systems and many of them reported difficulties when they tried to implement them. They found they had to change many of their internal procedures and in some cases had to modify the software. The Royal Free Hospital in London calculated that adopting the 'free' software cost them £7.2 million, caused them to lose many patient appointments and required additional software development to tailor the system to local requirements.

The general reaction amongst the health trusts was well summed up in the phrase 'once size does not fit all'. There is huge diversity in the functions that healthcare organizations perform and although the new systems had a proven track record and were 'best of breed' they were a product of the healthcare settings for which they were created. They were not, it seems, well suited to many of the settings in which they were now being implemented. This is a case where a number of different design efforts spread out in time and space have culminated in sociotechnical systems change activities that in many cases were doomed to fail. A very senior design team had created the NPfIT programme and determined that all should have the same systems in order that patient information could be shared. They had selected technical systems designed elsewhere, in some cases in the USA, and some time previous, and these systems were then to be 'rolled out' by consortia contracted by NPfIT across the healthcare trusts in England. This design team saw its task as largely technical: to install the new system and to transfer existing patient data to the new system. Within each trust, local staff were then left to deal with the consequential 'organisational

re-design' issues necessary for the new technical system to be made operational. We had an opportunity to work with the staff of several trusts as they grappled with this problem. Our approach was to see what flexibility existed in the new system, whether it could be tailored to the needs of the healthcare trust and what organisational changes might be necessary to get real benefit from the new system. In one case we made considerable progress [18]. We undertook a series of sociotechnical scenario workshops. We asked staff from each service to supply a scenario of a typical patient journey and we worked through the scenario with technical staff from the supplier and the local healthcare staff, to examine the implications of using the new system at each stage of the patient's journey. We identified many problems but also may possible benefits. The suppliers worked out whether they could tailor the system to meet the emergent needs and the staff worked on new adopted procedures. The new system was as a result adopted with relatively few problems.

Our efforts may have helped a few local design teams but they were minor contributions to a troublesome process underway across the country and, in 2011, the NPfIT programme was discontinued. Estimates of the loss to the tax payer varied from £8 billion to £20 billion [19] depending on how much account was taken of additional costs falling on the health trusts. It became widely recognized that using a common technical 'juggernaut' to make major changes across a very varied collection of healthcare organisations was not going to work.

3.2 Outside-in: The Faltering Progress of Telemedicine: Bottom-Up Developments Run into the Inertia of Current Systems

The development and dissemination of the SHINE system is an illustration of the problems encountered after a successful pilot study. SHINE is a mobile phone application to support people struggling to recover from drug or alcohol addiction. They may have a support worker who helps them to resist slipping back into addiction but the support worker cannot be on duty 24/7. In the SHINE system the client and the support worker develop a series of messages which have important motivational content tailored to the life of the client. They may say, for example, 'remember you are doing this for x, y and z (names of your children)'. These messages are then sent as text messages to the client at the times when they are most vulnerable. The system was trialed in a specially funded pilot study, was found very helpful by many clients and led to a significant reduction in relapses [20]. However, in seven subsequent applications usage of SHINE was very low and in the end was discontinued. We had the opportunity to evaluate what happened in these applications and in each case found there was substantial organizational work to be done if SHINE was to become a routine and effective part of the delivery of the support service. Amongst the issues were: who coordinates SHINE in the organization, how do they select the clients to be offered SHINE, how do support workers and clients get the time to create meaningful messages and how do SHINE records get coordinated with other client records? There were also a number of worries about long-term consequences, for example, the support workers wondered if SHINE would lead to expectations they would be able to support a bigger caseload or that fewer support workers would be needed. Dealing with all of these issues took organizational effort and most of these services were already stretched

having to manage with reduced funding and the threat of closure. In the case of the pilot study there was extra funding which meant there were resources to support the necessary organizational adaptation. There were no extra resources to support the subsequent applications and the result was that working through these issues often took time and was a secondary concern to the people who had the 'day job' to contend with. Most of the organizational adaptation had to occur before clients were able to receive messages and benefits could be discerned and that could be 6 to 9 months after the launch of SHINE in the organization. In this period any initial enthusiasm tended to wither away and the plans to use SHINE were not implemented.

