Creating Knowledge for Sustainability: Using SSM for Describing Knowledge Environments and Conceptualising Technological Interventions

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Abstract

This paper proposes a sociology of knowledge approach as a basis for understanding the potential of knowledge management for a complex inter-organisational domain– the UK construction industry–with a specific aim of increasing the sustainability of the processes and products of the industry. To this end, soft systems methodology is introduced as a method of conceptualising the industry's knowledge environment and moving towards technological interventions which enable a move towards sustainability in construction practice.

Introduction

The construction industry is concerned with the planning, design, production, alteration, maintenance and demolition of the built environment. In the contemporary world this industry is facing pressure to increase the sustainability of its practice (Parkin 2000). This pressure is understood to imply significant change 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. Kibert (1999) summarises the aims of such a sustainable practice in construction through the following principles:

1) Minimisation of resource consumption.
2) Maximisation of resource reuse.
3) Use of renewable and recyclable resources.
4) Protection of the natural environment.
5) Creation of a healthy and non-toxic environment.
6) Pursuit of quality in creating the built environment.

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) (Egan 1998) (Movement for Innovation 2001). But sustainability is still seen as a novel and contestable concept within the construction industry, with no settled definition or operationalisation, and no settled body of existing practice or processes. It is then as

much a philosophy of construction as a prescribed method. In the face of this the industry conceives it necessary to develop new understandings, practices and processes, achieved through attention to innovation and through dialogue. This often takes the form of attempts to apply learning from pilot (often high profile or prestige) sustainable construction projects to general construction; an approach, which if taken naïvely, seems to offer little prospect of sustained innovation. This research then starts with an agenda that seeks to problematise this situation in terms of some need for what the industry perceives as knowledge management.

This paper is concerned, in particular, with the choice of methodology to address such a situation, motivated by involvement in a joint academic-industry research project focused on creating, sustaining and disseminating knowledge for sustainable construction across the multiple stakeholders involved in construction projects – the C-SandD project[1]. The project focuses on identifying and supporting emerging sustainable construction practices: within companies, between companies engaged in construction projects (including construction clients), and as reflected in the behaviour of other relevant institutional actors. The research aims to apply principles from construction management, knowledge management and information systems to devise a technology or intervention which may aid the industry in achieving sustainability goals. This paper focuses on one particular aspect of this work, the application of a specific methodology, soft systems methodology (SSM) to understand issues of knowledge within the construction industry. Our chosen stance with regard to knowledge management is based on a sociological approach to knowledge, suggesting that knowledge is a consequence of social interaction. Consideration is given here to the features required of a methodology to develop knowledge management systems for the construction industry. The following section discusses our chosen stance for knowledge management and knowledge creation. This is followed by discussion of the role of ICTs and information systems development methods in knowledge management. The final section introduces and seeks to justify our choice of SSM as an appropriate methodology.

Knowledge management?

Knowledge management is a broad and expanding topic (Scarbrough *et al.* 1999). In reviewing the theory and literature of this field, and applying this to the challenge of sustainable construction, it is necessary to commit to an identifiable epistemic flavour of approach. Many such approaches have been identified, and have been categorised in various ways (Alavi and Leidner 2001, Earl 2001, McAdam and McCreedy 1999, Schultze 1998). Schultze (1998) engages Burrell and Morgan's (1979) framework in order to identify a two fold typology of knowledge within the debate; objectivist and subjectivist. An objectivist approach views knowledge as object to be discovered (Hedlund 1994). In identifying the existence of knowledge in various forms and locations, technology is employed in the codification of such knowledge objects (Hansen *et al.* 1999). In contrast, a subjectivist approach suggests knowledge is inherently identified and linked to human experience and the social practice of

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[1] The C-SanD project: Creating, Sustaining and Disseminating Knowledge for Sustainable Construction is supported by the UK EPSRC. The project includes staff from Loughbourough University , LSE and Salford University. Further details available at www.c-sand.org.uk.

knowing, as seen for example in the work of Tenkasi and Boland (1996) and Brown and Duguid (1998). In adopting such a stance, it is contended that knowledge is continuously shaped by the social practice of communities and institutions.

