Knowledge about Sustainability: SSM as a Method for Conceptualising the UK Construction Industry's Knowledge Environment

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

Keywords: Soft Systems Methodology, sustainability, knowledge management, methodology, construction industry, social constructivism.

1. 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 [1]. This pressure is understood to require significant change in the industry's understanding of the demands of society and of its clients, as well as change to its own sense of corporate social responsibility. This in turn implies major changes in the industry's work practices. Kibert [2] 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. the need to design and construct buildings in different ways, for ease of demolition as well as ease of construction) and the creation and application of new knowledge within new practices (e.g. the adoption of new sustainable ideas and concepts) [3] [4]. But, sustainability is still seen as a novel and contestable concept within the construction industry, with no settled definition or operationalisation, and thus has no settled body of existing practice or processes. It is as much a philosophy of construction as a prescribed method. In the face of this, the industry conceives it necessary to develop new understandings to lead to new sustainable practices and processes. It believes that this might be achieved through attention to innovation and through dialogue. Such innovation and dialogue often take the form of undertaking pilot sustainable construction projects (often high profile or prestige), learning from these pilots and then applying this learning to general construction; an approach, which if taken naïvely, seems to offer little prospect of sustained ongoing innovation. This research

then starts with an agenda that seeks to problematise such dialogue and innovation in terms of a need for what the industry perceives as knowledge management.

1.1. The C-SanD Project

This paper is concerned with the choice of methodology to address such a situation and is motivated by involvement in a joint academic-industry research project focused on creating, sustaining and disseminating knowledge for sustainable construction across multiple stakeholders involved in construction projects – the C-SanD project[1]. The project focuses on identifying and supporting emerging sustainable construction practices both within companies and between companies engaged in construction projects (including clients). The research project 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.

One particular aspect of this work is the focus of this paper, the application of a specific methodology, soft systems methodology (SSM) in order to gain an understanding of the issues associated with 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 and describes how the methodology is applied within the C-SanD project. The paper concludes with a discussion of the general appropriateness of SSM to Knowledge Management interventions.

2. Knowledge Management?

Knowledge management is a broad and expanding topic [5]. In reviewing the theory and literature of this field, and applying it 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 [6–9]. Schultze [9] engages Burrell and Morgan's [10] framework in order to identify a two fold typology of knowledge within the debate: objectivist and subjectivist. An objectivist approach views knowledge as an object to be discovered [11]. Identifying the existence of knowledge in various forms and locations, technology is then employed in the codification of such knowledge objects [12]. In contrast, a subjectivist approach suggests that knowledge is inherently identified and linked to human experience and the social practice of knowing, as seen, for example, in the work of Tenkasi and Boland [13] and Brown and Duguid [14]. In adopting such a stance, it is contended that knowledge is continuously shaped by the social practice of communities and institutions and far less amenable to codification.

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 [15] [16]. Subjectivity and objectivity are interlocked in a reciprocal relationship and both are always necessary [15]. In adopting such a position to knowledge, it is accepted that society (and thus knowledge processes within it) 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*" [16]. Taking such a broad approach, Demarest (1997) argues

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

that knowledge is embedded within the organisation, not just through individual actors or explicit programmes, but also through social interchange. This, however, may still tend 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. Having identified this third constructivist approach, the rest of this section explores this dialectic of knowledge, and, in particular, how a methodology may be employed to build such a picture of such a reality. Thus, in contrast to approaches which "map-knowledge" [17, 18], our approach to analysis aims to explore the social and individual activities and the interchange in the social setting, which constantly re-creates knowledge in new forms.

2.1. 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 [19], nor one driven only by personal explorations, but it 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 objectification; 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 [19], 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 [16]. 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 for the producer [16]. 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 20 for further discussion]. In Weick's [21] terms, the individual makes sense of their world by interacting within it.

