

CHALMERS



Knowledge Sharing Across Professional Boundaries in Construction

Facilitators and Hindrances

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Department of Civil and Environmental Engineering

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2012

THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

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*"Knowledge is a treasure chest
and exercise is the key to it."*

Thomas Fuller

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Abstract

In a separated processes according to professional functions, the ambition of becoming sustainable calls for collective innovation through collaboration. For this to happen, learning and the sharing of knowledge between professional groups and organisational entities needs to be improved in project-based contexts. Knowledge in the construction industry largely exists in its tacit form and is based on individuals' experiences and perceptions of the world. This knowledge is therefore bounded by their every day practice. Studies have pointed out that research on knowledge management in the construction industry has neglected to examine the actual practices of sharing knowledge. The aim of this thesis is to explore the factors influencing knowledge sharing across organisational entities and professional groups in construction. The community of practice conceptual framework has provided a way to explore how knowledge is created and shared in the social practices of this industry. Findings from three case studies based in different organisational and project environments addressing the challenge of energy efficiency of buildings showed that brokering was needed to create opportunities for professional groups and organisational entities to communicate and share knowledge. The most fertile environments for knowledge sharing were found in pilot projects, where resources like time and funding helped create the necessary space for knowledge sharing to take place. These findings contribute to a better understanding of how knowledge is created and disseminated in practice in construction. The study as a whole contributes empirically and theoretically to the current general debate on management of knowledge.

Keywords: *knowledge sharing, brokers, pilot projects, time, energy efficiency of buildings, project based settings, case study*

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Göteborg, August 2012

Karin Johansson

Appended papers and distribution of work

PAPER I:

Knowledge Sharing and Learning Across Community Boundaries in an Arena for Energy Efficient Buildings.

Gluch, Pernilla, Johansson, Karin, Räisänen, Christine. Journal of Cleaner Production, article accepted for publication.

This paper has an equal authorship. Johansson has carried out the interviews and most of the observations on which the article is based. She has had the main responsibility for writing up the research approach, the result section and has also contributed to the literature review, the discussion and the conclusions.

PAPER II:

The Role of the Individual in Sharing of Knowledge in Project-based Organisations

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All work by Johansson.

Additional publications by the author

Knowledge Management i byggindustrin: En förstudie med fokus på kunskapsbärare vid standardisering av produkter och processer i byggandet.

Johansson, Karin, rapport 2010:5, Chalmers Repro, Gothenburg, Sweden, 2010.

Constructing an Arena for Energy Efficient Multi-family Housing Development: A case study of inter-organisational knowledge sharing.

Johansson, Karin and Gluch, Pernilla, in proceedings of *The European Roundtable on Sustainable Consumption and Production and Environmental Management for Sustainable Universities conference* (ERSCP-EMSU 2010), Delft, The Netherlands, 2010.

Exploring the importance of organisational Culture in a Merger of Two Construction Companies.

Johansson, Karin, in *Performance Improvement in Construction Management*, Atkin, Brian and Borgbrant, Jan (Eds), Spon Press, Oxon, UK, 2010.

Environmental attitudes, management and performance.

Gluch, Pernilla; Brunklaus, Birgit; Johansson, Karin; Lundberg, Örjan; Stenberg, Ann-Charlotte and Thuvander, Liane in *Performance Improvement in Construction Management*, Atkin, B. and Borgbrant, J. (Eds), Spon Press, Oxon, UK, 2010.

What encourage clients and contractors to take common action on sustainability issues?

Johansson, Karin and Gluch, Pernilla, in proceedings of *The World Sustainable Building Conference* (SB08), Melbourne, Australia, 2008.

Miljöarbete inom bygg- och fastighetssektorn - en litteratursammanställning med fokus på miljöledning, avfall, energi, inomhusmiljö och farliga ämnen.

Johansson, Karin and Gluch, Pernilla, rapport 2007:9, Bygg- och miljöteknik, Chalmers Tekniska Högskola, 2007.

A Questionnaire Survey of Environmental Attitudes, Management and Performance of Swedish Architects and Technical Consultants.

Thuvnader, Liane, Brunklaus, Birgit, Gluch, Pernilla, Johansson, Karin, Lundberg, Örjan, Stenberg, Ann-Charlotte, in proceedings of the *CESB 07 Conference*, Prague, Czech Republic, 2007.

What makes it slow? A questionnaire survey of environmental attitudes, management and performance.

Gluch, Pernilla; Brunklaus, Birgit; Johansson, Karin; Lundberg, Örjan; Stenberg, Ann-Charlotte; Thuvander, Liane, in proceedings of the *4th Nordic Conference in Construction Economics and Organisation*, Luleå, Sweden, 2007.

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1. Introduction

In the ongoing debate on how to deal with climate change, the construction industry has been found to be significantly responsible for CO₂-emissions and energy consumption (e.g. Cole, 2011; Whyte and Sexton, 2011; Glad, 2012). To address these issues, the Swedish parliament has set the target of a 50% reduction of energy use in buildings by 2050. As a result, measures to improve the environmental performance of buildings are currently in focus (e.g. E2ReBuild, 2011; Dalenbäck and Mjörnell, 2011, Glad, 2012). The challenge of reducing energy use in buildings within the time frame set by the state affects all actors in the construction industry (e.g. Cole, 2011). Shouldering this challenge in a fragmented industry, where roles and interests diverge, has proven difficult (Whyte and Sexton, 2011).

The focus on energy efficiency puts demands on clients in the form of private and public builders as well as property owners to educate themselves so as to be able to consider energy use when engaging architects, consultancy firms and contractors in the construction process. These organisations in turn, have to educate themselves in order to be able to fulfil client demands. The knowledge sought after, i.e. how to make buildings more energy efficient, is held by not only groups and individuals within the organisations operating in the construction industry, but also by researchers at universities and research institutes. Thus, for the construction industry, the challenge of becoming more sustainable calls for innovation through collaboration. This entails addressing learning and the sharing of knowledge between professional groups and organisational entities in a highly projectified environment.

The number of buildings needing renovation to improve energy efficiency is enormous (Dalenbäck and Mjörnell, 2011; E2ReBuild, 2011). Standardisation of products and processes (E2ReBuild, 2011) and inter-organisational networks (Rubino *et al*, 2007) have been ways of addressing this challenge. In a highly projectified environment these measures involves

collective work across organisational boundaries. This provides opportunities to explore the creation, sharing and management of new knowledge in project based settings.

Managing, creating and sharing knowledge has been found to provide competitive advantages for the individual organisation (e.g. Koch 2002; Ahmad and An, 2008). Knowledge in the construction industry exists mostly in its tacit form, based on individuals' experiences and perceptions of the world (Ahmad and An, 2008; Styhre, 2009). This knowledge, which cannot be expressed orally or in writing, is bound to every day practice and plays a prominent role in the construction industry context (Styhre, 2009). As such, there is an interest for the individual organisation operating in this project based context to capture and manage tacit knowledge. However, it has been argued that in order to accomplish this, the traditional view of projects as a practical organisational form of addressing market expectations needs to be challenged (Sense, 2009). It has been suggested that projects should be viewed as multidisciplinary environments where individuals representing different professions and organisational entities interact and create and share knowledge (Sense, 2009; 2011) through problem solving and innovation (Sexton and Lu, 2009). Researchers have seen that creating and sharing knowledge requires bridging boundaries between different social practices (e.g. Ruuska and Teigland, 2009; Pemsel and Widén, 2011; Sense, 2011).

How to create, manage and/or support the bridging of boundaries requires an understanding of how knowing is acquired in and through practice and how knowledge is created in interconnected activities (Nicolini, 2011). Using Wenger's (1998) community of practice framework is a viable away of exploring knowledge sharing across disciplinary and professional boundaries.

In the context of the construction industry, Wenger's framework has been used to develop tools to measure management performance. For example,

Yu *et al* (2009) applied the model to provide support to Knowledge Management managers in architectural and engineering consultancy organisations on how to plan improvement strategies for value-adding processes. Wenger's framework has also been used to investigate what strategically implemented communities of practice in large construction firms needed in order to be seen as an organisational resource within the organisation (Elmualim and Govender, 2008). In their study, the concept's relevance as a driver of innovation within construction organisations was questioned, and it was concluded that further research was needed to investigate how its merits could be utilised. Further, the concept of communities of practice has been used as a means of creating collective competence in inter-organisational collaboration to achieve project success (Ruuska and Teigland, 2009). In this case, the need for clear project charters, a person with strong knowledge broker skills, the use of boundary objects and an open communication were found to be of essence to successfully bridge boundaries between professional groupings and organisational entities (*ibid*). Moreover, Wenger's framework has been applied to investigate how managers of intentionally created communities of practice in project-based organisations lead to achieve best practice (Bishop *et al*, 2008). Their study found that the means provided (such as steering group and workshops) to create communities of practice within an organisation facilitated the process rather than steered it. Further research was advocated to validate their findings, but also to establish how the element of time affects the possibilities of creating and managing communities of practice (*ibid*).

However, studies have shown that research on Knowledge Management in the construction industry insofar has neglected to study the actual practice of sharing knowledge (for overview see Styhre, 2009). Thus, in order to continue the debate on the management of knowledge more research is needed to uncover the informal and emergent practices within the intra-organisational context that constitutes the construction process, where tacit aspects of knowledge constitute a part (*c.f.* Chan and Räsänen, 2009).

1.2 Research aim

By investigating knowledge sharing on the energy efficiency of buildings in both intra- and inter-organisational settings, the aim of this thesis is to explore the factors that influence knowledge sharing across organisational entities and professional groups in construction. In pursuing this aim the following question is asked: *What factors facilitate and hinder knowledge sharing across organisational entities and professional groups in construction?* The reasons for examining this issue are to add to the understanding of how knowledge is created and diffused in practice and contribute to the debates on the management of knowledge in project based organisational settings.

