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Knowledge Mapping and Knowledge Communication in Decision Making and for Providing Effective Solutions for a Sustainable Urban Environment

C.O. Egbu

School of the Built and Natural Environment, Glasgow, Caledonian University, Cowcaddens Road, Glasgow, G4 0BA, Scotland, UK. Email: c.egbu@gcal.ac.uk

In order to be successful, sustainable developments must promote economic, social and environmental needs and benefits, focusing on inevitable trade-offs as well as synergies between these needs and benefits. Sustainability therefore means thinking in terms of whole systems, with all their interconnectedness, consequences, feed-forward and feed-backward loops. Sustainability issues inherently cut across many boundaries, and are transdisciplinary and transorganisational. This brings to the fore issues of how individuals, groups and organisations make knowledgeable interpretations for sustainability within organisations and professional structures and, in the cases of industries based on multi-firm and multi-professional projects, across these boundaries. The above discourse would suggest that the vagaries of different industrial sectors are likely to impact on how knowledge for sustainability is created, transferred and applied. Knowledge in the field of sustainability is also subject to ideological pressures that can be at odds with what makes both business and ecological sense. The challenge of knowledge management is to understand how to create practical solutions to support individuals and groups as they generate or acquire this multi-faceted knowledge, so as to suit the particular requirements of their application context. Drawing on a recently completed study funded by the UK Engineering and Physical Sciences Research Council (EPSRC), this paper discusses the role of knowledge communication and knowledge mapping in contributing to decision making in offering sustainable development solutions. It presents and discusses a model for effective knowledge mapping and its benefits in a sustainable urban environment (SUE) context, as well as the main techniques currently in use for knowledge mapping. Also presented are key success factors for effective knowledge communication. It is concluded that firms and institutions need to find out if the individuals with 'higher stocks' of technical and tacit knowledge for sustainability solutions have a relevant place in the social organisation of the firm/institution, and that this relevant place plays a central role in the network. The mapping instrument has to fulfil three needs to achieve a satisfactory level of dynamic modelling. Firstly, the need to depict over time the relations that are most representative or central. Secondly, the need to make relative assumptions as to the 'richness of the social interactions', since individuals with high technical ability might not have, at the same time, a superior stock of social interventions. Thirdly, the need to evaluate the capabilities that for a given moment are most relevant to the firm; these are usually associated with global strategies (integrated into relative competitive positioning) such as profit maximisation, and cost minimisation subject to environmental, social and financial constraints.

Keywords: knowledge communication, knowledge mapping, sustainable urban environment.

INTRODUCTION

Many industries are facing pressure to increase the sustainability of their practice (Parkin, 2000). This pressure, in many cases, implies significant changes in an industry's understanding of the demands of society and of its clients, as well as its own corporate social responsibility, and can imply major changes in its work practices. The awareness of the impact of sustainable development is growing around the globe. It is also firmly on the political agenda of most countries in both developed and developing countries. The Brundtland Report (Brundtland, 1987), the UN summit in Rio de Janiro (1992), the World Summit on Sustainable Development in Johannesburg (2002) and the UK National Sustainable Development Strategy (HM Government, 1999) are just a few initiatives which have provided additional impetus for this.

In order to be successful, sustainable development must promote economic, social and environmental needs and benefits, focusing on inevitable trade-offs as well as synergies between these needs and benefits. Sustainability therefore means thinking in terms of whole systems, with all their interconnectedness and consequences. Sustainability issues inherently cut across many boundaries, and are transdisciplinary and transorganisational. This brings to the fore issues of how individuals, groups and organisations make knowledgeable interpretations for sustainability within organisations and professional structures and, in industries based on multi-firm and multi-professional projects, across these boundaries. The above discourse would suggest that the vagaries of different industrial sectors are likely to impact on how knowledge for sustainability is created, transferred and applied. Knowledge in the field of sustainability is also subject to ideological pressures that can be at odds with what makes both business and ecological sense. Under these pressures, from many sources at many different levels of power, decision-making can be either paralysed or pushed into unsatisfactory directions. The challenge of knowledge management is to understand how to create practical solutions to support individuals and groups as they generate or acquire this multi-faceted knowledge so as to suit the particular requirements of their application context (Gurteen, 1998; Armistead, 1999; Alexander *et al.*, 1991; Storey and Barnett, 2000; Despres and Chauvel, 1999; and Coulson-Thomas, 1997). Organisations must also develop the capability to share knowledge between specialisms and across internal and external boundaries (Quintas, 2002). The ability to generate new technological knowledge is now viewed as being linked to a specific learning capability which draws from diverse knowledge bases and is able to activate a systemic recombination process (Antonelli, 1999). Identifying the sets of knowledge that will make the greatest difference, where they reside and how they can be accessed and exploited for team, organisational and communal benefits is integral to the issue of knowledge mapping.

