Environmental Modelling & Software 24 (2009) 588–602

Contents lists available at ScienceDirect

Environmental Modelling & Software

journal homepage: www.elsevier.com/locate/envsoft

A review of the factors which influence the use and usefulness of information systems

Esther Díez*, Brian S. McIntosh

Centre for Water Science, Cranfield University, College Road, Cranfield, Bedfordshire MK43 0AL, United Kingdom

ARTICLE INFO

Article history:
Received 7 February 2008
Received in revised form
10 September 2008
Accepted 13 October 2008
Available online 31 December 2008

Keywords:
Information systems (IS)
Environmental management
Users
Usefulness
Design
Implementation
Adoption
Evaluation

ABSTRACT

The potential usefulness of different kinds of Information System (IS) for environmental management is well recognised. However, concerns have been raised about the translation of this potential into actual use and benefit to policy and planning organisations and outcomes. The aims of this paper are to identify those factors which have been found to influence the use and usefulness of IS and in doing so to provide advice for managing development and implementation processes. There is no body of empirical work on the topic for environmental application. However a substantial literature on non-environmental IS has been developed and is used as source material. A classification of IS life cycle processes is developed and the best, worst and possible predicting factors for each process identified. The best predicting factors for IS usefulness across the life cycle were found to be user participation, user perceptions and intentions, user computer experience, top management support, support and training, external pressure, IS unit professionalism and the availability of external information sources. The state of knowledge about the determinants of IS usefulness is discussed and priorities for future research are identified. The factors identified are then discussed in terms of what they mean for managing IS development and for overcoming concerns about environmental IS development and use.

1. Introduction

Computer-based Information Systems (IS) are tools for the recording, storing, processing and dissemination of information designed to support groups of people acting together purposefully (Checkland and Holwell, 1999). IS include a variety of computational and software technologies including simulation models, decision support systems and tailored applications, and can be found utilised for a variety of purposes including data management, communication, supporting decision making at different scales and scenario exploration.

IS have acquired a central role in modern society. As such they have demonstrably modified normal routines of work (Dennis and Garfield, 2003) and been the subject of considerable investment. For example Seddon et al. (2002) report that worldwide expenditure on information technology exceeded one trillion US dollars in 2001 and it is expected to increase at a 10% rate per year. Regardless of the characteristics of organisations, it has been generally accepted that IS help reduce costs, boost productivity and improve the quality of services and products (Legris et al., 2003; Hevner et al., 2004).

Within the environmental field, it has been argued that different types of IS including integrated assessment models, GIS and decision support systems are well suited to informing environmental management and policy processes. Potential benefits include improved analysis and understanding of environmental processes and phenomena for policy formulation or delivery purposes, and better stakeholder engagement (Barr and Sharda, 1997; Cockerill et al., 2004).

However, despite these potential benefits, concerns have been raised outwith the environmental literature that IS are not always used or that they do not provide the outcomes desired. A study performed by the Standish Group (an American Consultancy specialising in IT research) in 1998 found that only 26% of all MIS projects are completed on time and within budget. Further, Legris et al. (2003) reported that almost one-third of IS projects (28%) are cancelled. A similar situation has been reported for environmental applications, where concerns have been raised about a lack of fit between IS like simulation models and the needs of policy and planning processes (McIntosh et al., 2005, in press), about low levels of usage for decision support systems (Giupponi et al., 2007) and about the difficulty of determining the benefits derived from using GIS despite their sometimes significant cost (Reeve and Petch, 1999).

In response IS research has been concerned with how to design more useful IS for organisations (Legris et al., 2003; Elbeltagi, 2005;

* Corresponding author. Tel.: +44 1908282703.
E-mail address: e.diezcebollero@cranfield.ac.uk (E. Díez).

1364-8152/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.envsoft.2008.10.009

Armstrong et al., 2005; Jeyaraj et al., 2006; King and He, 2006), and with evaluating the impacts of IS on individuals and organisations (Danzinger, 1985; Barr and Sharda, 1997; Torkzadeh and Doll, 1999; Serafeimidis and Smithson, 2000; Sojda, 2007). The importance of understanding how users interact with IS in the context of ergonomics, tasks and the organisation within which they are located is well recognised (Eason, 1991). Arguing for a better understanding of use and usefulness is equivalent to arguing for a better understanding of the ways in which information is acquired, manipulated and used by individuals and groups within organisations, and should be a fundamental influence on the process of developing IS. It is an agenda for understanding the organisational and socio-technical determinants of IS use.

However, a useful IS is not simply one that is used by individuals and organisations, or one that possesses specific desirable characteristics (such as output information quality, functionality or interface structure). Rather a useful IS is one which can, and does, support collective action through the nature of the relationships between technological attributes, individual users and organisationally situated tasks.

