A FRAMEWORK FOR INVESTIGATING HUMAN FACTORS ISSUES ASSOCIATED WITH THE IMPLEMENTATION OF NEW ICT SYSTEMS IN CONSTRUCTION ORGANISATIONS

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ABSTRACT

The failure of Information and Communication Technology (ICT) applications has been well documented in many industries and organisations. Many studies have attributed these failures to non-technical issues, i.e. those linked to human factors. A thorough review of the literature in ICT systems implementation and human factors domains suggests that a complete assessment of a new ICT systems implementation should address both organisation and end-user factors which demand different assessment approaches, but which are closely interrelated. This paper discusses the importance of taking account of socio-technical and user-centred issues in construction organisations, and presents a framework for enabling construction organisations to embed new ICT systems more effectively in the future. This framework combines aspects of action research methodology, the Technology Acceptance Model (TAM) and other usability evaluation studies, which allow integrated assessment of organisation and end-user factors. Due to their complementariness and synergy, the benefits gained from this integrated framework should be more than the sum of individual aspects. This integrated framework should help to reduce resistance to change within construction organisations, enhance user acceptance of new ICT systems and enhance organisation competitiveness.

Keywords: human factors, ICT systems implementation, action research, Technology Acceptance Model, usability evaluation

INTRODUCTION

Construction is a very competitive industry with a tradition of small profit margins. To be able to compete more effectively, construction organisations are realising that the application of Information and Communication Technology (ICT)[2] is inevitable. ICT allows construction organisations to be more efficient and effective in conducting their business. However, the failure of ICT applications in various industries has been well documented (e.g. Clegg *et al.*, 1997). ICT systems which are poorly planned, developed and implemented will hamper user and organisational performance (Martinsons and Chong, 1999). The most common reasons for this were non-technical

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[2] This term includes both information technology (IT) and communication technology (CT, that is technology to assist communication). Many references are regarding applications of IT systems which are also applicable and relevant to CT. For the purpose of this paper and consistency, the broader ICT term is used.

issues, i.e. human and organisational factors (Clegg *et al*., 1997; Shani and Sena, 1994; Eason, 2001).

This paper presents a review of literature related to human factors issues associated with ICT systems implementation. The aim of the paper is to present a framework for addressing these issues prior and during implementation. Specifically, this framework 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. A thorough review of literature in the ICT applications and human factors domains suggested that an investigation of human factors should focus on organisational and end-user factors because of their significance in the acceptance of an ICT system. Discussion of these factors now follows.

ORGANISATIONAL FACTORS RELATED TO ICT IMPLEMENTATION

Various organisational factors emerge as a new ICT is implemented in an organisation. Many scholars have recognised the importance of these organisational factors on ICT implementation. For examples, Cross and Bawden (1987) investigated the effect of ICT adoption on organisation 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 organisation levels and in time-frame patterns of the decision making process. Dasgupta (1997) reported that organisation size, the degree of centralisation in decision making, formalisation of work and organisational culture are organisational factors influencing ICT adoption. More recently, Whyte *et al*. (2002) studied implementation of a virtual reality system for internal design review in 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 whole, this literature suggests these 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 recognised that successful implementation of new technology should consider existing organisational culture (e.g. Hackney and McBride, 1995). Changes in other organisational factors necessary to adopt ICT are to a large extent contingent upon cultural (and organisational) changes. Specifically, the characteristics of organisational culture influence how ICT is introduced to its staff (Sutherland and Morieux, 1988). How does a new technology interact with existing culture? The problem is which should be adapted to the other to allow fully utilisation of the technology. There is considerable debate on this issue. Some scholars indicated that implementation of ICT is associated with changes of organisational culture to accommodate technology diffusion within that organisation (e.g. Dasgupta, 1997). Other argue that ICT has to be designed to fit organisational culture. In a case study of a large construction organisation, Harty (2002) proposed both ways of adaptation, that is the appropriation of new technology to the organisational culture and the configuration of organisational culture to fit with adopted technology. This was supported by Morieux and Sutherland (1988) who argued that ICT and organisational

culture influence each other and therefore each has to adapt to the other. This argument needs a robust and reliable approach so that it could be applied in practice 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 organisational change, discussed as follows.