The principal purpose and clearest benefit of a knowledge map is to show people in an organisation or within a network/supply chain where to go when they need expertise. A knowledge map can also serve as an inventory. It is a 'picture' of what exists in an organisation or a 'network' of where it is located. It therefore can be used as a tool to evaluate the corporate knowledge stock (for example, knowledge for sustainability), revealing strengths to be exploited and gaps that need to be filled (Davenport and Prusak, 1998). The dynamics of knowledge management can be just as important, particularly where change is an important issue. Dynamic approaches to modelling and mapping consider the flow of knowledge - how it is created, distributed and accessed - as much as the knowledge itself. To this end, the Transition Project sought to appraise the options for knowledge mapping tools which would meet this need. The results were then used as the basis for the selection and implementation of tools in the main study. At the same time, a structured method to assess and evaluate the efficacy of these knowledge mapping tools against some identified criteria was developed.

RESEARCH METHODOLOGY

The aim of the 6-month study on which this paper is based was to support an integrated approach to the creation, identification, accessing, transfer, mapping and the exploitation of sustainable urban environment (SUE) knowledge in bringing about change by the provision of tools, protocols, guidelines, benchmark indicators and training. The three main objectives of the transition study were:

1. Appraise the options (i.e. tools) for dynamic approaches to modelling and mapping knowledge, which consider the flow of knowledge for sustainability - how it is created, distributed and accessed.

2. Develop a structured assessment to evaluate these knowledge mapping tools against stated study requirements and produce recommendations for use by the main core-plus study.

3. Test and refine the generic model of knowledge mapping for SUE, which would form the basis for the main study.

The overall research process of the 6-month's study is illustrated in Figure 1. The project was given direction through its research aims and identifiable objectives. A combination of research strategies (literature review, semi-structured interviews, and workshop) was adopted. A total of 18 semi-structured interviews were conducted; of these, 14 were with construction industry personnel (architects, main contractors and developers) and 4 were with software developers.

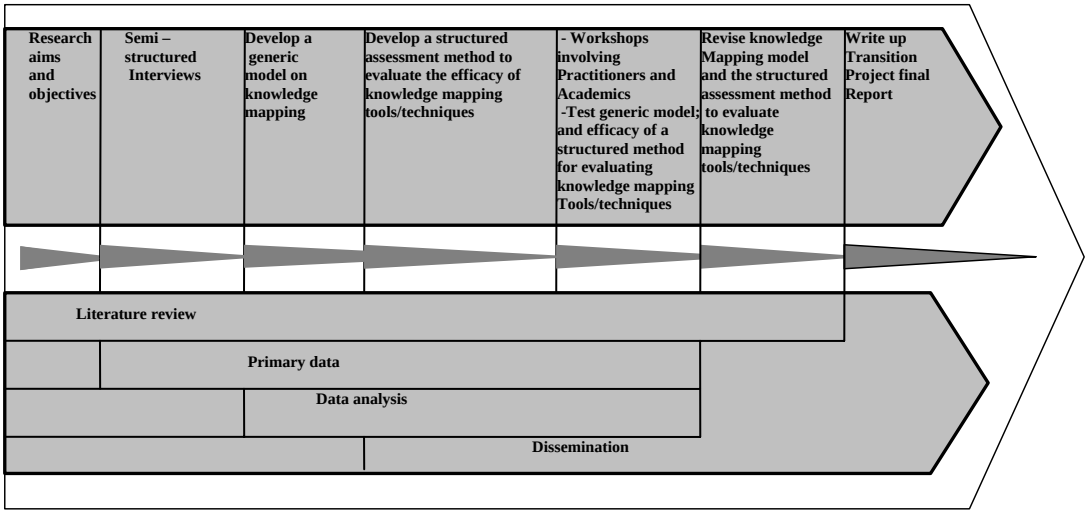

Fig. 1: Research methodology.

The data from the interviews were primarily analysed using content analysis. The workshop conducted (involving 30 practitioners and academics) was useful in testing the developed model on knowledge mapping as well as the structured method for evaluating/assessing the efficacy of knowledge mapping techniques.

