UTILIZING SOCIO-TECHNICAL SYSTEMS DESIGN PRINCIPLES TO IMPLEMENT NEW ICT SYSTEMS

R. Soetanto[1], A.R.J. Dainty[2], A.D.F. Price[3] and J. Glass[4]

Department of Civil and Building Engineering, Loughborough University, Leics, LE11 3TU, UK

The optimum joint design of social and technical systems (socio-technical systems) is a pre-requisite for successful implementation of technological innovation in organizations, which is ultimately pivotal for competitive performance. Literature suggests a lack of consideration towards socio-technical systems design in the implementation of new Information and Communication Technology (ICT) systems. This results in system failure or less than optimum systems and organization performance. This paper attempts to address this gap by proposing a methodology based on socio-technical systems design principles to guide ICT managers in implementing new ICT systems within construction organizations. Essential features of this methodology include proactively involving the user in the design process and involving them in design decisions. Appropriate use of this methodology should secure user support and commitment, which should ultimately help to reduce resistance to change, enhance user acceptance and organizational competitiveness.

Keywords: construction organizations, ICT systems implementation, socio-technical systems, user participation.

INTRODUCTION

The implementation of technological innovation into organizations could be considered as an amalgamation of technical and social systems. A social system could be construed as the users of the technical system and organizational context where the system is going to be used. To make the overall system work effectively and efficiency, both systems should be considered and designed with regard to each other. In construction, many organizations have implemented Information and Communication Technology (ICT) systems, hoping to gain many promised benefits including efficiency and competitiveness, as a result of successful systems implementation. Here, apart from the appropriate design of technical systems, the success of implementing a new ICT system requires complete understanding of end-users and organizational requirements. Ideally, these requirements should be captured at the initial stage of system design and used to design the technical systems. However, this is not the case in many ICT system implementations. Often, implementation of ICT within organizations becomes a technology-led exercise, where cost reduction is the most common driver (Clegg *et al.* 1997). Here, end-users are informed and trained on how to use the systems without prior consideration of their needs, inspirations and task requirements. While this approach may benefit organizations in the short term, they may not be able to explore fully many of the

[1] r.soetanto@lboro.ac.uk
[2] a.r.j.dainty@lboro.ac.uk
[3] a.d.f.price@lboro.ac.uk
[4] j.glass@lboro.ac.uk

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promised potential benefits of ICT implementation. In many cases, these have led to the failure of ICT systems implementation as experienced by various industries (e.g. Clegg *et al.* 1997). ICT systems that are poorly planned, developed and implemented will hamper user and organizational performance (Martinsons and Chong 1999).

This paper presents a methodology for addressing end-user issues prior to and during implementation. Specifically, this methodology provides a useful reference of what ICT managers should be doing prior and during implementation and how to incorporate human factors into ICT systems design, so that the promised benefits are more likely to be achieved. Initially, human factors suggested by various scholars are described. Then, the discussion focuses on how a new ICT system influences organizational culture, suggesting the need to consider socio-technical systems design principles which constitute the basis of a robust methodology to ICT systems implementation.

HUMAN FACTORS INFLUENCING ICT SYSTEMS IMPLEMENTATION

Many scholars have acknowledged the importance of human factors on ICT implementation. For example, Cross and Bawden (1987) investigated the effect of ICT adoption on organization structure, which in turn will influence the jobs of individuals particularly in terms of job content, the types and nature of jobs available. Failla and Bagnara (1992) described how the introduction of ICT caused significant changes in decision making behaviour at individual and organization levels and in the timing and nature of the decision making process. Sroka and Stanek (1996) argued that organizational culture plays an important balancing role which influences management, leadership, individuals and their aspirations and the usage of appropriate technology to adapt to rapidly changing environments. Dasgupta (1997) reported that organization size, the degree of centralization in decision making, formalization of work and organizational culture all influence ICT adoption. More recently, Whyte *et al.* (2002) studied implementation of a virtual reality system for internal design review of a major UK house building company. They found two critical factors for successful ICT systems implementation; user-developer communications and strategic decision making by top level management and decision making by technical managers. As a whole, this literature suggests human factors influence the success of ICT systems and therefore need to be considered and addressed appropriately, especially prior to ICT systems implementation.