To understand these relationships we must understand how IS relate to organisational processes and outcomes. In this paper we will do so through characterising the organisational outcomes of the major IS life cycle processes, and identifying the factors which exert a significant positive or negative influence on them. Specifically we will answer the following research questions:

1. What are the outcomes of the major processes involved in the IS life cycle?
2. What factors influence the achievement of these outcomes, and how?
3. Which factors are controllable, by whom, how and with what effect?

By life cycle processes we refer to the set of processes involved in the development, adoption, use and disposal of IS 'from cradle to grave' by different organisations. We will study IS life cycle processes rather than specific organisational processes which utilise IS, as we wish to develop a general understanding of the influences on the use and usefulness of IS.

Having done so without reference to particular types of organisation or IS we will then interpret our findings in terms of the concerns which have been raised by authors about the use and usefulness of environmental IS. Clearly, issues relating to validity and transferability of results are raised by our agenda which we will discuss in Section 2.

The reader should note that a few examples of studies of the use and usefulness of IS can be found within the environmental literature (e.g. Walker, 2002; Giupponi, 2007; Giupponi et al., 2007) but none of these studies provide detailed or systematic empirical analysis of the relationships between organisational and socio-technical factors and the use and usefulness of IS. The outputs of such studies tend to be more anecdotal and experiential. Related analyses have been carried out for the process of adoption (Jeyaraj et al., 2006) but not within the environmental area. This is the first study to review all processes across the IS life cycle, and to interpret the findings for environmental IS.

The paper commences with a discussion concerned with justifying the validity and transferability of results. This is followed by a brief review of IS life cycle process theory and evidence then a description of the methodology used. The literature review findings are then presented and discussed in terms of what they mean generally for IS development and more specifically for the development of environmental IS. The state of knowledge regarding the process determinants of IS is also discussed and future research priorities identified.

2. Validity and transferability of findings

As mentioned, our analysis will be carried out across a range of IS and organisations. We will not attempt to make claims about the factors which influence the use or usefulness of particular types of IS to particular types of organisation (environmental or non-environmental in concern). Rather our goal is to identify a generically applicable set of IS life cycle processes, the outcomes of those processes and the factors which influence the likelihood of achieving those outcomes. We will then interpret these conclusions with respect to some of the concerns raised within the environmental literature about the use (or non-use) of IS like integrated assessment models and decision support systems. This agenda raises issues about validity (do general findings have any meaning for specific IS and organisations?) and transferability (do general findings from outwith environmental policy and management organisations have any meaning for such organisations?) which we will discuss here.

Taking validity first, it is clear from the IS literature that common determining factors exist, have been identified and can be used to explain different aspects of IS use regardless of the IS involved or the organisational context. Taking the Technology Acceptance Model (TAM – we will review this in Section 3) as an example, a substantial proportion of the variation in individual scale IS adoption outcomes can be explained by a set of simple factors including perceived ease of use and perceived usefulness (defined as perceived impact on work effectiveness). The TAM demonstrates that it is possible to generate general knowledge about the determinants of IS use, and is an exemplar of a common approach to researching IS without differentiating IS types or organisations (see the 36 references in Table 1 under 'IS/IT'). The knowledge generated will tend to provide insight into organisational and socio-technical factors but there are many well documented arguments as to why these are critical for IS success (Reeve and Petch, 1999; Checkland and Holwell, 1999; Winter et al., 1995).

Of course to then determine how to improve or manage individual perceptions of IS ease of use and usefulness for a specific organisation, further investigation would be required to understand the determinants of perceived ease of use and perceived usefulness for the individuals within the organisation concerned. These factors may be a mix of the technological attributes (e.g. information provided, functionality, ergonomics) and how they are perceived to relate to the attributes of work (e.g. information inputs and outputs, functionality in relation to the transformation process of work, etc.) and to personal and organisational capabilities (e.g. knowledge, IT support and training). The purpose of the general approach is to identify the factors to manage in the first place.

Regarding transferability of findings to environmental policy and management use of IS, it is our position that it is reasonable to do so given that empirical regularities in the determinants of IS use have been established within the IS literature regardless of organisational and IS types. We cannot think of any in principle arguments as to why environmental policy and management organisations should 'behave' differently to other organisational types with regards to IS use. Indeed, it would be surprising to find that findings robust over the diversity of organisational types and functions studied within the IS literature from (to list a few) commercial banking and manufacturing to governmental, military and health care delivery, did not apply to environmental policy and management organisations.

One area where there may be a difference might be in terms of the roles which IS fulfil for environmental policy and management organisations. Table 1 presents the various IS types reviewed for this study and the roles which they fulfil. The roles, and indeed IS types listed are not particularly different from those discussed within the environmental literature and include supporting