Sociotechnical systems perspective

The socio-technical systems (STS) perspective believes that a systematic design embracing and combining both social and technical systems is essential for successful ICT systems implementation. The objective of this approach is to optimise the relationship between the social/human systems of the organisation and the technology used by the organisation to produce valuable outcomes (Pasmore and Sherwood, 1978). The introduction of an ICT system (technical system) into organisation (social system) imposes inevitable changes in the social system which should be redesigned to fit the requirements of the technical system. However, rather than extensively redesigning the social system to fit the technical system, both systems have to be designed to achieve an optimum form which will maximise acceptance and minimise resistance to the technical system.

Pivotal to the successful STS design is *user participation*, in which the 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. 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). Due to a lack of necessary user expertise and complexity of the process, the most common user involvement is *informative*, where technical system designers interview users to acquire requirements and knowledge. However, Damodaran (1996) further suggested that the *participative* form of user involvement is the most desirable. For this to work effectively, the commitment of senior managers to support and encourage users and the involvement of consultants to facilitate the process are crucial. User participation is also needed during the assessment of usability and acceptability of ICT systems, explained in the following section.

USABILITY AND ACCEPTANCE OF ICT SYSTEMS

Apart from the intended function that any ICT systems must perform, the systems should be usable and acceptable to individual users. These aspects are distinct from organisational factors mainly due to their close link with design of the user interface and cognitive psychology of the end-users. They reside within individual users and therefore it is the end-users' discretion to decide whether the system is useable and acceptable. Therefore, it is imperative to put end-users in the centre of ICT systems design. Although both issues are interrelated, they can be defined thus:

Usability

The term 'usability' is applicable to all sorts of products made for human use. Generally, usability concerns how easily a product can be used by its specific users for

a specific task in a specific environment. Usability is a context dependent term where, apart from the characteristics of the product, the characteristics of user, task and environment determine the ease with which the product is going to be used (Jordan, 1998). From these, product/system characteristics are regarded as the variables upon which ICT system designers have most influence (Eason, 1988). Various measures of usability have been proposed. Shackel (1991) proposed four measures of usability including effectiveness, learnability, flexibility and attitude. The International Standards Organisation (c.f. Jordan, 1998) suggested effectiveness, efficiency and satisfaction with which the users can complete their goals in a specific environment as measures of usability. However, Lindgaard (1994) argued that appropriate usability measures are contingent upon the context where the system is being used. Usability of tools or systems should be appropriately addressed since it relates closely to productivity and performance of organisations.

Usability evaluation is a means to assess the extent to which an ICT system is usable or otherwise for its end-users. The evaluation would point out which features are unusable. Only by this, the designers of the system are able to identify design faults and their potential remedies. The forms of evaluation, in terms of the kinds of tests, performance measures and attitude scales, interviews or surveys, depend on the purpose of the evaluation (Lindgaard, 1994). Whatever the form, it is important that the usability evaluation should adopt an iterative approach (Jordan, 1998) so that the system could be refined gradually as its development progresses. Here, user participation is crucial. A comprehensive description of usability evaluation is clearly beyond the remit of this paper, but interested readers may wish to consult Lindgaard (1994).

Acceptability

Acceptability concerns the willingness of users to actually utilise an ICT system for the task it is designed and supposedly supports (e.g. Eason, 1988; Dillon and Morris, 1996). A usable ICT system is a necessary but insufficient condition to guarantee its actual use. Although some regard acceptability to include usability aspects of an ICT system (e.g. Shackel, 1991), it does not emphasise designing a user interface (Dillon and Morris, 1996). Instead it concerns non-technical and somewhat wider user issues including e.g. end-user values, psychology, culture and fears, influencing the decision to accept or reject a new ICT system.

Early studies of technology acceptance in general revolved around innovation diffusion theory as pioneered by Rogers (1995). He suggested that the decision to adopt a new technology is a result of the evaluation process of the relative advantages of that technology in comparison with existing technology. However, he did not explain relative advantages in operational terms (Toole, 2001) and describe factors that lead and/or determine user acceptance of the new technology (Dillon and Morris, 1996). Nevertheless, this theory provides a conceptual framework for understanding the process of innovation diffusion, which is particularly relevant for individual users adoption of a new technology.