Generally, it is accepted that successful implementation of new technology should consider the existing organizational culture (e.g. Hackney and McBride 1995). Changes in other organizational factors necessary to adopt ICT are to a large extent contingent upon cultural (and organizational) changes. Specifically, the characteristics of organizational culture influence how ICT is introduced to its staff (Sutherland and Morieux 1988). However, this raises the question of how a new technology interacts with existing culture and more specifically, which should be adapted to the other to allow a proper utilization of the technology. There is considerable debate on this issue. One school of thought suggests that implementation of ICT is associated with changes of organizational culture to accommodate technology diffusion within that organization (e.g. Dasgupta 1997). Others argue that ICT has to be designed to fit organizational culture. In a case study of a large construction organization, Harty (2002) proposed both types of adaptation, that is the appropriation of new technology to the organizational culture and the configuration of organizational culture to fit with

the adopted technology. This was supported by Morieux and Sutherland (1988), and Grote and Baitsch (1991) who argued that ICT and organizational culture influence each other and therefore each has to adapt to the other. The following discussion explores the interaction between ICT implementation and organizational culture.

ORGANIZATIONAL CULTURE AND ICT SYSTEMS IMPLEMENTATION

Organizational culture influences all processes and behaviours of its members. The implementation of new ICT therefore imposes new requirements on the organizational processes and behaviours of the users and so successful ICT implementation is contingent upon compatibility between IT requirements and culture (Cabrera *et al.* 2001). However, this implementation does not necessarily change culture if there is such compatibility (Grote and Baitsch 1991).

Schein (1990) regarded culture as changeable and manageable to meet managerial needs. However, Avison and Myers (1995) added that managing and changing culture is a difficult, if not impossible task. In a similar vein, Claver *et al.* (2001) claimed that aligning or modifying organizational culture is a difficult and lengthy task, however the implementation of ICT may take a shorter time. This provides the basis of popular technology-led implementation where in most cases, organizations do not have time and energy to deal with 'culture', l*et al.*one manage and change it.

Schein (1992) recognized three levels of organizational culture; artifacts, values and basic assumptions, for which definitions and relationships are presented in Figure 1. In the context of a construction firm, artifacts could include design and decision making processes, drawings, flow of information, organizational structure, technology used. A new ICT system brings with it a new set of artifacts which replace the existing artifacts (Morieux and Sutherland 1988). Values are often expressed within the mission statements of the firm (e.g. to provide design solution to the satisfaction of client, to the quality, budget and time specified). Basic assumptions are implicit assumptions underlying human culture which are to some extent connected to the culture of a particular nation where the firm is located (e.g. Hofstede 1980), for example the assumptions about relationships between members of an organization in relation to their position in the organizational hierarchy, how they perceived time, space and activities (i.e. their work ethos).

The implementation of a new ICT system influences one or more such levels of culture (Dasgupta 1997). At the artifacts level, implementation of ICT to assist designers (such as CAD operators) will reduce the use of paper-based drawings that in turn will eliminate the function of conventional drafters in the organization. The drafters may feel that their employment is at risk and so may resist this change. At the values level, this may change company's mission statements in terms of product performance specifications (e.g. cost, time and quality) delivered to the clients. At basic assumptions level, the use of ICT may change people's views regarding time, space and relationships with others. In terms of time, the use of ICT significantly reduces the time taken to conduct activities. In terms of space, the use of ICT dissolves the constraints of physical location in which people can work in any place and are still connected with other people/members of the same company. In terms of relationships between people, the use of ICT may reduce face-to-face contact since information could be conveyed easily and efficiency through internet and e-mail. This brings with it social and psychological consequences (Kiesler *et al.* 1987).

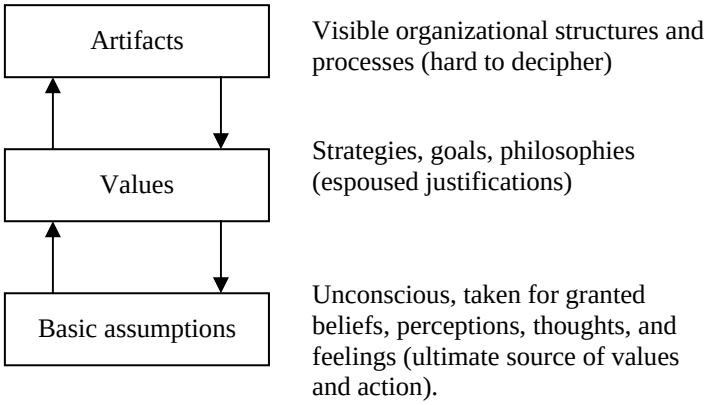

Figure 1: Levels of culture and their interaction (after Schein 1992)