2.2. Knowledge Only Makes Sense in Context. . .

Such a sociology of knowledge suggests that knowledge (and knowledge practices) may only be made sense of fully within the situation that it was generated and by the actors involved in its creation. And, yet, the aim of knowledge management is to enable the relocation of knowledge. 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 [22]: knowledge being what made action appropriate in that situation at that time – what emerges as the obvious next step [23]. 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 his/her own practice. This maybe through a local (or virtual) community of practice [24], where much of the context is visible; it maybe 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 [25]. 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 [26] 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 [27] explore this at an organisational level, describing 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, given the contested concept and evident challenge of sustainability to the *status quo*, such structures of institutionalised practice may lead an individual to habitualisation of action, where a given approach is embedded in routine [16]. Such institutionalised practice is reciprocated by others in the social structure as products of history [16, 28, 29]; to the 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 throughout their career, acquiring the approaches and adopted practices of their profession and their firm, creating a set of dispositions for how they encounter the world, in Bourdieu's [30] framework a *habitus*.

A concern for sustainability needs to successfully challenge such institutionalised sets of dispositions governing practice. If ICT-based systems are to be a part of this, then they must be built on an understanding of individuals' actions and habitualised practices, rather than on the espoused theories which may attempt to rationalise such habitualisation through theory [31].

This study focuses upon practice across an industrial sector, rather than intra-organisationally, so comparisons between practices will be required. A methodology is thus required which can capture and challenge such habitualised practice, and explore the social structures within which the activity occurs. We have thus sought a methodology that allows us to focus upon the shared social context of the parties involved in knowledge processes and which can serve our attempt to develop a picture of the creation and use of artefacts, and identify the knowledge perceived to be contained within them. The selected sociology of knowledge approach suggests that knowledge is only fully applicable within the context in which it was created by the creators of the knowledge. However, we are working against such an assertion by attempting to move knowledge through ICT. The paper further identifies that habitualised structures and routines limit the ability to challenge existing practice. On this basis, ICT for knowledge management presents difficult challenges. The next section explores such challenges in the context of the C-SanD project's attempt to develop a technology to challenge existing practices within the UK construction industry in order to promote sustainability practice.

3. 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 [32–34], 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 [7, 35], and in the creation, dissemination and application of knowledge within and between organisations? This simple question remains a contentious issue [5, 36, 37]. 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 [33]. However, such approaches imply 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 [18]. 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" [38].

Further criticism of ICT-driven knowledge management approaches preface the objectivist approach to knowledge while ignoring the subjectivist dimension [38–40]. In contrast to such approaches, we 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." [40]

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 [19], we adopt an approach which focuses on what people do and how others interpret this [41].

Thus, we can accept a potentially important role for ICT in knowledge management activity, which 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 [42]. 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 [34] 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.

In summary, the paper thus identifies a need for a methodology which can problematise existing practices (sustainable or otherwise) of the UK construction industry in order to develop new ICT tools which effectively support the development and dissemination of sustainability practice. Such a methodology should be relevant to the adopted social constructivist stance towards knowledge and it should seek to explore the social and individual activities and interchange conjunct with the social setting in which they are practiced.

Such a methodology should enable the identification of elements which may contain, express or inscribe meaning (accepting that knowledge only makes sense fully within the situation in which it was generated and by the actors involved in its generation). In this research we identify Soft Systems Methodology as a methodology capable of such application. The following section introduces this methodology, describes its relevance to this research and outlines how it was used.

4. Soft Systems Methodology

The discussion so far 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) [43, 44]. Soft systems methodology is founded on the analysis of a hierarchy of models (systems) of purposeful activity. By employing systems concepts in the exploration of organisational knowledge behaviour, this work also contributes to the debate begun by Galliers who suggested that systems thinking be introduced within transdisciplinary research into organisational theory [45].

The complexity and unbounded nature of the sustainability issue, the implied need to do something new, faced by the construction industry, leads this research to see beyond supporting knowledge processes within the *status quo*. Instead, our research aims to explore and support emergent, innovatory sustainable practice. SSM considers social reality as continuously socially constructed and reconstructed by individuals and groups, and is thus in keeping with our stance. Within the SSM, systemic thinking is employed as a method of making sense of this world. The systems outlined through the method (known as relevant human activity 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 such systemic thinking to the issue of sustainability we can apprehend the evident confusion and doubt. We can elicit models of how individuals within the industry conceptualise and approach sustainability concepts and sustainability problems and possibly offer innovations in support of this.