Such an objectivist versus subjectivist account, if taken too literally, may indeed be too binary. We thus recognise a third constructivist approach, suggesting that a position of either absolute subjectivity or absolute objectivity is untenable; rather these become relative positions in the intersubjective social consciousness (Schultze 2000) (Berger and Luckman 1966). Subjectivity and objectivity are interlocked in a reciprocal relationship so that both are always necessary (Schultze 2000). In adopting such a position to knowledge it is accepted that society (and thus knowledge processes) are both a subjective and objective reality. Social reality is to be understood in terms of an ongoing dialectical process composed of an individual simultaneously externalising their being into the social world, and internalising the social world as objective reality; "*to be in society is to participate in this dialectic"* (Berger and Luckman 1966). Taking such a broad approach Demarest (1997) argues that knowledge is embedded within the organisation not just through individual actors or explicit programmes, but also through social interchange. This, however, still tends to suggest that knowledge is an object that can be embedded and distributed rather than as a change in the perceptions of individual actors who can institute practices that embody and perpetuate their increased understanding. For us it is these new practices that are disseminated, and other actors encountering these new practices may learn from them and develop their knowledge.

The rest of this section explores this dialectic of knowledge, and in particular how a methodology may be employed to build a picture of such a reality. Thus, in contrast to approaches which "map-knowledge" (Seemann 1996, Vail 1999), our approach to analysis aims to explore the social and individual activity and interchange in the social setting, and which constantly re-creates knowledge in new forms.

Knowledge creation?

As identified in the introduction, sustainability is seen within the construction industry to require the creation and dissemination of new understanding and knowledge. In line with the position outlined above, such creation of new knowledge is not simply a codification effort, nor one driven only by personal explorations, but involves the ability to interact with and convince others. The construction community within which such knowledge might be shared and communicated thus forms an important component of the knowledge process we study. Adopting such a perspective, our interest shifts from supporting, mapping, storing and disseminating knowledge as object, to supporting (and creating or shaping) many possible activities undertaken by individuals engaged in social action. We can still however argue that human knowledge is capable of some degree of objectivation; that is, manifested as products of human activity, available to producer and others as elements of their intersubjective world. But we suggest that such objects do not "possess" knowledge, as would be argued by codification of tacit knowledge into explicit knowledge (Nonaka and Takeuchi 1995), nor does technology simply act as a conduit by which knowledge may the shared. Rather, such elements may contain, express and inscribe accumulations of meaning and experience (Berger and Luckman 1966). An act of objectivation, for example an answer to a request for information on a company

intranet, may make an individual's subjectivity appear to have greater reality, not only for the receiver, but also the producer (Berger and Luckman 1966). Equally, an architect's production of design documents acts as both communication (to demonstrate the design to a client) and as individual subjective tool – the architect is not simply codifying a pre-conceived picture but making real a subjective thought (see Schön 1982 for further discussion). In Weick's (1995) terms, the individual makes sense of their world by interacting within it.

Such a sociology of knowledge suggests that knowledge (and knowledge practices) can only be made sense of fully within the situation that it was generated and by the actors involved in its creation. Any abstraction of knowledge from that context removes it (to some degree) from the chain of because-ofs and in-order-tos that brought an insight to the focal awareness of the individuals concerned. (Ciborra 2002): knowledge being what made action appropriate in that situation at that time - what emerges as the obvious next step (Introna 1997). Shared experience is what makes an informed actor able to infer some of the surrounding context on hearing or reading an account of the insight and relate it (appropriately) to their own practice. This may be through a local (or virtual) community of practice, where much of the context is visible; it may be through a shared professional training and practice; or it maybe through an organisational affiliation, where ways of doing things are shared.