KNOWLEDGE COMMUNICATION AND THE BENEFITS OF KNOWLEDGE MAPPING – A SUSTAINABLE URBAN ENVIRONMENT CONTEXT

Martin Eppler informs us that

knowledge communication is the deliberate activity of interactively conveying and co-constructing insights, assessments, experience, or skills through verbal and non-verbal means. This involves the exchange of know-how, know-why, know-what, and know-who through face-to-face or media-based interaction (2005).

A great deal of knowledge for addressing sustainability challenges in the urban environment is tacit in nature. Evidence from the current study indicates that some organisations have been successful at collecting and storing explicit knowledge in organisational databases, but are not always successful at tracking and sharing tacit knowledge.

The distributed nature of organisations makes it difficult to obtain a clear and complete overview of knowledge that is available within organisations. Also, there is a lack of effective communication of sustainability issues within and between organisations, and with customers, clients and key suppliers. The study also revealed that a substantial number of professionals operating in the urban environment find it difficult to access core knowledge for highly knowledge intensive activities, and calls for the need for knowledge mapping. Knowledge mapping helps to increase the 'visibility' of knowledge sources and hence facilitate and accelerate the process of locating relevant expertise or experience. The benefits of knowledge mapping are as follows:

- Helps to find critical information quickly and highlights islands of expertise.
- Improves awareness of organisational cultural issues and their value.
- Improves decision making and problem solving.
- Provides insights into corporate knowledge.
- Increases the ease of access to relevant knowledge.
- Shows the flow of knowledge within and across the organisations.
- Provides an inventory of knowledge assets.

AN APPRAISAL OF THE OPTIONS (I.E. TOOLS) FOR DYNAMIC APPROACHES TO MODELLING AND MAPPING KNOWLEDGE

Through a thorough review of literature and discussions with industrial partners, software developers and trainers involved in knowledge mapping, seventeen key knowledge mapping tools and techniques were identified - each having its strengths and weaknesses in different contexts. These knowledge mapping tools and techniques are: concept maps, mind maps/idea maps, concept circle diagrams, semantic maps, cognitive maps, process maps, social mess maps or cross boundary causality maps, conceptual maps and knowledge flow maps, ontology, Petri-nets, cluster vee diagrams, thesauri, visual thinking networks, topic maps and perceptual maps. The study revealed that many of these tools and techniques are not widely used in the construction industry. The market solutions (off-the-peg tools / techniques) are not perceived to offer added value and are likely to exceed the company's requirements. Many organisations rather prefer to invest in in-house development of intranets and other IT enabled tools. They also rely on techniques long established in the firms. Table 1 presents the most commonly used knowledge mapping tools / techniques which are perceived to be most successful by construction industry actors and software

developers. The study also revealed that the industry actively uses different combinations of nine out of the seventeen tools / techniques (i.e. those in Table 1).

The dynamic mapping of knowledge requires the identification of temporal properties of the content elements and of ways to map them in a dynamic manner. Examples of temporal properties of maps are time, duration, or behaviour. All the tools and techniques investigated might present dynamic characteristics (adaptable to change); however, the cost of adjustment to change (time) may prove prohibitive in some cases. It is therefore necessary to consider the cost benefit analysis prior to designing or choosing the tool / technique. Knowledge mapping activity needs to constantly re-evaluate the location of actors within the network of firms, and their relative importance and significance within the interdependences and hierarchies of the division of labour. Firms and institutions need to find out if the individuals with higher stocks of technical and tacit knowledge have a relevant place in the social organisation of the firm / institution, and whether the individual has a central role in the network. The mapping instrument has to fulfil three needs to achieve a satisfactory level of dynamic modelling. Firstly, the need to depict over time the relations that are most representative or central. Secondly, the need to make relative assumptions as to the 'richness of the social interactions', since individuals with high technical ability might not have, at the same time, a superior stock of social interventions. Thirdly, the need to evaluate the capabilities that for a given moment are most relevant to the firm; these are usually associated with global strategies (integrated into relative competitive positioning) such as profit maximisation, and cost minimisation subject to environmental, social and financial constraints.