4.1. Expressing the Problem Situation

In the SSM, so-called rich-pictures are drawn as a method of capturing the problem situation, while recognising that different parties involved in the construction conceptualise their work (including issues of sustainability) differently [44]. For instance: to a client, sustainability 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". Since rich pictures "are a better means for recording relationships and connections than is linear prose"[43], they provided this project with a tool to effectively express such problem situations. Initial interviews and meetings were thus undertaken with around 17 key individuals across 10 different UK construction firms and from these, research officers drew around 16 different rich pictures to represent the sustainability domain identified (see Figure 1 for an example of one of these rich pictures).

From these rich pictures the researchers then attempted to highlight different world-views (*Weltanschauungen*) held by various parties. The pictures also attempted to express the degree of social interaction and began to draw out the activity which was considered purposeful from among the uncertainty, disagreement and conflict associated with the sustainability issue. Existing information systems were also included within these pictures, in as far as they are involved in such conceptualised purposeful activity.

4.2. Identifying Human Activity Systems

Through this field research and through the drawing of such pictures for the different *Weltanschauungen,* a dialogue and debate were initiated with industry participants to support the modelling of "human activity systems" which were perceived as relevant to a sustainable construction practice, by some or all of the parties involved. This debate was undertaken through a series of workshops with key academic and industry partners. An oval mapping technique [46] was used to aid the identification of such human activity systems from across the various rich pictures (see Figure 2 for an example of these oval maps).