We can take this a stage further to look at the communicative competencies that are involved in language games embedded in forms-of life (Wittgenstein 1967). The form-of-life of the construction professional gives meanings to fragments of speech or writing that are impenetrable to outsiders for reasons that go beyond a lack of understanding of technical terminology. It is the apprenticeship and induction process of becoming a services engineer or an architect that enables an increasing ability to translate communications into appropriated knowledge, rather than a received instruction. Being a services engineer or an architect means not just having a qualification but more it means being a respected member of a community where judgements are regarded as knowledgeable by others. In this way Dreyfus (2001) describes the process of developing mastery and practical wisdom in a field and the possibilities and limitations of ICTs in enabling such a knowledge process, while Prusak and Cohen (2001) explore this at an organisational level and describe the ability to share understandings as the social capital of a firm.

Thus, a key problematic of this current research is the investigation of how individuals and groups within the construction industry can be assisted to make knowledgeable interpretations for sustainability within company and professional structures and, crucially in an industry based on multi-firm and multi-professional projects, across these boundaries. The later section of this paper on the application of soft systems methodology describes our approach to this issue. However, and of significance given the contested concept and evident challenge of sustainability which we address in this research, such structures of institutionalised practice may lead an individual to habitualisation of action, where a given approach is embedded in routine (Berger and Luckman 1966). Such institutionalised practice is reciprocated by others in the social structure as products of history (Berger and Luckman 1966, Kuhn 1996, Latour 1987); to those individuals concerned they appear as objective reality. Within the construction industry we see that, professional engineers and managers often remain with the same organisation for extended periods and their professional identity

often lasts their whole career, acquiring the approaches and adopted practice of their profession and their firm, creating a set of dispositions for how they encounter the world, in Bourdieu's (1977) framework a *habitus*.

If a concern for sustainability is to successfully challenge such institutionalised sets of dispositions governing practice, and if ICT based systems are to be a part of this, then an understanding is required of individuals actions, and habitualised routine practices, rather than of the espoused theories which may attempt to rationalise such habitulisation through theory (Argyris 1995). Furthermore, since this study focuses upon practice across an industrial sector, rather than intra-organisationally, comparisons between practices will be required. A methodology is thus required which can capture and challenge such practice, and explore the social structures within which activity occurs. We have thus sought a methodology that can allow us to focus upon the shared social context of the parties involved in knowledge processes and which can serve in our attempt to develop a picture of the creation and use of artefacts, and identify the knowledge perceived to be contained within them.

Knowledge and ICTs

This discussion of knowledge and sustainability provides a distinctive context for a consideration of the role of ICT in providing enabling resources to such environments. While many authors argue that improvement in the way knowledge is created and applied cannot be sought through technology alone (Bhatt 2001, Davenport and Prusak 1998, McDermott 1999), technological development and innovation clearly remain central to the research agenda of the topic. Furthermore, some parts of the construction industry already employ ICTs extensively for information work; ISDN networking, CAD, project management applications and office tools are standard. Large firms in the construction sector have invested heavily in intranets as a key informational resource, though we also must recognise that most of this industry is composed of small specialist firms, and their technology platforms may be at best modest. We therefore have to ask what role ICTs have in supporting knowledge work (Alavi and Leidner 2001, Bacon and Fitzgerald 1999), and in the creation, dissemination and application of knowledge within and between organisations?

This simple question remains a contentious issue (Galliers 1999, Milton *et al.* 1999, Scarbrough *et al.* 1999). Initial approaches to employing ICT within knowledge management attempted to marry the capabilities of technology with the generic features of knowledge management, for example considering the Internet as a knowledge repository or data mining as knowledge discovery (Davenport and Prusak 1998). However such an approach implies conformity among activities and essentially the objectivist epistemology. Other approaches have attempted to "map" the knowledge existent within an organisation, devising pictures of communication which may be translated (in whole or in part) into ICT solutions (Vail 1999). But as Hendricks notes

> "…no ICT (information and communication technology) application deserves the label of a knowledge management tool purely because of its own

> characteristics. It is essential when valuing ICT applications as knowledge management tools to consider the situation in which they are used" (Hendriks 2001).