Culture and organizational changes are inevitable in the implementation of a new ICT system. Here, the perceptions of individual users play a crucial role in the change process (Macri *et al.* 2002). From an individual's point of view, culture and organizational changes bring psychological consequences. Since there is a limit to which individual can handle change, rapid change can cause unbearable stress which is ultimately detrimental to the organization itself (Toffler 1970 c.f. Huczynski and Buchanan 1991). Huczynski and Buchanan (1991) suggested that managing change is about communication and consultation with those affected. In fact, cultural changes could be more successful if end-users are allowed to participate in the process (Grote and Baitsch 1991). Shani and Sena (1994) contended that successful managers should be able to integrate changes within an organization. Therefore, it is their role to communicate the aim of the process and the implications it has on those affected so alleviating resistance to change. It is also important that awareness of the individuals towards the need for change be created so that they proactively initiate change actions (Sillince 1999). Implementing change involves a rigorous process. Winklhofer (2002) suggested that changes, even minor ones, must be identified due to their collective effect on implementation failure.

This argument indicates the need for a robust and reliable approach that could be applied in practices and its potential benefits reaped. In this case, Eason (1988) and Shani and Sena (1994) advocated the use of a socio-technical system perspective as a framework for ICT implementation and organizational change.

SOCIO-TECHNICAL SYSTEMS PERPECTIVE

The socio-technical systems (STS) perspective proposes that a systematic design embracing and combining both social and technical systems is essential for successful ICT system implementation. The objective of this approach is to optimize the relationship between the social/human systems of the organization and the technology used by the organization to produce valuable outcomes (Pasmore and Sherwood 1978). The approach is believed by many (e.g. Shani and Sena 1994; Eason *et al.* 1996) to provide a guiding framework for ICT systems implementation and integration, as well as managing organizational change.

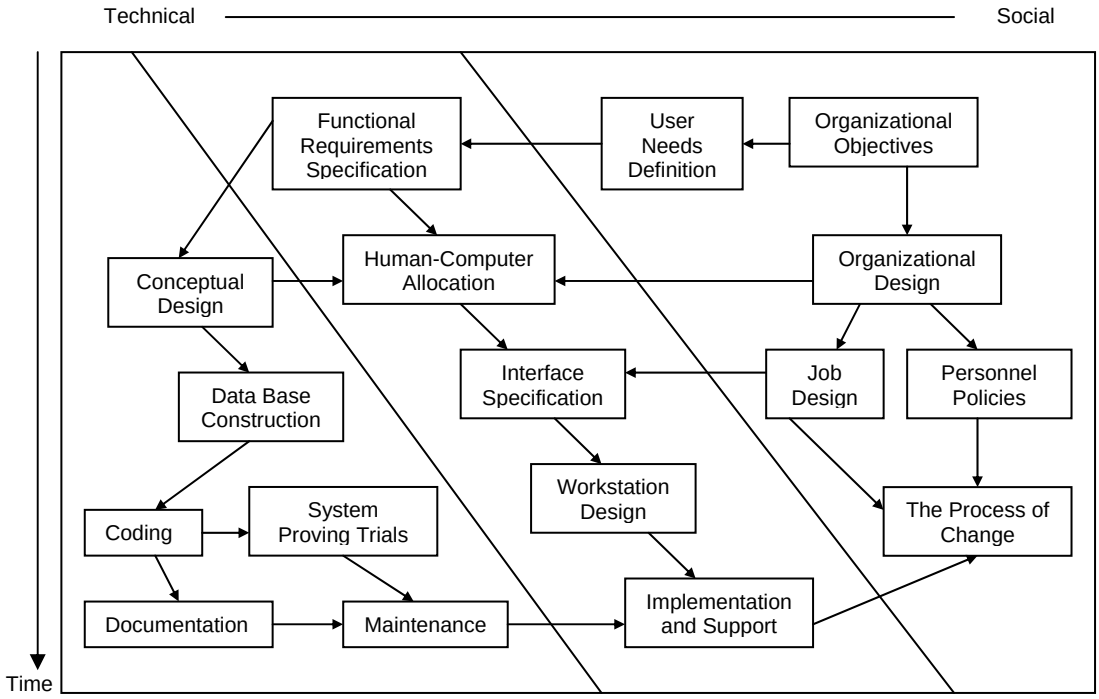

Figure 2: Generic main activities in the socio-technical systems design of ICT systems (after Eason 1988)

Generic main activities of STS design in the ICT development and implementation have been explored by Eason (1988) as presented in Figure 2. The model depicts three areas including activities for specifying technical and social systems and those which integrate both systems. The model also shows a common sequence of sociotechnical design. The design process is initiated by establishing organizational objectives which are central for ICT implementation, indicating the emphasis that technology should serve organizational objectives. The model also suggests that the organization should be designed in parallel with technical design. Eason (1988) further suggested that the design of each activity is an evolutionary and iterative process meaning that these activities need to be revisited and adjusted to fit the overall design of the systems. Therefore, the activities may not follow a common sequence and could be designed in parallel and interconnected with each other.