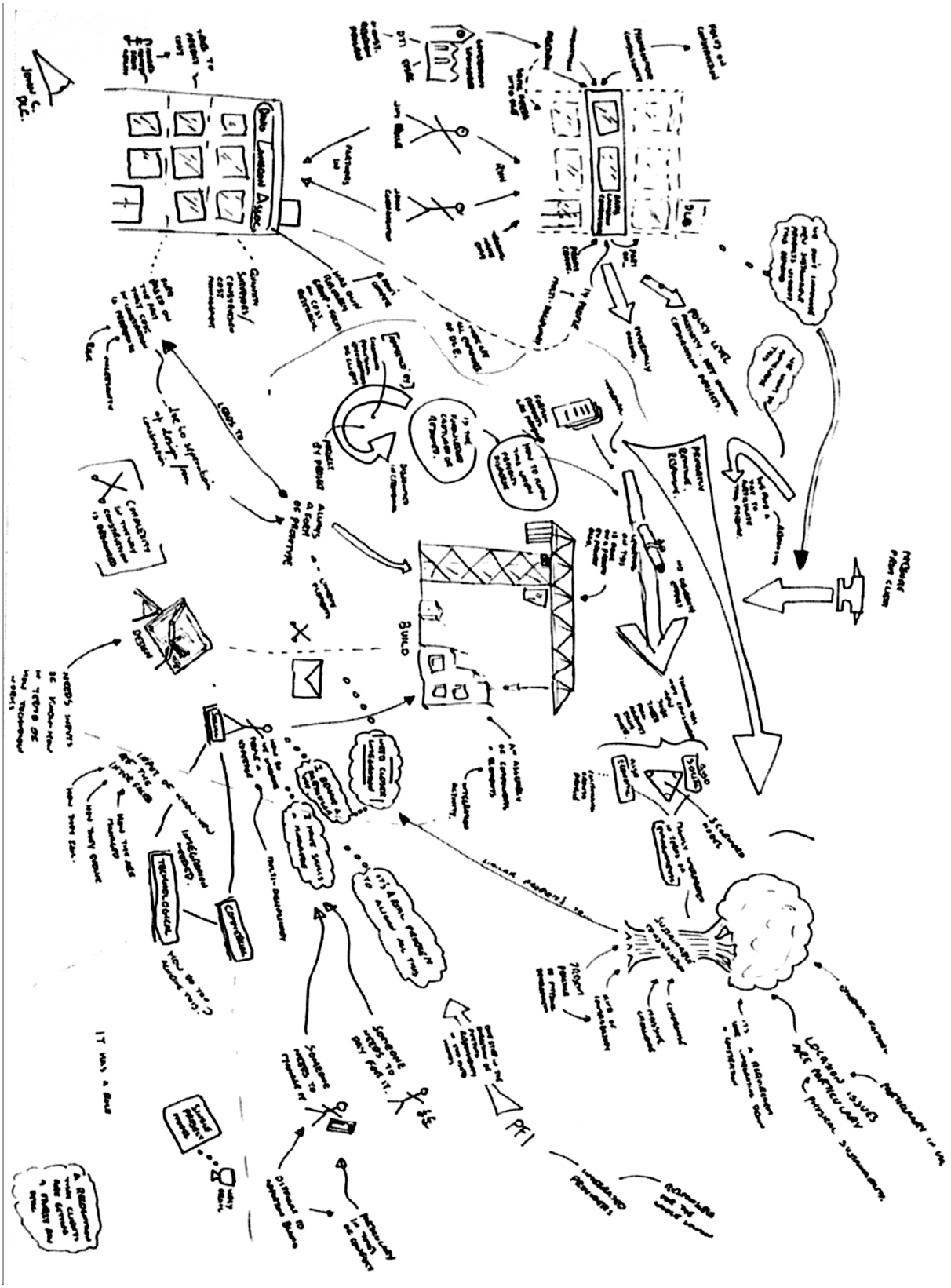

Fig. 1. Example of a rich picture from the C-SanD project relating to the issue of sustainability regarding construction consultancy and quantity surveying.

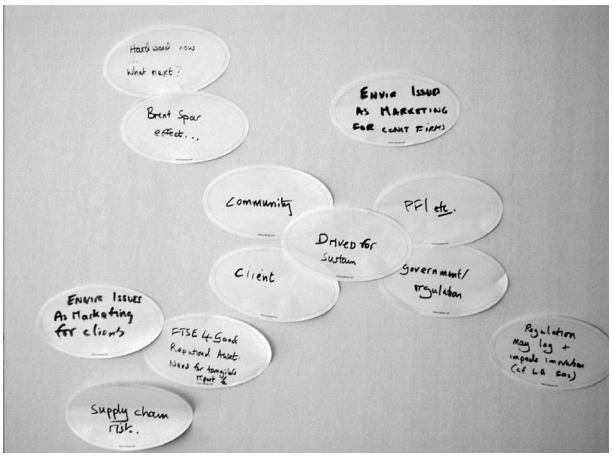

Fig. 2. Photograph of Oval Mapping used to discuss the rich pictures.

Relevant human activity systems were then expressed as root definitions which "express the core or essence of the perception to be modelled" [43] – the core purpose of the human activity system.

These were presented to the industry partners in diagrammatic form (as introduced by Peter Checkland [44]), such that industry participants might discuss them without specific knowledge of SSM. An example of such root definitions is shown in Figure 3. Having identified such models of human activity systems, a second round of interviews was undertaken to explore their relevance to individual work practices.

The identified human activity systems began to raise and identify institutionalised practices, and enabled an exploration of the social structures in which the activity occurs, for instance identifying the role of "chartered surveyor" or of some "community of practice" in a design office. The rich pictures encouraged a holistic rather than reductionist approach to apprehending the social context of the organisation, an approach to thinking, necessary for our adopted stance on knowledge management [47]. This consideration of the social and institutional structure, roles and opinions, separately from more formalised structures such as organisations or projects, was of further value, given the distributed nature of the construction industry. Through developing such an understanding we were able to propose and develop prototype ICTs as part of human activity systems that aim to improve sustainable practice.

To this end, SSM was employed in devising technological systems which ostensibly only process data, but with a clear ambition of improving / supporting / moving / sharing knowledge practices within this community. Since sustainable construction practice is constantly emerging, such interventions needed to be conceived in a flexible and emergent manner. The