Further criticism of ICT-driven knowledge management approaches preface the objectivist approach to knowledge while ignoring the subjectivist dimension (Blackler 1995, Hendriks 2001, Tsoukas 1996). In contrast to such approaches, these authors argue that for the development of effective knowledge management systems there is a need to build an understanding of the knowledge environment and context

> "Knowledge is analysed as an active process that is mediated, situated, provisional, pragmatic and contested. The approach suggests that attention should be focused on the systems through which people achieve their knowledge and on the processes through which new knowledge may be generated." (Blackler 1995)

Responding to Blackler's call, we conceptualise such systems not as instrumental artefacts but as purposeful human activity systems. Rather than focusing on ICTs as driven by concern for what people know (or want to know), which in any case proves elusive to describe (Nonaka and Takeuchi 1995), we adopt an approach which focuses on what people do (Blackler *et al.* 1993).

Still, we can accept a potentially important role for ICT in knowledge management activity, and this leads us to explore the relevance of information systems methodologies to aid the task of understanding the knowledge environment, as guides to the establishment of relevant innovations/interventions of a technological character. Our interest in the application of information systems development methods to knowledge systems is still, however, based on the belief that, while the claims of knowledge management systems may be the creation, dissemination and application of knowledge, a computer based system is only capable of processing data (Galliers and Newell 2001). Exploring techniques seen as effective in developing data-processing machines which support information systems is understood as relevant, but not the whole answer. We are thus mindful of McDermott's (1999) comment that *"the great trap in knowledge management is using information management tools and concepts to design knowledge management systems"* as such systems often ignore the cultural issues and become little more than (or even less than) information systems.

Soft Systems Methodology

The discussion above suggests a need to explicitly recognise and incorporate technical, organisational and social modalities within any approach to designing and introducing knowledge management technologies. This implies, among other things, that a selected methodology needs to be able to retain and combine such aspects. On this basis our selected methodology is soft systems methodology (SSM) (Checkland 1981, Checkland and Scholes 1990). Soft systems methodology is founded on analysis of a hierarchy of models (systems) of purposeful activity. By employing systems concepts in the exploration of organisational knowledge behaviour, we also contribute to the debate begun by Galliers who suggests that systems thinking be introduced within transdisciplinary research into organisational theory (Galliers and Jackson 1997).

The complexity and unbounded nature of the sustainability issue faced by the construction industry leads our research focus to see beyond supporting knowledge processes within the *status quo*, but rather to exploring and supporting emergent, innovatory sustainable practice. SSM considers social reality as continuously socially constructed and reconstructed by individuals and groups, in keeping with our knowledge management stance. Systemic thinking is employed within the method as a method of making sense of this world. The systems outlined through the method (relevant systems) provide a lens through which to make sense of this complex and changing world, not representations of systems existing in or proposed for the world. By applying systemic thinking in this way to the issue of sustainability we can appreciate the evident confusion and doubt, and elicit models of how individuals within the industry conceptualise and approach sustainability concepts and sustainability problems.

In SSM rich-pictures are employed as a method of capturing the problem situation; recognising that different parties involved in construction conceptualise sustainability differently. For instance: to a client it may consist of a public-relations exercise; to an architect it may be a method of achieving competitive advantage by differentiation; for an engineer meeting the requirements of the building regulations; for a contractor it may be a tiresome interference in "getting the job done". Through rich-pictures we can highlight such different world-views (*Weltanschauungen*). Such pictures can also highlight the degree of social interaction and begin to draw out activity which is considered purposeful from among the uncertainty, disagreement and conflict associated with the sustainability issue. Existing information systems may also be included within such pictures, in as far as they are involved in such conceptualised purposeful activity. Through field research and the drawing of such pictures for the different existent *Weltanschauungen* a dialogue and debate can be initiated to support the modelling of "human activity systems" which are perceived as relevant to a sustainable construction practice by some or all of those involved.