We had an opportunity to tackle some of these problems in a separate project in which videoconferencing equipment was used to enable people with learning difficulties to communicate with their families and with medical staff [23]. People with learning difficulties can become isolated from their communities and have particular difficulties accessing medical facilities and communicating their problems. Videoconferencing can provide a way of reducing these problems. But who could make use of it (there are many types of learning difficulty and different degrees of severity)? And what are the implications for GP practices, specialist health services, the support workers of the people with learning difficulties, their families etc.? There were many technical and organizational issues to resolve in order to find the best ways of making effective use of this technology. In this project the technology supplier engaged with five locations where local organisations supported people with different types and degrees of learning difficulty. A co-design approach was taken which allowed all the relevant stakeholders to explore what was possible and to find sociotechnical solutions that worked best for them. The technology was provided on a trial basis and connections of various kinds were explored. The easiest to implement were connections between people in sheltered housing and their families who may live some distance away. Valued connections were also made between people with learning difficulties who lived with their families and their local support workers and friends. There was wide recognition of the potential value of setting up connections with GPs and other health services but these were slower to develop because of the many organizational, procedural and governance issues that were encountered. In one case regular video consultations were organized between a day-care centre and a local healthcare service that meant the healthcare specialists could advise without necessarily having to visit the day-care centre on every occasion. The process of co-design involved many organizational design issues, potentially changing the role of the support workers for example, but also led to many technical developments. The technology supplier provided a flexible platform that could be used in many ways and, as a result of the engagement with the user locations, they added other functionality during the project. They introduced a three-way video capability so that the person with learning difficulties, their family and medical staff could communicate from three different locations. They also added call management facilities so that calls to busy medical staff could be planned in an effective way.

4 Conclusions – Updating the Principles

All of the principles remain relevant – the more so as we deal with increasingly interdependent complex systems. Rather than make a systematic re-appraisal of all the principles we have selected a few that our case studies suggest are becoming of greater significance and we have begun the process of 're-crafting' them so they may have heightened relevance in the next decade (examples where this has been attempted are underlined in Table 2).

Table 2. Updating the principles of STS for systems design [1]

Meta-principles	
1.	Design is systemic, emergent and context-sensitive *Comment: It is obvious that major change cannot be pre-planned and 'rolled out' (NPfIT). It has to be undertaken iteratively taking account of many local contexts and the sociotechnical systems will need to be emergent to fit each context*
2.	Values, organizational culture and mindsets are central to design *Comment: Sociotechnical design involves many different stakeholders who come with different values, cultures and mindsets. Attaining an agreed and shared sociotechnical vision that can be sustained through the design process is a crucial part of the delivery of an effective system*
3.	Design involves making choices and trade-offs *Comment: Inevitably there will be hard choices to be made during systems development and the use of design methods needs to be sensitive and flexible enough to cope with these* (Waterson et al. 2014)
4.	Design should be business and user-centred *Comment: The original principle was modified in order to encourage a user-centred point-of-view and to combine other principles*
5.	Design is an extended social, contingent process which is socially shaped *Comment: In the examples design is a multi-level process involving many design teams and spread over an extensive time period. The early and high level design work needs to leave room for later, local implementations to be socially shaped by front-line stakeholders*
Content principles	
6.	Core processes should be integrated and components congruent *Comment: Combining principles in Clegg* [1]
7.	Design entails multiple task allocations which should be flexibly specified *Comment: Combining principles in Clegg* [1]
8.	Systems should be simple and make problems visible
9.	Problems should be controlled at source
Process principles	
10.	Design practice is a dynamic, evolutionary sociotechnical system *Comment: The design process in all these cases was a complex sociotechnical system engaging technologists, policy makers, managers, front-line staff and special staff in different combinations at different stages of the process*
11.	Resources, support and evaluation are required for design *Comment: In all the cases the resources needed to adopt and tailor new technical systems and to amend local work processes and practices were underestimated. The need also to undertake formative evaluation to 'learn the early lessons' was also very clear because those lessons allowed revised plans for sociotechnical solutions to emerge*
12.	System design involves political processes

Our current and planned work on updating the principles partly involves applying the principles to other case studies from our recent work (e.g., on accident analysis and the use of HFE methods). Finally, we would like to pay tribute to Chris's work on the principles, they continue to encourage and inspire a new generation of researchers and practitioners and their impact is likely to grow in the future.

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