NO.	**Knowledge Mapping Tools / Techniques**	**Construction Industry Actors**	**Software Developer**
1.	Casual Map	✓	✓
2.	Cognitive Map	✓	
3.	Concept Map	✓	✓
4.	Knowledge Flow Map	✓	
5.	Mind / Idea Map	✓	✓
6.	Perceptual Map	✓	
7.	Process Map	✓	✓
8.	Semantic Map	✓	
9.	Social Mess Map	✓	

Table 1: Most used and successful knowledge mapping tools/ techniques.

A STRUCTURED ASSESSMENT TO EVALUATE KNOWLEDGE MAPPING TOOLS AND TECHNIQUES

The study also sought to ascertain the efficacy of the knowledge mapping tools and techniques; document what factors are being considered by users in choosing and using knowledge mapping tools/techniques. The distinction between knowledge mapping tools and techniques is that the former is IT enabled. The key factors considered by users of knowledge mapping tools and techniques in the construction industry are robustness, cost, user friendliness, dynamism, the low level of training needed before their use, the degree of positive impact the tool/technique is likely to make on their businesses (processes, services and products) as well as their level of flexibility and adaptability. Table 2 summarises the perceptions of those interviewed with regard to how they evaluated the nine most used tools/techniques. The three scale of 'High', 'Medium' and 'Low' were used in the evaluation. For example, the Social Mess Map technique was rated high in terms of robustness, cost, user friendliness but low in terms of how adaptable or flexible it is.

Evaluation Criteria	**Knowledge Mapping Tools/ Techniques**								
	Casual Map	**Cognitive Map**	**Concept Map**	**Knowledge Flow Map**	**Mind / Idea Map**	**Perceptual Map**	**Process Map**	**Semantic Map**	**Social Mess Map**
Robustness	Medium	Low	High	High	High	Medium	High	High	High
Cost	Low	Medium	Low	Low	Medium	Low	Low	High	High
User Friendliness	High	Medium	Medium	High	Medium	High	Medium	High	High
Dynamism	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Training	Low	Low	Medium	Low	Medium	Low	Medium	Low	Low
Impact	Medium	Medium	Low	Medium	High	Medium	High	Medium	High
Adaptability	Medium	Medium	Low	Low	Low	Medium	Low	Medium	Low

Table 2: Structured assessment for knowledge mapping tools / techniques - construction industry perspective.

The information gleaned from the analysis of the semi-structured interviews with construction industry personnel and software developers was useful in the development of the generic knowledge mapping model.

DEVELOPING, TESTING AND REFINING A GENERIC MODEL OF KNOWLEDGE MAPPING FOR SUSTAINABILITY

An important objective of the Transition Project was to develop, test and refine a generic knowledge mapping model for sustainability. In developing the model, four main issues were seen as important: (1) simplicity; (2) pragmatism; (3) dynamism; and (4) the ability to consider the why, who, what and where of knowledge mapping. Figure 2 presents the generic model of knowledge mapping that was developed. In considering the triple bottom line of sustainability (economic, social and environmental), the model uses a five-step approach to address the main issues of knowledge mapping. The first step is to set out knowledge mapping goals (why knowledge mapping? – i.e. making a business case). The second step is to identify knowledge needs (which needs currently exist and which knowledge assets are needed?). The third step identifies the knowledge gap that needs to be addressed. This is followed by the need to either capture and/or create appropriate knowledge to fill the identified gap (step 4). This then leads to step 5, where the knowledge has to be leveraged, exploited and retained as appropriate.