Such human activity systems begin to raise and identify institutionalised practices, and explore the social structures in which activity occurs, for instance identifying the role of "chartered surveyor" or of some "community of practice" in a design office. Such pictures aim to encourage a holistic rather than reductionist approach to appreciating the social context of the organisation; an approach to thinking necessary for our adopted stance on knowledge management (Checkland 1999). This consideration of the social and institutional structure, roles and opinions, separately from more formalised structures such as organisations or projects, is of further value given the distributed nature of the construction industry. Through developing such an understanding we are then able to propose and develop ICTs as part of human activity systems and that may improve sustainable practice.

To this end SSM is employed in devising technological systems which ostensibly only process data, but with a clear ambition of improving/supporting knowledge practices within this community. Since sustainable construction practice is constantly emerging, so such interventions must be conceived in a flexible and emergent manner. SSM, as an action research methodology, embodies such flexibility, allowing an iterative approach to development. Through various cycles of iterative intervention, models of purposeful activity are developed and adapted to changing knowledge

practice. In this SSM directs us towards achieving change which is not just systemically desirable (change that improves performance against certain agreed parameters) but identifies that change must also be culturally feasible (change is meaningful and commands assent within the sensemaking environment) (Checkland 1981). Attention to these twin concerns make SSM particularly appropriate for exploring and contextualising this problem domain as we seek to identify potential (and potentially successful) technical intervention.

In line with the epistemology outlined at the start of this paper, we use conceptual models developed through SSM to identify patterns in the knowledge activities undertaken (Alexander 1977, Alexander 1999, Denning and Dargan 1996). Such patterns then form the basis of technical design and organizational and social intervention. Patterns within the knowledge practices of the construction industry may concern linguistic distinctions around which action is organised (e.g. blue-prints, project briefs), speech acts (e.g. to commission work), standard practices and protocols (e.g. assemble, build), sets of tools and equipment (e.g mobile telephones, CAD applications), breakdowns interrupting standard practice (e.g. machine failure, design errors) and a sets of ongoing concerns for people in the domain (e.g. issues of quality, sustainability, or career)(Denning and Dargan 1996).

Through such SSM analysis we can identify both responsible actors and transformations for which they are responsible. But in order to build or establish new ICT based systems we still need to translate these contextually rich understandings into the sparse language of modelling tools and the even sparser language of programming. How best to achieve these transformations so as to build tools that are appropriate to, of necessity, at best partially described human activity systems is the next task of this research. For this project we employ UML (unified modelling language) (Apicella 2000, Scott 2001) as a systems design and development method, and focus on the use of our SSM descriptions of a knowledge environment as a basis for beginning a UML description of a technology. In line with an incremental and iterative approach to system building (Boehm 1988) these descriptions may then be developed into a product and tested through an action research cycle.

Conclusions

The research reported here focuses on how knowledge processes and environments can be understood and modelled as the construction industry addresses the issue of sustainability. This unbounded, complex and emergent domain is seen as requiring some technological intervention. We address such intervention through a consideration of both established and potentially new practices. Through our epistemological stance on knowledge management we identify a need to engage with the social environment and the interaction that people are engaged upon. Leaving behind notions of identifying knowledge *per se*, we instead focus on the task of understanding “what people do” or might do, and the complex environment in which they operate, and we identify SSM as an appropriate methodology to aid this task. Our research is concerned to support some intervention into knowledge processes, yet the issue within which we aim to intervene is contested, emergent and changing. Thus our use of SSM, as a system to develop tools and contexts to support existent and new knowledge processes, is a learning and action research approach.

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