Pivotal to successful STS design is user participation in which users are proactively involved in the process of specifying requirements, evaluating options and choosing the optimum option for each activity. User participation reduces resistance to change, enhances systems acceptance and therefore the likelihood of success. In fact, empirical research has demonstrated increased job satisfaction as a result of user participation (Carayon and Karsh 2000). Generally, user participation is closely related to organizational culture where senior managers should encourage users to participate not only in the system development process but also in other areas.

The forms of user involvement in ICT system design could be informative (i.e. users provide and/or perceive information), consultative (i.e. users comment on a predefined service of range of facilities), and participative (i.e. users influence decisions relating to the whole system) (Damodaran 1996). Effort to involve users is not a simple exercise. The most common question raised is related to the expertise and experience of the users. Moreover, user involvement is a complex process which is largely contingent upon an organizational context where understanding of local conditions is imperative (Damodaran 1996). Due to this, the most common user involvement is

informative, where technical system designers interview users to acquire requirements and knowledge. However, Damodaran (1996) suggested that participative form of user involvement is the most desirable. To do this, she further offered specific guidance for various user roles (i.e. top manager, middle manager, user representative and end-user) in the ICT design process. Although this guidance is useful to remove the barriers of user participation, examples of good user participation practice is needed (Damodaran 1998). Here, Damodaran (1998) found that commitment of key individuals in an organization is critical. This indicates the need for a methodology based on STS design principles, in order to integrate human factors (i.e. social system) and ICT systems (i.e. technical system). This is presented in the following section.

A METHODOLOGY TO INTEGRATE SOCIAL AND TECHNICAL SYSTEMS

A methodology to integrate human factors and ICT systems should embrace STS design principles including user-centred/ participative, iterative, evolutionary approach to system design. A form of action research is possibly the most relevant methodology. The ORDIT (Organizational Requirements Definition for Information Technology Systems) methodology, developed by the ORDIT Consortium (1993), presents the most suitable research methodology. Due to its simplicity and capability, this methodology is preferable to other participative design methods such as ETHICS developed by Mumford (1983) (Eason 1988; Eason *et al.* 1996). Since this methodology was developed in other industries and has not been applied in the construction industry, the intention at this initial research stage is to offer a further development to the ORDIT methodology to fit with the construction context.

The ORDIT methodology aims to identify and generate organizational requirements of an ICT system, to represent those requirements to ICT system designers, and to help the early identification of organizational implications of each systems design option (ORDIT Consortium 1993). In contrast to the traditional methods for capturing the requirements for IT systems which focus extensively on business and functional needs, this methodology attempts to incorporate organizational and potential user requirements (Olphert and Harker 1994). The ORDIT methodology has been used in various ICT systems implementation projects. It is a flexible methodology which can be used at different stages, with different resources and design timescales, and could handle different system complexities and levels of client expertise. In essence, it generates existing organizational requirements, and uses them to create and present future STS scenarios. Although it could be used in parallel with technical system development, to maximize its impacts it should ideally be used before the technical systems development.

The methodology consists of two essential aspects, that is development of a diagrammatic representation of the future operation of the organization, and participation of stakeholders (defined as those who will be affected by implementation, including both users and non-users) in the process which allows them to redefine their requirements as the development progresses. Consequently, the methodology is predictive and essentially an iterative process. The principal outputs of the ORDIT process are a specification for the new IT system and a view of the social system towards which the organization will move (Eason *et al.* 1996).

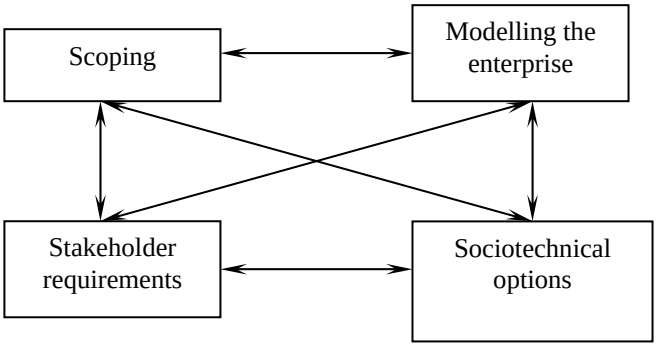

Figure 3: Activities in an ORDIT analysis (after Eason *et al.* 1996)