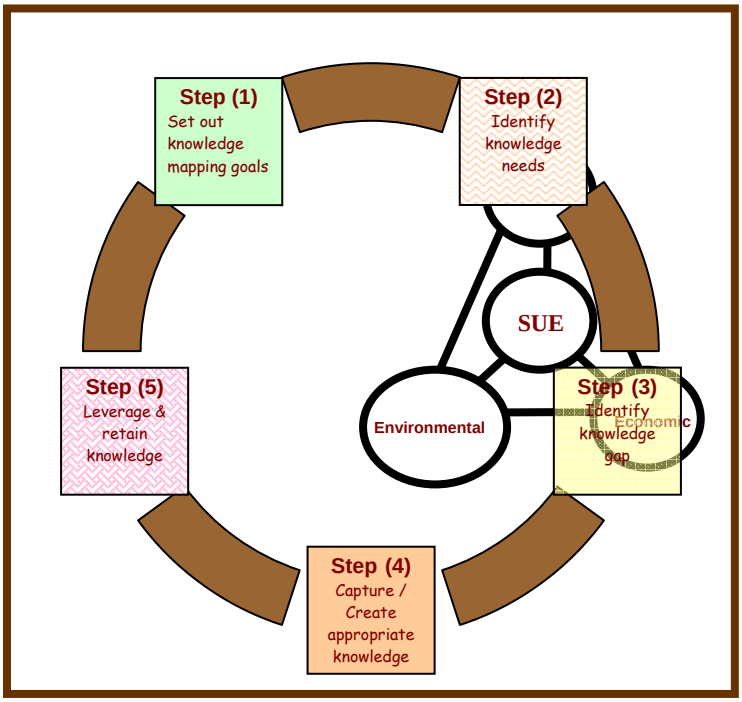

Fig. 2: A generic model of knowledge mapping.

These five steps have feed forward and backward loops, allowing for the possibility of evaluation and improvements at each stage. In this way the model is able to cater for the dynamic nature of knowledge in different contexts. The details and explanations of the processes of each of the stages are in the final study report (www.sue-km.org). Important lessons and helpful hints have been identified in our development of the generic model, which allow us to make useful recommendations for the benefit of industry and academia. The most important ingredient for effective knowledge mapping is the 'right' people who understand the processes or knowledge domain. Knowledge maps can be as sophisticated or as simple as a team /organisation wishes them to be. From a pragmatic point of view, there are instances where a process map, flip chart, sticky notes, Microsoft Word, Excel, PowerPoint and Visio software and the right people are all a knowledge mapping team needs. There are few things that a knowledge mapping team needs to pay due cognisance to – a form of checklist. It is important to start with the end in mind by clearly articulating and stating the goal of the knowledge mapping activity/exercise. Keep the Pareto principle (80/20 rule) in mind – map the most important and frequently used knowledge first. A high-level mapping of the process/area that the team/organisation wants to share knowledge around is important. Recruit the right people. Collate all the necessary strategy and policy documents, competency maps and process maps that are needed before starting the exercise. This is to be followed by collating available or previously created databases of operating procedures and knowledge sources. Also consider recruiting or employing someone with some expertise or working knowledge of readily available software such as MS Excel, Visio, PowerPoint and Word. Following the development and use of knowledge maps, it is important to accurately update the knowledge maps.

DYNAMIC KNOWLEDGE MAPPING WITHIN A SUSTAINABLE URBAN ENVIRONMENT CONTEXT

Dynamic knowledge mapping requires the identification of temporal properties of the content elements and of ways to map them in a dynamic manner. Examples of temporal properties of maps are time, duration, or behaviour over time. One approach of introducing dynamism into knowledge mapping tools is the integration of multimedia elements. These elements can display dynamic content like audio and video, but do not affect the map's structure. A dynamic knowledge map could be a web-based knowledge navigator that searches for experts and facilitates communication with the experts by using Internet technology. Logging into dynamic knowledge map could help search for an expert with relevant knowledge and connect him/her in real time by using instant messaging, email, telephone or internet conferencing. The knowledge mapping tool is still static, although it indicates what knowledge is needed to support processes, and the gaps between required skills and current skills. The usefulness and dynamism of knowledge maps for the sustainable urban environment is an issue worthy of deeper investigation.

Studies show that mapping tools are useful when they are used within a known context (i.e. where the user is a producer of map(s)). It also shows that if knowledge mapping is used with 'hyper net' then this helps the author to represent the knowledge in a formalised way, suitable for expression as a hypermedia domain. Whether this domain representation is more or less useful for the user is open to educational debate.

All the knowledge mapping techniques investigated in this study present dynamic characteristics (adaptable to change). However, the cost of adjustment to change (time) may prove prohibitive in some cases. It is therefore necessary to consider the cost prior to the design of the system.

The consequence is that the ‘mapping’ activity needs to constantly re-evaluate the location of actors within the network of firms, their relative importance and significance within the interdependences and hierarchies of the division of labour.

CONCLUSIONS AND RECOMMENDATIONS

Effective knowledge mapping and communication have a significant positive role to play in decision making and the provision of sustainable solutions for projects and activities within the urban environment. Knowledge mapping helps in finding critical information quickly and highlighting islands of expertise. It improves awareness of organisational cultural issues and helps to create shared understanding, mutual trust and process improvements.

The main knowledge mapping techniques in common usage are: concept maps, mind maps / idea maps, concept circle diagrams, semantic maps, cognitive maps, process maps, social mess maps / cross boundary causality maps, conceptual maps, and knowledge flow maps.

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