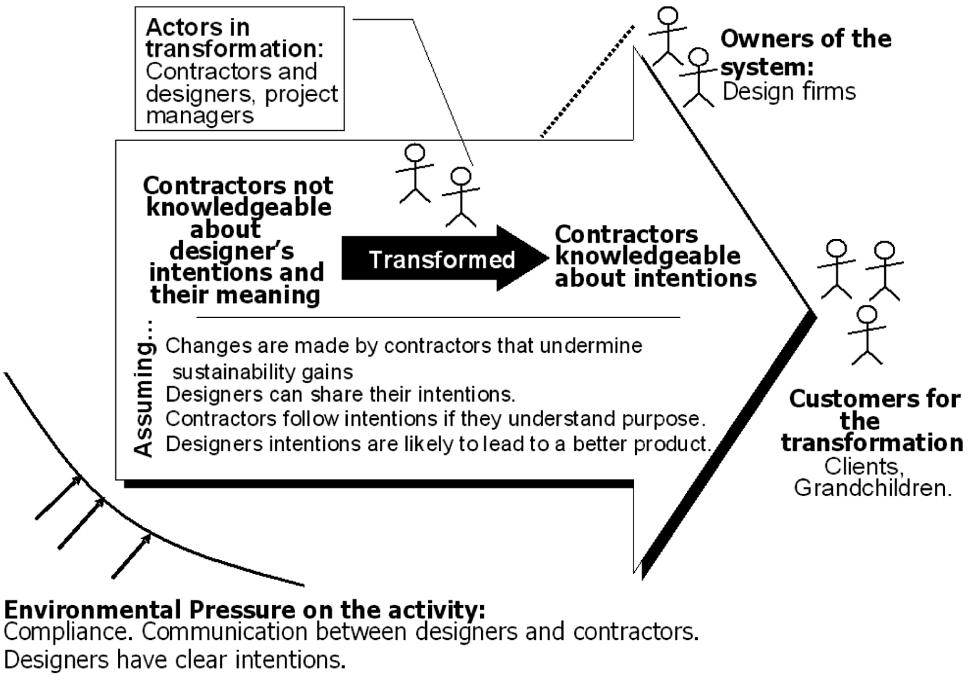

Fig. 3. Example of root definitions relating to contractors not being aware of designers' intentions.