2. Theoretical framework

The theoretical framework used in this thesis will begin by explaining the notions of knowledge, knowing and competence, followed by a presentation of the conceptual framework of community of practice, ways of sharing knowledge and how knowledge may be shared across community and organisational boundaries. The last sections describe how knowledge has been found to be shared, and how the concept of communities of practice has been applied in the construction industry context along with how networking, learning and social interaction have supported sustainable development and energy efficiency.

2.1 Knowledge, knowing and competence

By using Polanyi's (1983:4) much cited definition of tacit knowledge, "we know more than we can tell", in an organisational context, it is suggested that organisations may have access to more knowledge than they can explicitly express. Nicolini *et al* (2003) claimed that although the field of research on learning and knowing in organisations originates from different intellectual backgrounds, the commonly held view is that learning and knowledge are social and cultural phenomena. Knowledge then becomes a social expertise held in action which reflects its historical, social and cultural context. More, knowledge is constantly negotiated and reproduced by individuals in a social setting, i.e. it is always dynamic and provisional (Nicolini *et al*, 2003). According to the same line of reasoning, knowing is interpersonal (Strati, 2003) and always rooted in ongoing practice (Nicolini *et al*, 2003).

The interpretation and evaluation of knowledge in a social context where an individual's or group's internalised stock of knowledge is labelled, categorised and found interesting to seek out may best be described as perception of competence. In order to be seen as competent, a person has to be able to interpret a situation in context and adjust his/her actions accordingly. To evaluate and adjust actions in accordance with a situation

and in a context requires experience of similar situations (Elliot and Dweck, 2005). This means that a community as a social learning system will inherently encourage knowledge sharing concerning preferred competence (valued knowledge) and by nature will not explore the whole body of knowledge of its members. This also entails neglect to explore knowledge held by other communities as each individual is a member in multiple communities (e.g. Wenger, 1998).

2.2 The conceptual framework of communities of practice

In Wenger's (1998) social theory of learning, communities of practice, it is clear who is seen as competent, inferring that competent participation in a practice is recognised as knowing. Who is seen as competent and admitted into a community of practice is determined by a number of things: 1) the individual's ability to engage with other community members and take action in accordance with the community's practice (mutual engagement); 2) his/her ability to understand, take responsibility for, and contribute to the community's negotiation and pursuit of common goals (joint enterprise); and 3) the ability to make use of the community of practice's shared repertoire, i.e. tools, symbols and artifacts, in a way that legitimises participation and contributes to the practice (Wenger, 1998).

In their seminal work, Brown and Duguid (1991) noted that a shared repertoire is developed and maintained in practice through three communication-based processes: narration (storytelling to facilitate understanding of technology/events/work practice, and creating a vocabulary to solve problems), collaboration (an interactive process discussing group problems that leads to a reduction of conflicting meanings and the development of knowledge), and social construction (which is demonstrated through narration and collaboration, and displays how an individual identifies with a community). When an individual identifies with a community, this is exhibited by the adoption of the behavioural patterns of other members of the community as well as through a shared repertoire (Schenkel *et al*, 2001). Identification with a certain community of practice

can thus be detected through the discourses of preferred collaboration partners among individuals and implies that the individual has access to the community's collective body of knowledge (Brown and Duguid, 1991).

As such, communities of practice has been found attractive as a knowledge management tool when organising firms to connect employees across organisational entities and country borders to create and share new knowledge so as to create competitive advantages (e.g. Wenger and Snyder, 2000; Wenger *et al*, 2002; Koch, 2002; Roberts, 2006). Although organisations have been described as multiples of single communities of practice, these communities may also span organisational boundaries (e.g. Brown and Duguid, 2001). Communities of practice emerge and live organic and fluid lives which cannot be controlled or managed. Their existence within organisations can however be acknowledged, encouraged and supported (e.g. Brown and Duguid, 1991; Wenger *et al*, 2002). There is an ongoing debate on how far management of these communities can be taken. Wenger and Snyder (2000) and Wenger *et al* (2002) claim that managers can cultivate this form of organising to complement already existing organisational structures where, as Roberts (2006) found, simply focusing on how to manage these communities is not sufficient to make the creation of knowledge spark innovation. Instead, power relations, trust and predisposition to social codes (*habitus*) affect communities and even individuals within communities, and need thus to be taken into account. The context in which a community of practice exists may allow it to thrive or hampers its development and in extension the creation and sharing of knowledge (Much, 2003; Roberts, 2006) within and between them. The perspective of time has also been highlighted by researchers applying the concept of communities of practice onto management of knowledge within organisations. Here, time has been identified as one of the important factors that support the forming and development of communities of practice in accordance with organisational strategies (e.g. Bishop *et al*, 2008).

2.3 Sharing knowledge across community and organisational boundaries

As noted above, communities of practice are not isolated. To thrive they need outside influence. As communities of practice focus on their interests and/or tasks, they inevitably create boundaries (Wenger, 1998; Wenger *et al*, 2002). The boundaries of a practice are informal, and frequently even unarticulated. Nevertheless, they are real and can be identified via variations in the use of language, vocabulary, artifacts, sets of experiences and ways of carrying out a task.

Sharing knowledge across boundaries requires mediators. Depending on the context, Brown and Duguid (1998) called these persons translators or knowledge brokers, Wenger (1998; 2000) called them brokers, whereas Sverrisson (2001) saw them as entrepreneurs. The individuals referred to are 'importers-exporters' of knowledge between communities of practice. These knowledge brokers or mediators have central roles at the interface between different communities of practice, and facilitate the dialogue between them by translating vocabulary, symbols and tools (Wenger, 1998; Wenger *et al*, 2002; Yanow, 2004; Meyer, 2010).

One distinction between translators and knowledge brokers is that they mediate knowledge under different circumstances, i.e. between organisations seen as communities (translators) or within firms (brokers) (Brown and Duguid, 1998). A translator has to be familiar with the practices of both communities in order to be able to negotiate meaning and gain trust both within and between them. Gaining the trust of both communities of practice as she/he negotiates meaning within both of them was found to be crucial and achieved by simultaneously taking into consideration the interests of the other community (Brown and Duguid, 1998). The knowledge broker on the other hand belongs to the communities of practice she/he mediates knowledge between, e.g. a person who is a member of several communities such as workgroups or projects (Wenger, 1998). This type of knowledge brokering requires concurrent membership in those

communities of practice between which knowledge is to be shared. Consequently, here trust is of lesser importance (Brown and Duguid, 1998).

The term entrepreneur was used by Sverrisson (2001) to describe the activities of environmental brokers in the sense of intermediaries or negotiators who facilitate and channelled interaction in social settings. Conversely, or in extension to the definition of brokers as suggested by Wenger (1998) and Brown and Duguid (1998), Sverrisson (2001) claimed that a broker is likely to also have other missions and his usage of the term entrepreneur is to highlight a social role assumed in a practice. As Sverrisson (2001:319) put it “knowledge brokers do not merely identify which part of the process can be adjusted or changed in a direction currently seen as environmentally friendly. Simultaneously, they suggest which specific technical competence might be appropriate, and quite often they recommend or bring in persons who possess this specialized competence”. These brokers thus provide a service based on their knowledge; a knowledge which has to be deep enough to foresee the implications of actions and broad enough to make suggestions on how to proceed. Also, their skills in connecting networks are sustained by their success in appointing the appropriate expertise, i.e. they have to be seen as competent in their role. In industry, these services are associated with consultancy where activities are ‘taxed’ in a time-honored fashion (Sverrisson (2001).

2.4 Knowledge sharing in the construction industry

The project-based construction process offers an inter-organisational setting where different organisations contribute with certain kinds of knowledge. The process is driven by a shared interest in completing a common, specific task, which offers opportunities for sharing knowledge and learning across organisational and professional boundaries. The nature of the construction process has driven its participants to adhere to a practice of problem solving in the project setting, acquiring and developing knowledge by making use of multiple sources (Sense, 2009) of professional expertise. Besides carrying out their main operations, organisations in the construction industry, as in

many other industries, use projects to develop new technology and/or to innovate. Many times these full-size development projects are provided with further recourses, e.g. time and funding, and are called pilot projects. As the process evolves, actors come and leave at different stages. A construction project cannot therefore be separated from its context, i.e. its historical and organisational environment (Engwall, 2003). They are “contextually-embedded open systems, open in time as well as ‘space’” (ibid).

Sharing of knowledge within the construction industry is thus an inter-organisational challenge dependent on informal and personal contacts (e.g. Styhre *et al*, 2004). However, how to manage knowledge sharing has mainly been focused on by researchers and practitioners from an intra-organisational perspective as a means to sustain competitive advantage. A literature review of Knowledge Management in the construction industry showed that research to date has largely neglected studying the actual practice of sharing knowledge (Styhre, 2009). Further, Kamara *et al* (2002) found that Knowledge Management initiatives have mostly been focusing on “capturing, codifying and transmitting knowledge” (Kamara *et al*, 2002:55). There have of course been exceptions, such as Bresnen *et al* (2004), who by studying the use of a ‘dashboard’ explored the actual practice of management of knowledge in construction projects, and Gluch and Räisänen (2012) who highlighted tensions in the form of differences in goals and foci between project and environmental management practices. In their study, Bresnen *et al* (2004) found that it was important to understand not only how knowledge is created and implemented, but also how working practices effect its diffusion in project based organisations (cf. Gherardi and Nicolini, 2002). It was found that each organisation has its own logic of action based on how they view knowledge (Bresnen *et al*, 2004) and this in turn was influenced by the conditions under which a construction project had to be finalised: on time, on budget and with profit. These factors often define the conditions under which knowledge is created, shared and managed by actors in the construction process.

Unless bridged by brokers organisational and procedural differences have been found to create barriers between the different organisational and professional communities in the construction process (Ruuska and Teigland, 2009; Pemsel and Widén 2011). Similarly, capturing knowledge and mediating it across organisational boundaries has been found to be dependent on roles that support and connect projects and organisations (Bresnen *et al*, 2003). Mediating knowledge is often associated with support functions and domain experts who have been found to rely heavily on personal contacts in order to be able to do their work (Bresnen *et al*, 2003; 2005). As such, the roles of support function and domain expert have been suggested to constitute knowledge management mechanisms in project-based organisational settings as they through their practice have the possibility to transcend barriers in the construction process (Bresnen *et al*, 2003; Pemsel and Widén, 2011). More, Gluch and Räisänen (2012) have in their study of the interrelationships between environmental support functions and project practice pointed out the need to create arenas where these different practices can negotiate meaning and align operational activities.