In the context of ICT systems implementation, Davis (1989) developed a Technology Acceptance Model (TAM) to evaluate user acceptance of new ICT. The model seeks to understand cognitive psychology of users towards new ICT. Because of its simplicity, cost effectiveness and accuracy in predicting user behaviour, the model has

been widely accepted, supported and used to predict the likely usage of new ICTs (e.g. Morris and Dillon, 1997). TAM predicts user acceptance based on the influence of two factors, i.e. perceived usefulness and perceived ease of use. Perceived usefulness is defined as the degree to which a user believes that using a system will enhance his/her performance, whereas perceived ease of use is defined as the degree to which a user believes that using a system will be free from effort. Variables included in these two factors are exemplified by Davis (1993). TAM could be applied in all stages of ICT systems development process from early planning to actual use of the system. Morris and Dillon (1997) advocated the application of TAM in various points during system development, so that shifts in users' perceptions could be identified and incorporated in the system design. However, TAM can not be used to translate the assessment results into specific interface design improvement nor show what should be changed to increase usage (Morris and Dillon, 1997). For this, TAM could be complemented by a usability evaluation.

While TAM focuses on the user acceptance of the technical system, Eason (1988) placed more emphasis on the implications of the technical systems implementation which ultimately influence user acceptance. He classified factors influencing user acceptance into two groups, i.e. control, and discretion and growth. Control factors include access, reliability, confidentiality, monitoring, pacing, health and stress, and social contact which may stimulate negative responses from users. Discretion and growth factors embrace those that promote acceptability such as flexibilities which allow users to select levels of choice, to be the master of the system, to use intuition and informal approach; the system also allows users to assume knowledge, supports learning and cooperative work. In addition to these factors, an assessment of the likely impacts of a new ICT system to end-users, specifically in terms of job security, job content (e.g. skills required, job satisfaction), organisational procedures and policies (e.g. reward system, career prospect) should also be conducted. Eason (1988) proposed a checklist to assess these using a scoring system, which allow factors that promote and negate the user acceptance to be identified and then considered in the STS design. Both TAM and this checklist could be used simultaneously to form an acceptability evaluation in a research framework, which is explained in the following section.

A FRAMEWORK FOR NEW ICT SYSTEM IMPLEMENTATION

Having discussed organisational and user factors influencing successful ICT system implementation, an integrated methodology that is able to capture, consider and incorporate these factors and requirements into STS design is needed. The methodology should embody the STS design principles including user-centred/ participative, iterative, evolutionary approach to system design. For this, a form of action research is possibly the most relevant methodology. The Human Science and Advanced Technology (HUSAT) Research Institute has developed a methodology, entitled ORDIT (Organisational Requirements Definition for Information Technology Systems) which fits well with the required research method. Due to its simplicity and capability, this methodology is preferred to other participative design methods such as ETHICS developed by Mumford (1983) (Eason, 1988; Eason *et al*., 1996). In this proposed research framework, ORDIT represents a core methodology which is complemented by acceptability and usability evaluations. 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 this methodology to fit well with the construction context. It is described as follows.

ORDIT methodology

The ORDIT methodology aims to identify and generate organisational requirements of an ICT system, to represent these requirements to be used by ICT system designers, and to help the early identification of the organisational implications of ICT systems design options (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 organisational and potential user requirements which ultimately influence the take-up of new ICT systems (Olphert and Harker, 1994). As a result of a 5-year research project, the ORDIT methodology has been trialled in various ICT systems implementation projects. This is a flexible methodology which means that it could 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 organisational requirements, and uses them to create and present future STS scenarios which in turn allow their implications to be identified. Although it could be used in parallel with technical system development, to maximise its impacts it should ideally be used before the technical system development. Detailed description of this methodology is clearly beyond the scope of this paper, however a brief description of its main principles is presented here.

The methodology consists of two essential aspects, that is development of diagrammatic representation of the future operation of the organisation, and participation of stakeholders (defined as those who will be affected by the system 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 required technical system (i.e. new IT system), and a view of the social system towards which the organisation will move (Eason *et al*., 1996).