The ORDIT process has four interrelated activities as shown in Figure 3 (Eason *et al.* 1996). An initial scoping activity; defines the scope of the system, establishes the stakeholders who have an interest in the system, and establishes the nature of the relationship between the stakeholders and the consultant (i.e. researcher). The stakeholder requirements activity helps stakeholders to make an initial statement of their requirements, which are then analysed as a sociotechnical option, which reflects an interaction between the stakeholders and the new IT system. Simultaneously, the enterprise models which define the existing and future roles and responsibilities of the stakeholders are developed. Since the requirements of each stakeholder may be different, various future scenarios can be developed and their advantages and disadvantages identified and debated in workshops. Since the process is conducted earlier, during, or even before IT system development, potential resistance from stakeholders could be minimized, if not eliminated, and the IT system tailored to the requirements of stakeholders.

A FRAMEWORK FOR IMPLEMENTING THE ORDIT METHODOLOGY

Prior to the implementation of the ORDIT methodology, a consultant or researcher should be appointed to 'facilitate' the implementation of the methodology. Initial activity should include a scoping exercise; the results of which results should be used to map the stakeholders into several groups depending on their roles and responsibilities, from which stakeholder representatives could be selected. The selection of stakeholder representatives is the most practical option, bearing in mind that normal daily operations should be disrupted as little as possible. Next, a seminar attended by representatives should be held to communicate the aim of the methodology and planned actions. The seminar could also be used as a venue to train representatives to implement the methodology (e.g. interview skills, questionnaire design).

The next task is to acquire stakeholder requirements via their representatives. This could be done in two ways, by one-to-one interviews or focus groups. Interviews may be more advantageous than focus group, particularly due to the difficulty of gathering people at the same time. However, interviews are lengthy exercises for which the involvement of selected representatives is highly valued. These representatives should assume active roles such as interviewers or facilitators, which agree with the principles of user participation as exemplified by Damodaran (1998). On the other hand, focus groups offer discussion between stakeholders within a particular group, which may yield more refined requirements. At this stage, people from different

stakeholder groups should not be allowed to attend the same focus group. The discussion revolves around the requirements of technical and social systems. The outcomes of the exercise should be used for: constructing various representations of the future operation of the firm, developing enterprise models, and developing a vision for the technical system incorporating end-user requirements which ultimately provide useful inputs for technical system designers.

Based on this information, the representatives, with the help of the researcher, should be able to develop socio-technical options and enterprise models, and to generate detailed end-user requirements including various acceptability and usability issues, with consultation and additional inputs from technical system designers. Recent developments in rapid prototyping systems accelerate this process (e.g. Eason 1988). Consequently, analysis of end-user requirements could be conducted via a questionnaire survey to all stakeholders and interviews/focus groups with representatives. Questionnaire distribution to all stakeholders is made possible due to the succinct and easy-to-complete design. Interviews/focus groups can probe detailed issues which could not be obtained via questionnaire. The outcomes of this analysis provide useful inputs for the development of sociotechnical options and the refinement of the technical system.

The socio-technical options, enterprise models and the results of requirements analysis should be presented in a workshop involving various representatives of the stakeholders. This workshop provides a venue where these representatives could debate various socio-technical options and then agree on an 'optimum' option for the STS development. It is essential that all stakeholders are kept informed of progress and invited to participate whenever possible so that their support and commitment are secured. The outcomes of the workshop should also be communicated to all stakeholders, especially for non-attendees, via leaflets and/or bulletins. Their feedback should also be invited for subsequent development process. Based on the results of the workshop, STS design could be refined and the revised system prototype retrialled. On the whole, the methodology is flexible, iterative and participative in the real sense allowing stakeholders to proactively make decisions and to refine the systems during the implementation process. The ramifications to the company initially are a greater degree of staff time dedicated to such discussions, but the long-term benefits should outweigh this early investment (which may be perceived as 'expensive' in staff time).

CONCLUSION

The literature highlights the need to integrate social and technical systems for successful ICT systems implementation. However, the implementation of many ICT systems has failed to address human factors issues commonly due to lack of resources and knowledge. This results in under-utilized or less effective systems and often resistance to change on behalf of the end-users. Accordingly, there is a need to develop a methodology for addressing these factors in ICT systems design. Following a thorough review of the literature in ICT systems implementation domain, it was found that ORDIT methodology based on STS design principles was probably the most suitable methodology to integrate human factors and ICT system. Careful use of this methodology should reduce resistance to change within construction organizations, enhance user acceptance of new ICT systems and enhance organizational competitiveness. Further research will apply this framework into a real organizational context so that its efficacy can be tested within construction companies.

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