2.5 Communities of Practice applied in construction

Among researchers, the concept of communities of practice has emerged as both a theoretical lens to explain prerequisites for knowledge sharing in construction (e.g. Gherardi and Nicolini, 2002; Bresnen *et al*, 2003; Elumalim and Govender, 2008; Schenkel and Teigland, 2008), and as a management tool to address the possibilities of capturing and spreading tacit knowledge (e.g. Koch, 2002; Bresnen *et al*, 2003; Grisham and Walker, 2006). Whether taking an intra- or inter-organisational perspective on knowledge sharing, it has been claimed that communities of practice benefit organisations in the construction industry as they sustain a flow of information that facilitates sharing of knowledge and expertise in a projectified context (Grisham and Walker, 2006). To date, Schenkel and Teigland (2008) as well as others have found that in relation to

organisational performance stability in communication channels (e.g. face-to-face, paper based, telephone and/or email) was of importance for communities of practice in sustaining their ability to continuously develop and improve their performance. Informal face-to-face communication in problem solving and in enabling operations run smoothly was found to be the most beneficial (Schenkel and Teigland, 2008). More, improved performance was found to be dependent on continuous access through social interaction to a community's collective memory. By pointing out these interrelationships, Schenkel and Teigland (2008) directed management attention to the importance of respecting and supporting a community's cognitive processes and their dependence on close interaction to sustain momentum in their practice. Elmualim and Govender (2008) also concluded that management's understanding of, and commitment to support, a community of practice was essential to its continuous development and to drive best practice. This meant allocating time and facilities for the community to interact so that the community may mature (ibid).

The understanding that knowledge is created and shared in the multi-organisational setting of projects has also resulted in attempts to create social practices for sharing knowledge by introducing inter-organisational networks (e.g. Rubino *et al*, 2007) and in the form of communities of practice (Love and Ellis, 2009). Love and Ellis (2009) refer to communities of practice as an organisational form that has yet to be used as a strategic tool in the construction industry for inter-organisational knowledge sharing. These authors suggest that creating inter-organisational communities of practice, referred to as 'champions of practice', shoulder the challenges put on the construction industry by society. The argument for forming these inter-organisational collaborations was that construction industry actors "remain competitive in the long term and improve the industry's performance and productivity" (Love and Ellis, 2009:11).

3. Description of studied project settings

Managing knowledge in the scattered and segregated environment of the construction process has been attempted within organisations by trying, for instance, to capture knowledge and best practice and store these in standardised building systems. Conversely, facilitating knowledge sharing between organisations has been attempted by creating opportunities for social interaction through various networks.

The three studied case settings comprise a process including many professional roles and organisational entities. These three case settings are described below. For further reading see paper I and II.

3.1 The pre-study - exploring knowledge sharing behaviour in a construction group

Initially, a pre-study disclosed the difficulties the construction industry currently has in implementing sustainable actions to support knowledge sharing (see Johansson, 2010 in additional publications list).

The studied organisation was a construction group with approximately 17 500 employees working in four business areas: construction (contractor), housing development (builder), property development (builder) and roads and infrastructure (supplier and contractor). The construction group also has its own technical consultancy firm organised under the business area of construction. It is also under this organisational entity that the R&D department could be found. This department frequently hire in-house consultants for research and development projects.

3.2 Case I - an arena created to share knowledge on energy efficiency of standardised buildings during renovation

Case I investigated the possibilities for sharing knowledge on energy efficiency between professional groups and organisational entities during renovation of buildings constructed using standardised building systems.

Standardising building processes and products has been attempted before in the construction industry. In the 60'ies and 70'ies most buildings were constructed using standardised building methods. This time period has often been called 'the great development' since approximately 600 000 apartments were built in a period of 10 years. These buildings are today largely owned by public housing companies and they consume on average 185kWh/m²/year. Current regulations prescribe a consumption 110kWh/m²/year for similar types of new buildings (Swedish Energy Agency, 2011).

The Swedish parliament has set the target of a 50% reduction in energy use in buildings by 2050. To meet this target all existing buildings have to be replaced or appropriately renovated (Dalenbäck and Mjörnell, 2011). To meet these demands regulating the energy use in buildings, monetary incentives were put in place by the state.

The studied project setting in case I, the establishment of a knowledge sharing arena on energy efficiency of buildings during renovation, was a result of state funding. The arena project was created by researchers from a technical university together with researchers from a research institute. The initiative was thought to offer a meeting place for researchers and municipal-housing companies where issues related to energy efficient renovation of multi-family housing produced using standardised building techniques during the "great development" could be discussed. Other participants invited were an energy supplier and a local governmental authority. The arena objectives, as formulated in the application, were three-fold: 1) to share knowledge between researchers and practitioners (clients, contractors and consultants), 2) for researchers to gain knowledge from real-life projects in order 3) for them to disseminate this knowledge to future projects. The thought behind the planned activities was thus to create and share knowledge through social interaction in such common forums as pilot projects (provided by municipal-housing companies), open arena seminars and meetings (see paper I).

Apart from state funding, the arena was financed by membership fees from the practitioner organisations. These fees could later be used to engage researchers as consultants. The researchers would take part in project activities and share their knowledge when developing renovation techniques and processes to make the buildings more energy efficient.

3.3 Case II – the development of a standardised building system for energy efficient multi-family housing

Case II focused on the current industry efforts to meet market demands on energy efficiency and higher quality of delivered products by developing standardised building systems.

The studied development process was undertaken in the organisational setting of the same construction group as previously described in the pre-study.

To meet market demands, the housing development organisation made a strategic decision to set up one energy-efficient housing project in each of its four geographical regions. The decision marked the starting point of the development process of a standardised building system for energy efficient housing. This process proved to be dependent on two separate projects initiated by two different organisations within the construction group: a pilot project for energy efficient housing in line with the strategic decision in the housing development organisation, and a development project for the standardised building system for energy efficient housing initiated by the construction organisation. In order to get access to relevant expertise both projects hired in-house consultants. Also, the pilot project engaged an architect and external consultants to take part in the development of building descriptive documents, whilst the development project chose to engage suppliers as external expertise in this process.

4. Methodology

This section describes the methodological approach taken in this thesis. It starts with a brief description of the research approach followed by the description of how empirical data was collected. The process of collecting empirical data and applying theoretical frameworks for this thesis has evolved in a way best described as systematic combining (Dubois and Gadde, 2002).

4.1 Research approach and process

To explore how knowledge sharing is facilitated across community boundaries between organisational entities and professional groups and what role context play in this process, an abductive approach to case study research has been used. Here, the interplay between theoretical framework, collection and analysis of empirical data furthers the understanding of each other. Systematic combining draws on two processes: matching theory and reality, as well as directing and redirecting the collection of data and the search for an analytical framework. Decisions made by the researcher in these processes are affected by: “what is going on in reality, available theories, the case that gradually evolves, and the analytical framework” (Dubois and Gadde, 2002: 554).

For this thesis, case study methods have been used to collect data. Although they are set in different project based contexts, the thesis uses three separate cases that build on each other. More specifically, the understanding of the results in the pre-study was furthered by investigating knowledge sharing in the setting of case I, where the role of the individual as mediator in the multi-organisational and professional context of an arena project was found to be essential for knowledge sharing. This understanding was further explored in case II, a development project of a standardised building system, in which the role of the individual as mediator was also found to greatly influence the possibilities of sharing knowledge across organisational and professional boundaries. The process of matching theory

and reality, along with direction and redirection of data collection and analytical framework throughout the work on this thesis can be seen in *Figure 1*. In this process, the focus of inquiries shifted from Knowledge Management in project based settings to what influences knowledge sharing in these same settings. This has in turn, and in line with the systematic combining approach to case-study research, guided the “expansion of the boundaries of the case” (Dubois and Gadde, 2002: 557) from the management of knowledge using standardisation of products and processes towards the role of the individual in knowledge sharing across community boundaries.

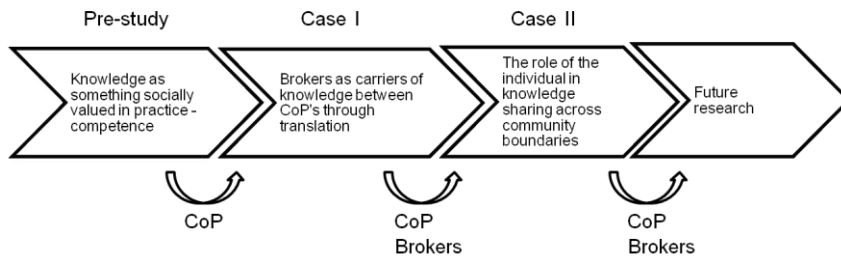


Figure 1: The systematic combining processes of matching theory and reality leading to the evolution of the analytical framework used in this thesis.

In the pre-study, focus was on exploring the knowledge sharing behaviour in the organisational setting of a large construction group by studying their use of standardised building systems, networks for competence and Knowledge Management tools. All these were designed to capture and share knowledge between organisational entities, i.e. different business areas and individual projects (see also Johansson, 2010 in additional publication list). The main emphasis was on making production more streamlined and cost and time efficient, a current trend among construction organisations within the construction industry, but in addition it was an attempt by management to capture and mediate knowledge within the organisation. Concerns raised in this case were associated with how to create development and user routines that would ensure the continuous development of a standardised

building system that facilitated knowledge sharing. More, the view of knowledge and knowledge sharing was found to be dependent on and associated with competence, i.e. what is seen as knowledge in a specific social context. Therefore, the focus of the next case study was directed towards knowledge sharing in social practice.