The ORDIT process has four interrelated activities as shown in Figure 1 (Eason *et al*., 1996). An initial *scoping* activity (i) defines the scope of the system, (ii) establishes the stakeholders who have an interest in the system, and (iii) establishes the nature of the relationship between the stakeholders and the consultant (i.e. researcher). *Stakeholder requirements* activity is to help the stakeholders to make an initial statement of their requirements for the system. These requirements 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 from others, various future scenarios can be developed. These allow advantages and disadvantages of each scenario to be identified and debated in workshops. Since the process is conducted earlier, during, or even before IT system development, potential resistance from stakeholders could be minimised, if not eliminated, and the IT system tailored to the requirements of stakeholders.

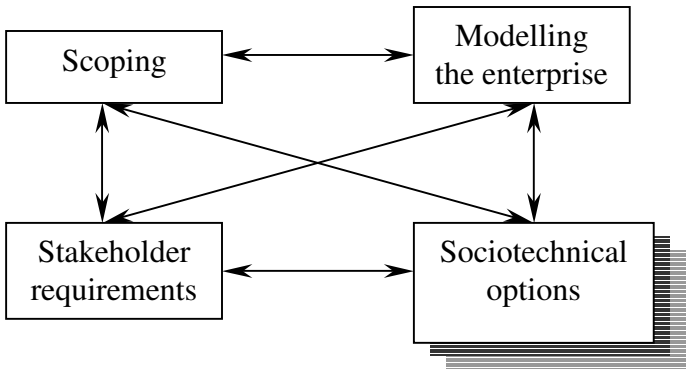

Figure 1 Activities in an ORDIT analysis (After Eason *et al*., 1996)

Integrated investigation framework of organisation and end-user factors

The investigation begins with the appointment of a consultant or researcher to 'facilitate' the implementation of the aforementioned methodology and evaluations. The implementation of ORDIT should be complemented by usability and acceptance evaluations which results would provide valuable inputs for STS design. Therefore, these evaluations should be run in parallel with the ORDIT methodology prior to ICT systems implementation. Initial activity would be a scoping exercise which results could 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 crucial due to impracticalities to include all stakeholders/employees, bearing in mind that normal daily operation should be disrupted as little as possible. Then, 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 for any skills needed 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 for each group of stakeholders. In terms of arrangement complexity, 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 particularly 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 topics discussed revolve around the requirements of technical and social systems. The outcomes of the exercise would be used for (i) constructing various representations of the future operation of the firm, (ii) developing enterprise models, and (iii) developing a vision of technical system for conducting usability and acceptability evaluations 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 sociotechnical options and enterprise models, and to generate various acceptability and usability factors with consultation and additional inputs from technical system designers. Recent developments in rapid prototyping systems allow a

prototype of a technical system to be developed and trialled (e.g. Eason, 1988). Consequently, acceptability and usability evaluations could be conducted involving questionnaire distribution 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 are to probe detailed issues which could not be obtained via questionnaire. The outcomes of these evaluations provide useful inputs for the development of sociotechnical options and the refinement of the technical system. It is important to note that the purpose and confidential nature of the exercise should be communicated clearly to the stakeholders so that honest answers can be obtained.

The socio-technical options, enterprise models and the results of acceptability and usability evaluations could 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 current progress and invited to participate in the process 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 so that acceptability and usability could be re-evaluated. 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.

CONCLUSION

The literature shows that when ICT applications failed or did not meet their objectives, the common reasons are non-technical issues or human and organisational factors. Although most managers are aware of these factors, they have no time and resources, or do not know how to address these factors appropriately due to their implicit nature (Doherty and King, 1998). Therefore, there is a need to devise a methodology for addressing these factors in ICT systems design. A thorough review of the literature of various ICT applications revealed that the lack of an integrated approach to addressing organisational and end-user factors which must be considered simultaneously for successful ICT systems implementations. For this, the authors propose a research framework which treats investigation of organisation and end-user factors as interrelated and complementary to each other. This integrated approach should help to reduce resistance to change within construction organisations, enhance user acceptance of new ICT systems and enhance organisation competitiveness. Further research would be to apply this framework into a real organisation context so that it could be refined further and its efficacy tested.

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