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Knowledge informed decision making in the building lifecycle: An application to the design of a water drainage system

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Abstract

Critical decisions which influence the sustainability of a construction project are made in a pressurised, time-critical environment. These decisions must be supported and informed by knowledge resources, with the reasons for these decisions feeding back into the body of knowledge. This paper reports on a research initiative which brings together a knowledge management environment and a decision support tool, bringing sustainability knowledge management into the applications used in architectural design. Validation of the resulting knowledge informed decision making environment emphasised the potential benefits that such environments can bring in assisting decision making by capitalizing on the wealth of existing related knowledge.

Keywords: Architectural design; Decision making; Design knowledge; Problem solving; Sustainable construction

The construction industry provides the buildings and infrastructure on which all other industries and public bodies depend. However, our built environment as a massive consumer of resources is responsible for some of the most serious global and local environmental changes [1,2]. In the contemporary world the construction industry is facing continual pressure to increase the sustainability of its practice. This pressure is understood to imply significant changes in the industry's understanding of the demands of society and of its clients, as well as its own sense of corporate social responsibility, and implies major changes in its work practices. The aims of such a sustainable practice in construction can be summarized through the following principles: (a) minimisation of resource consumption, (b) maximisation of resource reuse, (c) use of renewable and recyclable resources, (d) protection of the natural environment, (e) creation of a healthy and non-toxic environment, (f) pursuit of quality in creating the built environment [3]. Within the industry's own discourse, addressing these issues is seen to require the adaptation of present practice (e.g. designing and building for ease of demolition as well as ease of construction) as well as the creation and application of new knowledge within new practices, e.g. the adoption of new sustainable ideas and concepts [4].

At a project level it is clear that there are many decisions taken in the initial stages of a design, which will have a direct impact on the sustainability of the project [5]. Of course, in order to effectively promote sustainability, these decisions must be informed by sustainability related knowledge and experience. Architectural practice in particular can take a leading role in driving the sustainability agenda forward through client education and an innovative approach to 'designing in' sustainable solutions and technologies [6,7]. However, almost invariably, time and finances dictate that design choices made in the initial stages of a project are effectively fixed and cannot be 'revisited' or changed, hence it is crucially important that the correct choices are made at the outset.

It becomes apparent that there are two clear issues facing the actors working within the project design process: (a) the management of the diverse and ever changing body of sustainability

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related knowledge contained within the organisations and individuals which make up the project team [8,9]; and, (b) the need for timely, informed support for the decisions related to sustainability which are made in the pressurised environment of the tender and design process [10,11].

While research into these two areas has produced (a) valuable findings and (b) several research software prototypes and commercial offerings, it is the opinion of the authors that there is merit in viewing decision support and knowledge management as complementary technologies. There are clear synergies possible if decisions taken during the design phase of a project (and indeed throughout its life) are supported and informed by the knowledge resources of the respective project organisations, with the results and reasons for these decisions feeding back into the body of knowledge.

The paper reports on a research initiative bringing together a knowledge management environment and a decision support tool to provide designers with an environment that supports sustainability informed decision making, and brings just-in-time sustainability knowledge management into the applications used in architectural design offices. The paper first summarizes related work in the field. An overview of the knowledge management environment (C-Sand) and the decision support tool (ADS) is then given, followed by a description of their conceptual integration and the resulting Knowledge Informed Decision Making (KIDM) environment. The paper then reports on the validation of the resulting prototype in a laboratory environment. This is followed by a discussion informed by the validation results and the literature. Finally, the paper provides concluding remarks and directions for future work.

1. Related work

The research described in this paper fits best into the category of applications known as Group Decision Support Systems (GDSS), which are seen as a development of Group Support Systems (GSS). GSS can be described as interactive computer-based environments that support concerted and coordinated effort toward completion of joint tasks [12]. In Briggs et al. [13] this definition is extended to include the notion of reducing the '*cognitive cost*' of information access and the '*minimisation of distraction*' among teams working toward a goal. There is well-documented empirical support for the benefits of GSS. In an analysis of 54 GSS implementations, it was shown that over 80% of organisations using GSS, showed improved performance [14]. Similarly, laboratory research has shown marked potential for improved team performance [13,15,16].

Group Decision Support Systems (seen as a subset of GSS) are similarly the subject of considerable research in their own right. Even though GDSS are '*infrequently encountered*' they have the potential to considerably enhance management meetings [17]. Similarly in Dennis et al. [18], GDSS are discussed within a wider set of technologies which might support electronic meetings, concluding that GDSS has considerable potential to support management decision making. However, while research has continued, supported by advances in information and communications technologies, collaborative systems designed to support team decision making are still seen as a relatively recent development [16].

The multiplicity of circumstances governing the decision making processes inherent in architectural design leave scope for numerous misunderstandings, unforeseen difficulties created by inappropriate or ill-conceived changes and decisions which fail to propagate amongst all interested parties. Further, these circumstances are commonly compressed into short timeframes featuring periods of intense activity in which many decisions are made [11]. This multi-faceted aspect has been likened to juggling and the intensity is exemplified by the architect Richard MacCormac when he comments "it's rather like juggling actually, you know one couldn't juggle very slowly over a long period" [19]. Nevertheless, research has shown the value of computing systems explicitly designed to support decision making processes within organisations [10]. Accordingly there appears to be value in creating such systems for architectural design with a particular emphasis on minimising the necessity to break out of the intense bursts of design activity to use and maintain the system.

The field of knowledge management has been the subject of considerable research effort and within the construction sector it has been recognised that its practice is considered to be immature and under-utilised [20,8,21,22,9]. These efforts include innovative solutions which attempt to take account of the way that the Design and Construction process is fragmented, involving short term partnering between actors from a variety of disciplines, sitting at different locations, with varying levels of IT support for their individual business processes [21,23,4].

The integration of knowledge management with DSS techniques has received increasing attention over recent years [24]. However, while several studies have been proposed, there is little evidence of implementation (either laboratory, or in industry), which integrates knowledge management and decision support into existing desktop applications.

2. Creating, sustaining and disseminating knowledge for sustainable construction (C-Sand)

The C-Sand portal is the output of research aimed at promoting and disseminating knowledge about sustainable products, techniques and practice in the construction industry. The method employed to achieve these ends is based on intra and inter-organisational knowledge sharing through a set of web based services with a portal user interface. Together, the C-Sand services aim to mimic the social processes of knowledge sharing using implicit networks formed in the system's underlying knowledge model. The services are used first to create representations of real-world resources, namely 'knowledge representations' (KR), and then to link these representations to other representations using a construct characterised as a knowledge representation link (KRL). Having defined several types of link within the model, these KRs and KRLs form a number of networks dependent upon the type of link one examines [25] as illustrated in Fig. 1.

Once a resource is known to the system (i.e. stored as a KR), it is available as a search result to end-users. The system employs