The theoretical framework chosen in the pre-study consisted of social theories of learning, more specifically communities of practice, as this framework was found to explain how knowledge sharing took place in this project based organisational setting: through social interaction mostly delimited to a smaller group in everyday practice. The concept of communities of practice was also applied as an analytical framework in case I, where the initiative to create an arena project for sharing knowledge on energy efficiency of buildings across professional and organisational boundaries was explored.

Apart from semi-structured interviews where questions were designed to identify attributes (e.g. language, symbols, tools, worldviews and historical events) of communities of practice, several other case study methods were used to collect data (see *Table 1*). In line with Dubois and Gaddes' (2002) systematic combining approach to case study research, the methods chosen to collect data each helped directing inquiries and analysis in other sources of data, furthering the understanding of how knowledge was shared within the arena project. The analytical framework chosen helped identify different communities within the arena project setting. According to Dubois and Gadde (2002), this can be seen as passive data, i.e. data that the researcher set out to find.

The results showed that knowledge sharing within the arena project was dependent on social interaction over time. It was also found that individuals' actions in the translation of vocabulary between professional groups, characterised as brokering, were essential for knowledge sharing across community boundaries in this context. These findings endorsed the choice

of analytical framework, where brokers are seen as important for knowledge creation and sharing in practice. Also, the analytical framework was extended to include theories on knowledge brokering as these helped explain bridging mechanisms between the communities in this project-based setting.

The analytical framework used in case I guided the study of knowledge sharing in case II, which consisted of a different project-based setting. Here, the process of developing a standardised building system for energy efficient housing in a multi-organisational and professional environment was investigated.

4.2 Collection of empirical data

The empirical data used in this thesis have been collected using case study methods such as: interviews, document analyses, field observations and informal conversations in three different settings. A case study approach was chosen as it enables an exploration of the sharing of knowledge in different project environments. Methods chosen to collect data enhanced and furthered the understanding of knowledge sharing by reflecting different characteristics of the context studied. For an overview of methods used to collect data and a description of the interviewees see *Table 1*.

The represented organisations were: one architectural firm, one in-house consultancy firm, six municipal-housing companies, one housing development organisation, one construction organisation and two research organisations. These organisations were selected since they together covered the span of professional groups and the different phases of the construction process.

	Pre-study Spring 2009	Case I Spring 2010	Case II Spring 2011
Interviews	<p>8 interviews/9 respondents (at 1 interview 2 interviewees participated)</p> <p>Semi-structured interviews, audio recorded and iteratively summarised, resulting in a detailed list of quotes, phrases, concepts and key words</p> <p>1-2 hours/ interview</p> <p>7 middle managers (from 2 construction organisations) 2 technical consultant</p>	<p>18 interviews/ 18 respondents</p> <p>Semi-structured interviews, audio recorded and iteratively summarised, resulting in a detailed list of quotes, phrases, concepts and key words</p> <p>1-3 hours/ interview</p> <p>4 researchers (technical university) 4 researchers (research institute) 7 middle managers (different municipal-housing companies, practitioners) 1 middle manager (local governmental authority) 2 middle managers (energy supplier)</p>	<p>12 interviews/ 12 respondents (1 interviewee was also interviewed in the pre-study)</p> <p>Semi-structured interviews, audio recorded and fully transcribed</p> <p>1-2 hours/ interview</p> <p>3 middle managers (construction organisation) 2 middle managers (housing development organisation) 1 middle manager (architectural firm) 1 coordinator (housing development organisation) 3 technical consultant (in-house) 1 practitioner (construction organisation) 1 architect (architectural firm)</p>
Written documents		Seminar protocols, application for research funding, information leaflets, organisations websites	Meeting protocols, official presentations, information leaflet (book), standardised building system documents (drawings, photo documentation and text documents), organisations websites
Field observations		1 arena planning meeting 1 arena seminar 1 reference group meeting Visit to the pilot project	Visit to the pilot project construction site
Informal conversations		Notes taken during informal conversations with arena project leader	Notes taken during informal conversations with environmental coordinator

Table 1: show methods used to collect data for this thesis.

4.2.1 Interviews

Semi-structured interviews were carried out with 38 individuals representing five professional groups: architects, consultants, clients, contractors and researchers. All interviews were semi-structured (Bryman and Bell, 2007) and carried out face-to-face at the interviewees' workplaces with one exception in study I, where one interview was carried out by telephone. All interviews were recorded and either iteratively summarised resulting in a detailed list of quotes, phrases, concepts and key words (pre-study and case I) or fully transcribed (case II).

For the *Pre-study*, relevant interviewees were selected by the organisational contact the aim being to explore how knowledge sharing related to standardisation of products and processes was perceived during the construction process. A majority of the interviewees held managerial positions with responsibility for, or insight into, the utilisation and development of standardised building systems. The majority of the interviewees worked for the same construction group (6 interviewees) although within different organisational entities and geographical regions. The remaining interviewees held managerial positions with either a design and build construction organisation that solely utilised standardised building systems in their construction process (1 interviewee) or in a large technical consultancy organisation that provided services to all phases of the construction process (1 interview/2 interviewees). Interviewees were encouraged to elaborate on the themes knowledge sharing and knowledge management initiatives within the organisation, and perceived barriers for knowledge sharing. The interviewees were asked to exemplify when, where, how and with whom they perceived that knowledge was being shared, i.e. during what particular circumstances. Also, the development process and utilisation of knowledge management initiatives for gathering best practices in standardised building systems and centres for competence (specialist networks) were explored in more depth.

In *Case I*, interviewees were selected from the arena project's contact list to ensure all participating organisations were represented with a balanced distribution between different professional groups. The selected interviewees were either researchers within the fields of energy efficiency, building physics, architecture, systems and installations technology, and moisture in buildings or worked for municipal-housing companies, energy companies or a politically governed geographical region and were responsible for energy efficiency issues related to maintenance of buildings, energy or environmental strategy or purchasing of services. Interviewees in case I were encouraged to elaborate freely on themes related to how they viewed energy efficient renovation, reasons for their personal engagement in the arena project, and their own organisation's views on its participation in the project. The interviewees were asked to exemplify where, how and when they perceived that knowledge was being shared in the arena project, i.e. during what particular circumstances. Respondents were also asked to draw a map of their communication paths within the arena and identify the issues they communicated on, the media (e-mail, telephone, informal or formal meetings) they used, and how often they communicated.

In line with Dubois and Gaddes' (2002) systematic combining approach to case research, *Case II* was done in two stages, retrospectively exploring how knowledge was shared across professional and organisational boundaries during the development process of a standardised building system for energy efficient housing. In the first stage, seven interviews were selected. An initial analysis of these interviews revealed that the development process was undertaken in, and dependent on, two different project environments which also included other professional groups and individuals than those included in the first stage. This led to the researcher deciding to conduct five more interviews to further the understanding of these individuals' participation in knowledge sharing as well as their actions to facilitate the sharing in the development process. The interview guide used in case II was designed to focus on preferred ways of individual learning and knowledge sharing: with whom knowledge was shared and

how, how the development process of the standardised building system had proceeded, who had participated in this process, what their contributions were and how these had been made and perceived by the interviewees.

The synthesis of results from the pre-study and case I indicated that the role of the specialist was critical for knowledge sharing in the arena; therefore case II explored the perceptions of the role of specialists in an organisational contexts. Questions were posed in order to explore expectations on this role as well as how these individuals were able to mediate knowledge in project based settings.

4.2.2 Field observations

Observations through participation are, according to Bryman and Bell (2007: 283), made to “elicit the meanings [individuals] attribute to their environment and behaviour”. For the purpose of this thesis, observations have been used to map the actions of participants in the respective social settings of case I and II. In both cases, observations have, along with the interviews, contributed to distinguishing attributes of communities of practice and to understand how knowledge sharing took place. The researchers’ position in observations made in case I has been what Gold (1958) categorises as ‘participant-as-observer’, where the researcher during observation over time develops a relationship with the informants. Here, both observer and informants are aware of the observation taking place. While, in case II, the researcher took the position as an ‘observer-as-participant’ (Gold, 1958). In this type of observation interaction between observer and informant is more superficial since observations are often limited to one occasion.

To further the understanding of how knowledge was shared in case I, participant observations were made of the interaction between arena project participants during one arena seminar, one planning and one reference group meeting. During the observations extensive notes were taken on what was discussed and by whom, what were the participants’ reactions

throughout the discussions, as well as of the use of language and visual presentations. In combination with the maps interviewees had drawn of their communication paths within the arena project, the observations contributed to detecting who different individuals preferred to interact with and the variations in language use and communication tools among arena participants – all indicators of membership in communities of practice. Also, these observations, along with the maps and keywords extracted in interviews, made it possible to identify mediators of knowledge across community boundaries.

In case II, a visit to the construction site of the pilot project as a part of the development of the standardised building system gave the researcher the possibility to observe work procedures and interaction on site. Additionally, these observations made it possible to view the ways in which the specifications concerning standardised building systems looked like in production. Observations together with interviews and data from the documents made it possible to establish what knowledge had been shared between the two projects in the development process.

4.2.3 Written documents

The documents collected made it possible to compare what was said in the interviews with the official view of events. The dating of the documents helped the sorting of events in cases I and II into a timeframe.

In case I, planning documents such as arena seminar protocols, visual presentations used at seminars, the arena proposal document and information leaflets were collected. These documents provided the background information for the arena project setting. Also, the wording used in different documents made it possible to explore the features of different communities of practice.

In case II, the documents collected were meeting protocols, presentation material, information leaflet (book), standardised building system

documents (drawings, photo documentation and text documents) and information from the construction group's websites. The type of documents that the standardised building system consists of can be seen as visual objects that capture information that cannot fully be communicated in interviews (Bryman and Bell, 2007). Combined, they offered a better understanding of the development process of the standardised building system. Thus, in addition to establishing an event timeline, these documents furthered the understanding of the individuals' roles at different stages of the development process of the standardised building system as well as what and how knowledge was incorporated into the drawings, photo documentation and text documents.