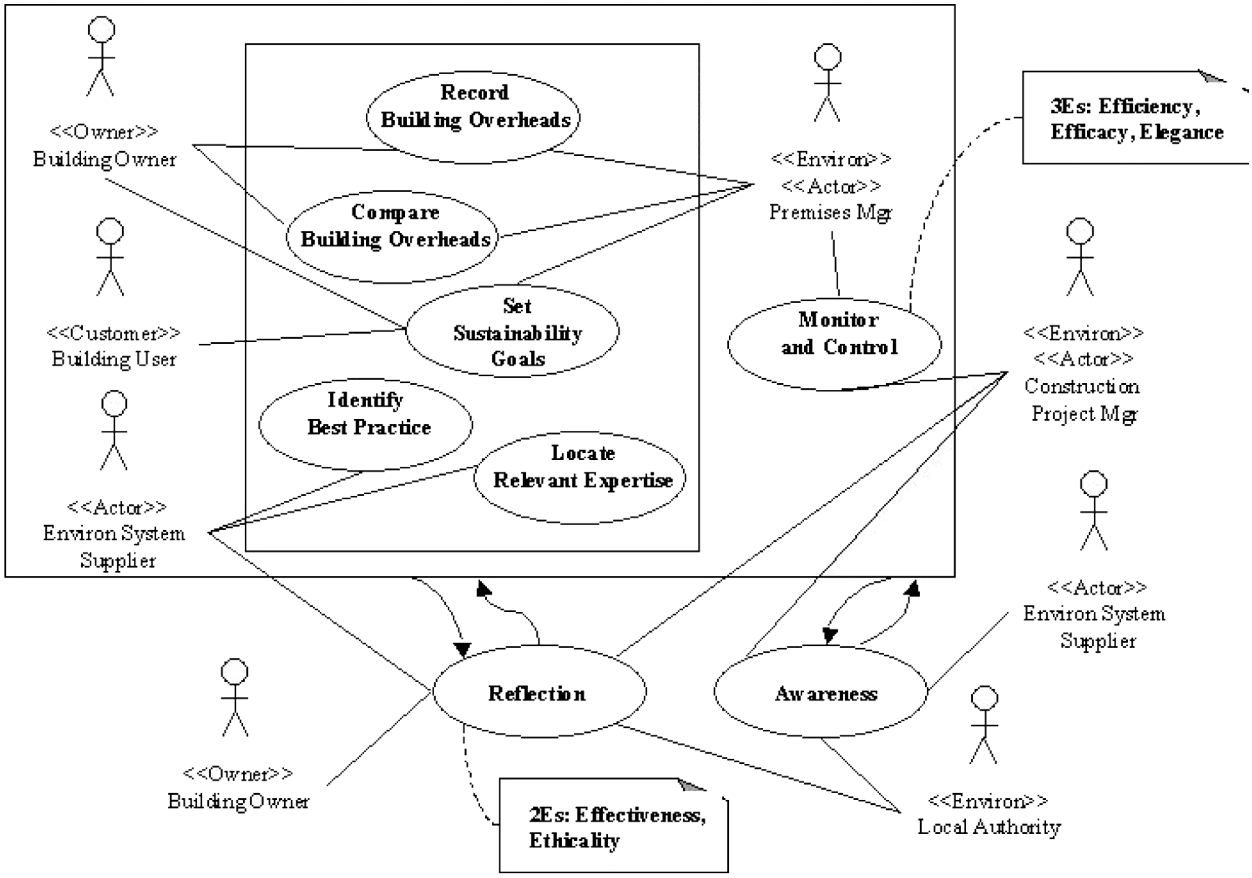

Fig. 4. Example Conceptual Model expressed as a root definition.

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 were developed and adapted to changing knowledge practice. In this, SSM directed us towards achieving the change which was not just systemically desirable (change that improves performance against certain agreed parameters), but also to identify change which might be culturally feasible (change is meaningful and commands assent within the sense-making environment) (Checkland [44]). Attention paid to these twin concerns made SSM particularly appropriate for exploring and contextualising this problem domain as we sought to identify potential technical interventions.

4.3. Moving from Soft Systems Methodology to IT Systems Development

Through such SSM analysis we could identify both responsible actors and transformations for which they were (potentially) responsible. But, in order to build or establish new ICT-based systems, we still needed to translate these contextually rich understandings into the sparse language of modelling tools and the even sparser language of programming. How to achieve these transformations so as to build the tools that are appropriate to at least partially described human activity systems, was the next task of this research. For this purpose we employed UML (unified modelling language) [48, 49] as a systems design and development method, and we focused on the use of our SSM descriptions of a knowledge environment as a basis for beginning a UML description of a potential technology. In line with an incremental and iterative approach to system building [50], these descriptions were then developed into a product which could be tested through further action research cycles. Our first step along this process was the construction of a conceptual model expressed in UML form (as a Use Case diagram). An example of this is shown in Figure 4.

5. 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 (a sociology of knowledge) 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 with supporting the development and introduction of an ICT system into the practice of the UK construction industry, yet aware of the fact that the issue within which we aim to intervene is contested, emergent and changing. Thus our use of SSM as an approach to develop tools to support existent and new knowledge practices, is a learning and action research approach.

This final section of the paper critically reviews the benefits of SSM (as a learning and action research approach) within this research and extrapolates this research's experience to present a general set of points regarding the use of SSM within knowledge management.

SSM presents an approach focused on the ongoing practice of individuals and the *Weltanschauungen* by which such practice is deemed sensible. The approach thus identifies social structures neither from the espoused views of individuals, nor from the legitimized view of organisational hierarchy, but rather from exploring the social interactions inherent to the doing of work. The methodology thus avoids a deterministic identification of social structures, for example where Communities of Practice are identified simply because "community" is a deceptive and warmly persuasive word [51] to use in describing poorly understood social structures[52]. Furthermore, such a focus on practice enables the research to focus on the actions and activities of individuals rather than on their espoused views of knowledge needs and expectations of what a knowledge management system might do.

SSM is thus a process of enquiry [53] involving participants in reflexively discussing their working practices. Such discussion and debate helps focus the development of technology on the practice of the UK construction industry rather than on the basis of how technology might be generically used in Knowledge Management. It avoids focusing on what people want, rather focusing on what people do.

Finally, the cyclical nature of SSM and its action research approach aligns well with iterative and incremental software development processes. It thus allows the technology to be introduced into the practice and the changes in this practice to be observed. This further allows a focus on how the industry is able to innovate new sustainable practices and then to further shape the technology to better reflect such new practice.

6. Acknowledgements

We would like to thank our academic collaborators at Loughborough University and the University of Salford and our industrial collaborators for their support in this research. The C-SanD project is funded by the EPSRC.

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Received: July, 2004
Revised: August, 2004
Accepted: August, 2004

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