4.3 Analysis of data

The unit of analysis used in all three studied project settings was the interaction between professional groups (communities).

Text documents, such as interview transcripts and summaries along with collected written documents and field notes were analysed to obtain detailed descriptions of case settings and to explain how knowledge sharing was facilitated across community boundaries and what role context played in this process.

The process of analysing in all three studies consisted of coding texts and indentifying and compiling key words used by interviewees in describing how they viewed knowledge and knowledge sharing. Also, coding carried out to map how interviewees viewed their own possibilities to share knowledge in this context and the differences in wording used to describe their work on energy efficiency of buildings. Later, these codes were grouped into themes describing what facilitated knowledge sharing in project based settings and what role individual actions had in creating opportunities for knowledge sharing and how contexts affected these actions.

In case I relationships between various communities and brokers for knowledge sharing across organisational and professional boundaries were mapped. Data - principally knowledge sharing patterns - for the maps came from the interviews describing interaction patterns amongst arena participants. This final compiled image illustrated interaction and knowledge sharing in the arena project (see *Figure 1* in paper I).

The data analysis has been guided by the evolving research questions related to knowledge management in project based settings and successively became more focused on what influences knowledge sharing in these settings.

5. Summary of results

The results of this study are presented in two sections: the first concerns factors hindering knowledge sharing in the studied project-based settings; the second accounts for factors that seemed to facilitate knowledge sharing in these contexts. Paper I provides a more thorough description of knowledge sharing and learning processes in the context of the knowledge arena for energy efficient renovation of multi-family buildings in study I. Paper II, based on the pre-study and on study II accounts for knowledge sharing that took place during the development of a standardised building system for energy efficient multi-family buildings.

5.1 Factors hindering knowledge sharing in project-based settings

“We are segregated according to professional functions in the building sector. We’re not organised according to the flow of the process, but rather according to function.”

Project leader, case II

The professional groups had different ways of addressing the demand for energy efficient buildings contingent on the worldviews they had developed in their professional functions/roles in society and/or the construction process. Such differences in turn gave rise to tensions between the actors as they interacted and communicated in the studied project settings. In case I, these tensions were primarily created by the diverging knowledge and information-sharing practices between the researcher group and the municipal-housing companies, which created differences in these actors’ framing of the challenge of energy efficiency of buildings (see figure 2 in paper I). In case II, tensions were created between clients, contractors and consultants, whose roles and functions in the construction process was effected by internal power relations and represented different perspectives and strategic goals.

In the setting of the arena project, researchers preferred to communicate and share knowledge through the mediation of written texts such as scientific reports and by attending academic conferences where they could interact and discuss each others' work. This preferred way of sharing knowledge was used in the planning and execution of arena events. However, these ways of interacting and sharing knowledge were not familiar to the municipal-housing companies. Instead, these actors preferred verbal communication and sharing experiences by working practically together in projects.

Although pilot projects were seen as opportunities for the researchers and municipal-housing companies to interact within the arena project, only two such interactive opportunities were initiated (one of which was an object of study in this thesis). The reason given by interviewed municipal-housing company representatives for not supplying pilot projects for the arena was that they had understood the arena goals as being a means of providing researchers with knowledge from real-life projects. Moreover, these arena representatives had within their own organisations experienced resistance against addressing the energy efficiency of buildings in any other way than that of fine-tuning already existing heating infrastructure and the improving of technical details. This solution for reducing energy use in buildings was due to budgetary directives for rent-setting from the municipality. Thus, arena representatives with knowledge about, and a vested interest in, energy efficiency of buildings felt hindered by their own organisations to take actions toward renovation as a measure for reducing energy-use in buildings.

The budgetary constraints on the municipal-housing companies were also mirrored by the interviewees' use of certain key terms to frame the challenge of energy-efficient renovation. Examples of this are *technical solution*, *reduced energy use* and *return of investment*. The use of such terms reflected a pragmatic mindset oriented toward the present. This mindset indicated a short-term perspective - a 'save where you can'

mentality - on energy efficiency with return-of-investment in focus, and was manifested in day-to-day building maintenance.

Framing the same challenge, the researchers preferred a *socio-technical approach* and used terms like *passive housing* and *sustainable solutions*. Their concerns reflecting a technocratic mindset oriented toward future possibilities rather than toward day-to-day problems. In taking on a long-term perspective on energy efficiency, the researchers thought fulfilment of state demands on energy use within the set timeframes could only be achieved through a socio-technical approach and in collaboration with various actors in society. In this case their different perceptions of time thus lead to miscommunication and in extension to distrust as it emphasised the different views on energy efficiency of buildings. These differences in framing the challenge of reducing energy use in buildings created barriers between professional and organisational entities, barriers that needed to be bridged in order for knowledge sharing to take place in the arena (see paper I).

In contrast to case I, the actors in the pilot project in case II, also in a multi-professional and organisational setting like the arena project, framed the challenge of reducing energy use in buildings using monetary and technical terms. Also, they utilised the same communication channels (i.e. project meetings and documents and drawings) that are commonly used in the construction process to present and negotiate technical solutions. Here, tension could be seen between the different organisational entities - client, contractor and in-house consultants - in connection to their practices and roles within the construction group. In many respects, the construction organisation stood out as the more powerful organisational entity within the group as the housing development organisation had to engage them as contractors when carrying out their building projects. Also, both the R&D department and the in-house consultants were organised under the construction organisation which made other organisational entities dependent on this organisation when pursuing the development of products

and processes. Prominent in the construction group were also the in-house consultants, whose business was to sell knowledge rather than products, in that their service minded approach to other construction group organisations. The organisational structure within the construction group was thus biased towards the construction organisation that controlled the management and development of the standardised building systems used in the internal construction process. In pursuing the strategic goals taken by the different organisations, two projects were initiated to address the challenge of energy efficiency of buildings: a pilot project aimed at meeting market demands was initiated by the housing development organisation, and a development project to standardise energy efficient building practices (see paper II).

Perceived time constraints in the development project initiated by the construction organisation led to the exclusion of in-house consultants knowledgeable within the field of installations when the project leader for this project felt he had to prioritise between work tasks (see paper I). Despite these actions, this project leader saw it as his role to seek information. However, the information he sought under these circumstances was primarily related to his personal interest in production efficiency. This approach to seeking and processing information could be detected throughout the whole construction group. Interviewees in case II expressed a need to navigate through a large flow of information which led them to acquire and process information only at exactly the time they felt they needed it. Thus, time constraints were given as the main reason for not seeking knowledge in, for example, databases, documents, or by contacting subject specialists or support functions (see paper II).

Tension between not only different professional groups, but also within organisational entities, could thus be seen in both case I and II as hindering individuals from seeking knowledge made available through knowledge management initiatives or in participating in knowledge sharing practices.

5.2 Factors facilitating knowledge sharing in project-based settings

"We talked about every detail and then we arrived at an agreement [on what techniques to use in the pilot project]. It was great! We opened up and spoke about what we knew best."

Researcher, case I

The common ground between different professional groups and organisational entities, in both case I and II, was found in the pilot projects. These projects offered a space where individuals that had not come into contact before could interact face-to-face. The workshops held within the planning and execution phases of the pilot projects made actors from various professional backgrounds and organisational entities focus on, and negotiate solutions to, a common problem. This activity enabled each participant to contribute with their piece of the puzzle seen from their knowledge base; the result was an aggregated sustainable solution. Interaction in the pilot projects facilitated knowledge sharing in that they provided platforms where participants could negotiate meaning, explain usage of tools, develop a shared vocabulary and discuss how to address the regulations and goals for energy use in buildings.

In all the studied project settings the project leaders decided who would participate in the knowledge sharing space, e.g. the planning meetings and the workshops. For example, the site manager of the pilot project in case II chose to form focus groups to solve problems and to take on on-site challenges such as how to classify the building environmentally. Invited to participate in these focus groups were in-house consultants and support functions that were deemed to be able to provide specialist knowledge that would add to the knowledge already residing in the project (see paper II). A specialist was described as an individual employed within and/or outside the own organisation and possessing a certain type of knowledge that "did not exist" in the immediate and closed-off surroundings, e.g. in a project, but was acquired in this social setting as the quote below illustrates.

“A specialist to me [is] someone who has more knowledge than I or the group on a specific issue. [Therefore] I’ll invite that person so he or she can share his/her knowledge with us [...]. He or she does not have to know a lot more than us, but enough so that we learn something.”

Site manager, case II

As the quote suggests, specialists were expected to share their knowledge when required. As means of structuring knowledge sharing across organisational entities, the construction group studied in case II created horizontal networks within the organisation that were based on specialist or support functions, like for instance the environmental coordinators network, so as to facilitate the exchange of experiences made in various project settings (see paper II).

Also, the arena project could be viewed as an attempt to form and maintain a similar knowledge network among researchers interested in energy efficiency of buildings (see *Figure 1*, paper I). In this case, the researchers were seen by both themselves and by the interviewed municipal-housing company representatives to be more knowledgeable on energy efficiency of buildings than they. In fact, the construction of the arena project was set for the researchers to act as consultants mediating their knowledge to and between the municipal-housing companies as they were invited to participate in pilot projects presented by these practitioner organisations (see paper I).

However, in taking on the role as consultants, the researchers in case I approached their clients in a somewhat different manner than the in-house consultants in case II. The researchers rarely sought face-to-face interaction with the municipal-housing companies when offering their expertise. Instead, they expressed their frustration and disappointment with the municipal-housing companies for not seizing the opportunity to interact with them by inviting them to participate as consultants in projects (see paper I). Conversely, the in-house consultants in case II focused on creating

trust through social interaction with other organisational entities when seeking to create channels for knowledge sharing. Their actions were related to meeting the expectations on their role, but also to the fact that knowledge was viewed as competence within the construction group. This term was frequently used to describe the perception of a trusted individual's personal stock of knowledge in this case (see paper II).

The environmental coordinator with the housing development organisation in case II managed the above mentioned expectations on her role as specialist by adjusting her actions in a social context in seeking to realise her visions for the organisation. By taking help from in-house consultants on energy efficient housing and by engaging an institute of public opinion to investigate clients' interest in energy efficient products, she acquired the vocabulary and the means – in form of documents – to argue for her personal interest in sustainable development within her organisation. Her actions inspired trust for herself and her role and this led to her being offered membership in the pilot project planning group. It was in this context that she continued to translate vocabulary and use the tools needed to take action in sustainable directions as advocated for by society in the form of market demands, rules and regulations (see paper II).

Similarly, in case I, due to her genuine interest and deep commitment to sustainability and energy-efficient renovation the project leader of the pilot project picked up and internalised the discourse used by the researchers by studying research reports and documents. In being able to interchangeably translate researchers' and practitioners' worldviews and use of terms, she took on the role as mediator of knowledge between professional groups and organisational entities on the arena (see paper I).

These mediators' success in facilitating knowledge sharing was thus dependent on whether they had the possibility to create and take part in formal and informal social settings (see papers I and II). Other ways of bridging project settings, professional and organisational boundaries was the

informal social networks created around a shared interest. For example, the main channel for sharing knowledge between the studied project settings in case II was the already existing informal social network comprising, among others, the project leader of the development project and the site manager of the pilot project which had come into being during the pre-phase of the development project (see paper II). Knowledge was here shared by discussing their common interest - production efficiency of energy efficient building during visits to the pilot project construction site (see paper II).

The interviews as well as the observations of arena activities in case I indicate that the researchers and the practitioners, through their discussions and dialogue, gradually developed a shared understanding of the challenges that needed to be overcome to achieve energy-efficient renovation of housing. The arena project offered a platform where this interaction could take place, although the development of social ties between actors who had not previously met proved to be a process that required time.

Similarly, by providing extra time and financial resources to finalise the pilot project in case II, these project team members felt they were allowed to create tight social bonds amongst themselves. The continuity of their work together as a project team across several phases of the construction process was felt by these interviewees to prevent knowledge loss since descriptive documents were continued to be developed and used by the same people. This opportunity was perceived by these individuals as beneficial to the final project outcome – the building.

6. Discussion

The aim of this thesis was to explore the factors influencing knowledge sharing across organisational entities and professional groups in construction industry context. The guiding question was *What factors facilitate and hinder knowledge sharing across organisational entities and professional groups in construction?* This question was explored in three different project based settings where the challenge of reducing energy use in buildings in association with standardised products and processes was in focus. The chosen case settings allowed for opportunities to create an understanding of, and contribute to the ongoing debate on, management of knowledge.

Although it has been suggested that construction projects offer a multidisciplinary environment where individuals representing different professions and organisational entities, i.e. different actors in the construction process, can interact and create and share knowledge (Sense, 2009; 2011) the results show that a construction process segregated along professional functions also gives rise to friction among the actors. Each actor plays a specific role in this process, which was reflected in the different ways they addressed the challenge on energy efficiency of buildings. Therefore, the perceptions of the challenge depended on the aggregated knowledge within each actor's professional social context. In order to share knowledge in such an inter-organisational environment, boundaries firstly needed to be bridged (e.g. Ruuska and Teigland, 2009; Pemsel and Widén, 2011; Sense, 2011) to attain a common view on how to address energy efficiency of buildings.

In line with previous research (Bresnen *et al*, 2003; Rubino *et al*, 2007; Love and Ellis, 2009), opportunities to bridge these boundaries were in both case I and II, found to be given in pilot projects. In these project settings a space was given where individuals who had not come into contact previously could interact face-to-face. The social interaction taking place in these multi-professional and organisational settings was in the studied cases

facilitated by the actions of translators (Brown and Duguid, 1998) and/or brokers (Brown and Duguid, 1998; Wenger, 1998). These individuals' actions proved to be paramount to bridging differences in worldviews thus making possible the sharing of knowledge across professional groups and organisational entities in the studied project based settings. The individuals identified as brokers and/or translators in the studied cases, intentionally or unintentionally acted so that they gained trust by members of several communities (Wenger, 1998; Brown and Duguid, 1998). Their work led to them being seen as knowledgeable individuals by those around them. Or, as Elliot and Dweck (2005) put it, they were seen as competent as their knowledge was labelled as social expertise (Nicolini *et al*, 2003), categorised and found interesting to incorporate into the social setting of other communities. Being seen as knowledgeable also caused these individuals to be labelled as specialists.

A skilled specialist was expected, when asked to do so, to readily share his/her knowledge in a way that the receiver could comprehend. In other words, these specialists felt they were expected to feed their surrounding with knowledge, to adjust their way of communication with a person according to context. Thus, the specialists felt a need to service and anticipate the needs for support and knowledge of the surrounding organisation. This in turn put high demands on the actors expected to mediate knowledge, i.e. researchers, support functions and in-house consultants. Also, to be able to share their knowledge the so called specialists needed to meet the expectations put on them. This meant firstly to interpret the situation in a context and then adjust his/her actions accordingly in order to be seen as trustworthy and be invited into the community (Wenger, 1998; Elliot and Dweck, 2005). The ability to meet these demands was associated with skills like being able to communicate with different professional groups, to organise and coordinate actions and to interact with people to facilitate their work together towards a common goal. In short, they were expected to bring down barriers between professional groups and organisational entities in project based settings.

This description of a specialist is very similar to what Sverrisson (2001) refers to as an entrepreneur, i.e. a broker of knowledge taxing his/her services in a time-honored fashion to facilitate project operations in accordance with organisational goals and strategies. The in-house consultants and support functions in case II acknowledged that they had to create personal relationships with the people approaching them so that the information they mediated would be trusted and acted upon, whereas the researchers in case I did not make this connection and thus failed to mediate their knowledge to any larger extent even though their role, through the arrangements on the arena, was consulting. Instead, the informal role as a translator on the arena was given to the leader of the pilot project as she gained the different actors' trust by bridging differences in worldviews based on different perspectives of time.

The nature of social relations should therefore not be neglected (Roberts, 2006) as they play an important role for creating the trust needed to share knowledge and sustain cooperation within communities. Creating social relations takes time, which is normally not available as actors come and leave at different stages in the construction process. In fact, a perceived shortage of time was used as an excuse for not seeking knowledge. It is this reluctance to seek knowledge that enforces the behaviour of specialists as salesmen of their time and knowledge, as well as their conscious and unconscious actions to create social relations. In the studied cases, pilot projects were given extra resources such as financial means and time. Time to create the social bonding needed for establishing common repertoires of vocabulary, tools and documents that could facilitate knowledge sharing. Time thus gave room for the negotiation of a common understanding of technology and practice when actors were solving problems in collaboration (Brown and Duguid, 1998; Gherardi and Nicolini, 2002) during workshops and project meetings. More, the allocated time and financial means also offered an opportunity for specialists to become involved in day-to-day practices as these resources helped create the space needed to develop the informal and personal contacts (cf. Gherardi and Nicolini, 2002; Styhre *et*

al, 2004) to become seen as competent and lend a membership in various communities.

The findings of this thesis adds to establishing how the element of time affects the possibility to create opportunities for knowledge sharing as previously advocated for by Bishop *et al* (2008). Also, findings made add to previous research discussing the management of knowledge in project-based settings. The factors found influencing knowledge sharing across organisational entities and professional groups could be used by management to in a non-intrusive way to support the delicate process of forming inter-organisational communities of practice as previously discussed by Bishop *et al* (2008), Schenkel and Teigland (2008), Elmualim and Govender (2008) and Love and Ellis (2009). Contribution of time and financial means would also create opportunities for brokering (Bresnen *et al*, 2003; Pemsel and Widén, 2011) by the so called specialists in making it possible for them to act as entrepreneurs as described by Sverrisson (2001). However, as Roberts (2006) advocated, the factors of power and trust also have to be taken into consideration when planning to support the forming of communities of practice and thus also in creating opportunities for brokering. These factors have an effect on social interaction, just like the allocating of time and money has proven to have in the studied cases in this thesis.

In studying the actual practice of knowledge sharing in construction it has been possible to explore some of the informal and emergent practices within the intra-organisational context that constitutes the construction process, where tacit aspects of knowledge constitute a part. By doing so, the white spot within research on knowledge management in construction as identified by Styhre (2009) has been partly filled. The challenge of reducing energy use in buildings has proven difficult to take on as knowledge transfer is dependent on the mutual engagement of individuals representing different professions and organisational entities in every day practice over time. However, as presented in this thesis, day-to-day practice can be shaped and supported so that identified barriers to knowledge sharing can be overcome.

7. Conclusions

This thesis contributes to bridging a gap identified in construction management research (e.g. Bresnen *et al*, 2004; Styhre, 2009), namely that of understanding how knowledge can be created and diffused in practice in the construction industry. The thesis also contributes to the ongoing debate on how to manage knowledge in such a context.

The theoretical framework of communities of practice as presented by Wenger (1998) has informed the research, making it possible to explore how organisations through individuals share knowledge and thus learn from each other. Taking into account the tacit and dynamic aspects of knowledge, the framework has helped identify facilitators and hindrances of knowledge sharing in practice.

By ensuring stability and continuity in multi-professional work groups throughout the various stages of the construction process, room may be given project participants to collaborate better in solving common problems in day-to-day practice. Hence, when social interaction is enhanced, knowledge sharing across professional groups and organisational entities is facilitated in project-based settings.

In this thesis, increased opportunities to interact with other professionals were found in the pilot projects, where workshops and work groups were frequently gathered to solve problems. Pilot projects thus enabled face-to-face communication between actors over time, resulting in the creation of common tools, vocabulary and means of communication. As a result, communities of practice were allowed to flourish. In this process, time and funding are important factors to consider.

However, time may also act as a hindrance. Lack of time was given as the main reason for not acquiring knowledge from outside the organisation or project setting. Considering the time factor and that knowledge was associated with and expected to be mediated by specialists in form of

support functions, awarding of resources could encourage practitioners to search for knowledge held by so called specialists. Also, as acts of brokering, translation and mediation of knowledge in practice were found to be more dependent on individuals being seen as competent in a specific social setting than on them holding a formal role within an organisation and/or project setting. It is therefore concluded that the interrelation between individual and context is of more importance for mediation of knowledge than the formal role of specialist.

Based on the findings in this thesis, and in line with previous research (e.g. Schenkel and Teigland, 2008; Elmualim and Govender, 2008), it is concluded that communities of practice can be stimulated and supported e.g. by management in an organisation. They can also be influenced from the outside. With support from the organisation and/or the project setting, individuals were able to take on the role of brokers and/or translators in a way described by Sverrisson (2001) as entrepreneurs. Therefore, it can be concluded that the individuals acting on their personal interest and using skills associated with 'entrepreneurship' can constitute 'importers-exporters' of knowledge between different communities in project-based organisational settings.

Moreover, a further understanding of the prerequisites for knowledge sharing in practice acquired through these studies will aid the creation of future collaborative actions between researchers and practitioners, and also within organisations in the construction industry. Finally, more collaboration between various actors in the practical setting of pilot projects in construction as well as with academia would be a viable way forward in addressing issues in need of acute development.

8. Future research

It is clear that the practice on how to manage knowledge in project-based settings still needs more insights, in construction as well as in other project-based industrial contexts. For instance, the role of brokers and translators as drivers of, and support for, sharing knowledge needs further investigation and would be interesting for both researchers and practitioners to explore. Interesting issues are:

- *What makes an individual become a broker/translator? Is it the context or personal skills, identity or profession?*
- *How can management identify potential knowledge brokers?*
- *How can management support these individuals so they can create environments for knowledge sharing as well as sustaining these within and between project-based settings?*

In the light of the industry's ongoing measures to standardise the construction process by promoting best practices of transferring knowledge between projects, it is also of interest to investigate the following issues:

- *What implications could an extensive use of standardised products have for knowledge sharing between project settings?*
- *What effects do the industrialisation and standardisation of products and processes have on social interaction and knowledge sharing between the project organisation and specialist functions?*
- *How can organisations in the construction industry organise so that specialists' knowledge is shared in practice?*
- *What does an increased influence of specialists' knowledge have on organisations in the construction industry?*

Also, if a pilot project approach to innovation in construction, as suggested in this thesis, were to be implemented in large scale, the following issues are important to explore further:

- *How will the involvement of more actors over several phases of the construction process cycle affect sharing of knowledge in and between project settings?*
- *What implications would an extensive use of pilot projects in construction have for the organising of and for actors involved in the construction process?*

Based on the experiences acquired through this thesis work, longitudinal studies, in terms of action research and/or ethnographic studies would be beneficial approaches when exploring these questions and actual practice of knowledge sharing in construction.

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PAPER I

Knowledge Sharing and Learning Across Community Boundaries in an Arena for Energy Efficient Buildings.

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KNOWLEDGE SHARING AND LEARNING ACROSS COMMUNITY BOUNDARIES IN AN ARENA FOR ENERGY EFFICIENT BUILDINGS

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ABSTRACT

Within the field of sustainable development, collaborative and interdisciplinary actions are imperative for the development and implementation of proactive holistic renovation solutions. In an attempt to enhance cross-disciplinary and inter-organisational knowledge sharing, a project aimed at developing an arena for sharing knowledge pertaining to energy-efficient renovations of multi-family buildings was initiated. The authors have followed the development and implementation of this knowledge arena over a period of three years. The aim of this paper is to understand how knowledge sharing between different professional groups and practices may be facilitated: in this case between various research organisations, municipal housing companies, energy suppliers and governmental organisations. Specific focus has been on identifying mechanisms for interaction and knowledge sharing between actors that normally do not meet in their everyday practice. The theoretical approach adopted concerns social processes related to the sharing of knowledge in and between organisations and professional groups and individuals. Findings show that in the arena knowledge was mainly shared within a pilot project where researchers and practitioners were jointly engaged in the planning and renovation of a building. Interaction within the arena was enabled by the individuals' mutual willingness to adapt and attempt to translate the disciplinary discourses and modes of communication of researchers and of practitioner specialists. Moreover, the motivation to share knowledge was related to their expectations of, and invested interest in,

various arena activities. By empirically highlighting the facilitators and hindrances for knowledge-sharing in an arena for cleaner production, the paper contributes to increased understanding of inter-disciplinary communication and collaborative interaction.

Keywords: *knowledge sharing, inter-organisational learning, mediating objects, situated learning, socio-technical experiments, energy efficiency, renovation of residential housing*

INTRODUCTION

The Swedish parliament has set the target of a 50% reduction of energy use in buildings by 2050. To meet this target all existing buildings have to be replaced by new ones, or be renovated to attain the same energy performance as new buildings (Dalenbäck and Mjörnell, 2011). Today, a majority of the multi-family buildings built between 1965 and 1975 are in imminent need of extensive renovation as a result of many years' neglected maintenance. These buildings are largely owned by public housing companies and comprise approx. 600.000 apartments, which consume on average 185 kWh/m²/year each. The regulated demand is at present 110 kWh/m²/year for new buildings (Swedish Energy Agency, 2011). How to address this challenge is currently a much debated issue among researchers, practitioners and policy makers. One point of agreement among the parties is that to meet the challenge of reducing the energy consumption of buildings, reliable knowledge must inform the planning, building and operating of sustainable residential housing.

Over the last decade, the construction industry in Sweden has invested much effort into developing green technology (e.g. low energy buildings) and implementing various control systems (e.g. classifications) to make buildings energy efficient (Malmqvist *et al*, 2011; Swedish National Board of Housing Building and Planning, 2010; Thuvander *et al*, 2011; Toller *et al*, 2011). In line with other countries, this development has been driven by governmental regulation and policies, self-regulation activities (through standards such as ISO14001, LEED) and R&D collaborations between industry and research institutions (e.g. E2ReBuild, 2012; Lågan, 2012;

Tofield and Ingham, 2012;). One such initiative was launched in 2007 when the governmental Swedish Energy Agency instituted a grant aimed at stimulating R&D initiatives for sustainable renovation of apartment buildings (Cerbof, 2011). This incentive served as grounds for the creation of a ‘network project’ with the articulated ambition to create interaction and shared knowledge between actors engaged in energy efficiency and renovation endeavours (Dalenbäck and Mjörnell, 2011).

What was to later be called a ‘knowledge arena’ was thus initiated in 2008 as a means of creating a meeting place for joint activities and discussions on issues related to energy efficient renovation of multi-family housing. The interaction within the arena was intended to evolve around ongoing pilot projects, open arena seminars and meetings. The objective of the knowledge arena was to share existing knowledge as well as create new knowledge pertaining to the framework for energy renovation of multi-family buildings (Dalenbäck and Mjörnell, 2011). The anticipated contributions of this network project were: 1) to increase knowledge sharing between the participating researchers and practitioners, e.g. real estate owners and building contractors, 2) to facilitate the mediation of practical knowledge from ongoing projects to researchers, and 3) to disseminate this knowledge to other and future projects. These prospective contributions seem to reflect the underlying assumption that knowledge is created and exchanged when people from various knowledge fields meet and interact around a shared interest and/or tasks. However, much due to the projectified, multidisciplinary and fragmented nature of the construction industry, creating common spaces for reflection and knowledge sharing is difficult to accomplish. Moreover, empirical evidence for the assumption remains elusive (Bresnen *et al*, 2005; Dainty *et al.*, 2006; Dubois and Gadde, 2002).

Yet within the field of sustainable development, collaborative and interdisciplinary actions have been found to be crucial for the development and implementation of proactive, holistic and innovative green solutions (Brown *et al*, 2003; Vergragt and Brown, 2007; Quist *et al*, 2011). The same applies to the field of energy-efficient building (e.g. Brown and Vergragt, 2008; Cole, 2011; Glad, 2012; Heiskanen and Lovio, 2010). For example, Cole (2011) concluded that there is a lack of understanding of the

social and organisational interplay amongst and between different stakeholders involved in sustainable building. Whyte and Sexton (2011) substantiated this lack, by calling for research that specifically addresses stakeholder engagement in the transformation of the built environment. In line with their call the aim of this paper is to further the understanding on how knowledge sharing between different professional groups and practices may be facilitated: in this case between various research organisations, municipal-housing companies, energy suppliers and governmental organisations. To fulfil this aim, we have followed the development and implementation of the above mentioned knowledge arena for energy efficient renovation of buildings over a period of three years (August 2007 – May 2010). Specific focus has been on identifying interactions and knowledge-sharing processes/activities between actors that normally do not meet in their everyday practices.

The theoretical approach draws on socio-cultural perspectives of knowledge creating and sharing in and between organisations, professional groups and among individuals and is informed by research reported in e.g. Wenger (1998), Gherardi and Nicolini (2000), Gluch and Räsänen (2009), Heiskanen and Lovio (2010) and Heiskanen *et al* (2010). Findings show that in the current arena, knowledge was mainly shared within a pilot project in which researchers and practitioners jointly engaged in the planning and renovation of a specific building. Within the arena as a whole, fruitful interaction was facilitated by certain individuals' interest and willingness to translate the disciplinary discourses and modes of communication of the researchers to others. Motivation to share knowledge was largely related to expectations of, and invested interest in, various arena activities. To conclude, suggestions on how to encourage individuals to engage in knowledge-sharing activities in inter-organisational and inter-professional settings are offered. By empirically highlighting what facilitates and what constrains knowledge-sharing in an arena of cleaner production (improved energy efficiency in existing buildings), the paper contributes to increased understanding of inter-disciplinary communication and collaborative knowledge sharing.

THEORETICAL FRAME: KNOWLEDGE SHARING IN COMMUNITIES OF PRACTICE

The study reported here is framed by a socio-cultural view, in which learning and knowing, are dynamic activities that take place in situated contexts and practices (e.g. Lave and Wenger, 1991; Gherardi and Nicolini, 2000). Seen from this perspective, knowledge is not a decontextualised abstraction that is transferred from one individual to another and stored in a knowledge repository to be accessed when needed; rather it is embedded in the processes, methods and tools of a practice as well as in the people that carry out the practice (Gherardi and Nicolini, 2000). Practice is viewed as some kind of institutionalised ‘doing’, which has been socially and culturally constructed through a social system of relations, where agency may be distributed between individuals and artefacts. Practice, in the same way as learning and knowing, is emergent, consisting of collective and situational activities that take place through interconnected people in a group, community or network (Gherardi and Nicolini, 2000; Gluch and Räsänen, 2009; Gherardi, 2009). Thus, meaningful learning and knowing takes place when individuals collectively engage in practices in which they have a strong commitment or vested interest, e.g. in a community of practice, CoP (e.g. Wenger, 1998). It is in these practices that information may be exchanged and knowledge may be shaped and shared. In such a relational shaping process, notions of, for example, energy efficiency and climate change may be verbalised in the discourse of a particular party, but these notions also need to be translated into the relevant discourses of other parties before the notions may be appropriated and made sense of by all parties (Füssel, 2005; Stenberg and Räsänen, 2006).

Elements of the CoP perspective on learning are relevant for a study of the shaping of a knowledge arena: individuals actively engaging in an area of concern (domain) form a community focused on growing the domain through group and individual meaning-making in a situated, relevant collective practice (Wenger, 1998). Brown and Duguid (2001:200) suggest that it would be “fruitful to look to the context in which knowledge sticks or leaks”. In areas where there are distinct fields of knowledge, for instance in development and innovation processes for low-energy housing, knowledge seems to get stuck within particular fields. It is much more difficult to

diffuse and share it beyond the fields' boundaries (e.g. Heiskanen and Lovio, 2010). The challenge for researchers and practitioners with interests in the same domain, but inhabiting different fields is finding ways of making community boundaries sufficiently plastic to allow knowledge sharing.

A particularly interesting aspect of CoPs is that they develop shared repertoires of routines and semiotic and technical mediating tools that shape their identity (Räisänen, 1999). It is thus through their practices that a CoPs can be identified. The interpretation and use of a shared repertoire also discloses a CoP's boundaries to another. Although CoPs are far from discrete and isolated entities, they often tend to be viewed as such (Brown and Duguid, 2001). This may be because the knowledge that a community possesses reflects its norms and preoccupations and, in the long run, limits its ability to develop new ideas (Kimble *et al.*, 2010).

Today boundary-crossing activities for accessing information from outside a group are becoming increasingly important in interdisciplinary and fragmented industries such as construction. Knowledge sharing across community boundaries can, according to Teigland and Wasko (2003), be facilitated through participation in social networks, informal meetings and workgroups. Furthermore, governing entities may act as enablers for knowledge sharing across community boundaries by mobilising incentives for collaborative endeavours and mutual engagement to solve societal or organisational problems (Brown and Duguid, 2001). To achieve mutual engagement across community boundaries, proactive attention needs to be focused on practice, interaction and participation since interaction between individuals arise from their mutual engagement in practice and not from an idealised view of what a community should be (Heiskanen *et al.*, 2010). Moreover, based on a study of a zero-energy residential building project, Brown and Vergragt (2008) concluded that higher order learning within a project community was stimulated when there were overlaps of the interpretive frameworks and practices held by the participants, such as developer, urban planner, architect and energy analyst. To stimulate learning in boundary-crossing communities means supporting activities

where overlapping practices can meet so that the framework is expanded and in turn can foster cross-fertilization between professional communities.

In interdisciplinary and boundary-crossing communities, it is important to pay attention to how engagement and knowledge sharing within communities evolve. CoPs develop over time when the members collectively begin to act as member of the community and not merely as representatives of their other communities and commitments (Heiskanen *et al.*, 2010). To facilitate appropriation of information and knowledge in an interdisciplinary community requires competent mediators such as boundary brokers who can translate the jargon of one field into that of another. The community also needs effective, preferably co-constructed mediation tools (semiotic and technical) which are acknowledged and understood by the different groups of members (Brown and Vergragt, 2008). It is therefore critical to consider what artefacts may serve as mediating representations and what challenges may arise when attempting to align divergent interests (Gluch and Räsänen, 2012; Heiskanen *et al.*, 2010). It is with these issues in mind that we have used the concept of CoP as a point of departure in our study of the energy-efficiency arena.

RESEARCH APPROACH

The empirical data were gathered using different qualitative methods: observations, interviews and document analysis. Over a period of three years (August 2007 – May 2010) the following events were observed: two workshops at the initial stage of the arena project, then five planning meetings, two open seminars, one reference-group meeting, two company presentations which included construction-site visits, and lastly three site meetings of a pilot project within the arena. Extensive field notes covering formal and informal interactions, talk and body language provided a contextual understanding, which helped us make sense of the ensuing interviews (Bryman, 2008).

In the spring of 2010, 18 interviews lasting between 1 to 3 hours were carried out. The interviewees were selected from the arena's contact list of 50 individuals, ensuring all participating organisations were represented. All the interviews were recorded. The interviewees were divided into two

groups: researchers (8 interviewees: R1-8) and practitioners (10 interviewees: P1-10). R1-8 were employed either at a Technical University (TU) or at a Research Institute (RI). Interviewees employed within municipal housing companies, a local energy company and the local governing authority made up the P1-10 group. We, the authors, were positioned as academic observers trying to understand and interpret the dynamics of the arena, with as little direct participation as possible.

The interviewees were encouraged to elaborate freely on three themes: 1) energy-efficient renovation as a field of knowledge, 2) their personal engagement and knowledge sharing in the arena project, and 3) their own organisation's views on its taking part in the arena. The interviewees were asked to exemplify where, how and when they perceived that knowledge was being shared i.e. in what particular circumstances. They were also asked about their perceived possibilities of sharing any newly acquired knowledge within and across their own professional community boundaries. Respondents were asked to draw a map of their communication paths within the arena and identify the issues they communicated about, the medium they used (e-mail, telephone, informal or formal meetings), and how often they communicated.

For the purpose of this paper, a content analysis (Salkie, 1995) of the interviews was carried out focusing on the interviewees' perceptions and stories concerning the three themes. The interviews were listened to and summarised iteratively, resulting in a detailed list of quotes, phrases, concepts and key words pertaining to the themes in focus. The detailed summaries were then further analysed to compile representative stories, depicting the different views and attitudes toward arena activities and events. To minimise researcher bias, each author processed the data separately and then compared interpretations. The few discrepancies that arose were resolved through dialogue. The interviewees' personal contact maps were analysed to identify common communication paths. Documents produced within the arena, such as meeting protocols, information leaflets and seminar material, were analysed and served as background information.

FINDINGS: ARENA FOR ENERGY EFFICIENT RENOVATION OF BUILDINGS

The initiative to create a knowledge-sharing arena can be ascribed to a few researchers from a Technical University and a Research Institute. A professor in building energy technology took on the role of self-assigned arena leader without any apparent resistance from the others. Together, these researchers successfully applied for the state-instituted Energy Agency grant for the development of a knowledge arena in collaboration with interested municipal housing companies. The arena objectives, as formulated in the application, was three-fold: 1) to share knowledge between researchers and practitioners (clients, contractors and consultants), 2) for researchers to gain knowledge from real-life projects and, 3) to disseminate this knowledge to future projects. A dominant idea was that participants in the forum would create and share knowledge by interacting with each other in common forums where particular and relevant mediating objects and tools would be used. These objectives reflect the assumption that knowledge is exchanged when people from different knowledge fields within a general domain meet and interact around a shared interest and/or task.

Since the domain of the arena was renovation of multi-family housing, local authorities, housing companies and energy suppliers were solicited to join forces with the researchers to develop the arena. Altogether, six municipal housing companies, one local energy company and the local governing authority were co-opted as partners in the shaping of the arena community. Each partner was assigned an account on which it could draw to fund consultants within those areas in which they lacked expertise, e.g. business operations and quality testing of technical solutions in climate laboratories. Notable in this arena context was that hardly any of the participating entities made use of this possibility.

Perceptions of energy-efficient renovation as a knowledge domain

Table 1 presents the findings from the analysis of theme one in the interviews. It shows how the two groups, R1-8 and P1-10, described energy-efficient renovation of buildings.

	Researchers	Practitioners
Scope	Integrated on a societal level Long term perspective (10-50 years)	Limited to local interest within a specific type of business organisation or renovation project Short term (now - 2 years forward)
Technical frame	A systems approach in which change toward energy-efficient renovation of buildings lies in the managing of system structures. Knowledge needs to be disseminated	A practice-oriented approach in which energy-efficient renovation of buildings lies in fine-tuning existing systems and changing technical details Knowledge is acquired
Problem solving approach	To influence system structures through full-scale socio-technical experiments (pilot projects) Peer collaboration and practitioner participation Provide normative guidelines	To influence practice by identifying technical solutions through one-off development projects (pilot projects) Interaction with peers to identify best practices Use of tools
Conceptual frames	Zero-energy, passive housing, sustainable solutions, socio-technical approach, societal values	Reduce energy use per m ² , technical solutions, performance, return on investment

Table 1: How energy-efficient renovation of buildings was framed by the interviewees

The researchers talked of energy efficiency in housing as a concern that implicated society as a whole, both current and future generations, and must therefore be dealt with in a long-term perspective. For them, particular technical solutions only marginally impacted the societal imperative of developing sustainable energy consumption. In their view, energy-efficient renovation can only be fully achieved through a socio-technical approach, involving the collaboration of actors at various levels and spheres of society and using a variety of integrated technologies and artefacts, as the quote illustrates:

“It is not in the advanced technology, and by that I mean material development or advanced installations, but in the interaction and the discussion, a sensible discussion between for example the architects and the engineers” (R6).

The researchers claimed that the change towards energy-efficient housing lies in the handling of system structures, i.e. the way technical structures and/or society is able to support change toward using less energy, energy reuse and small-scale production of 'clean' energy such as solar panels and waste energy delivered to the grid. In order to be able to influence system structures and systems thinking, researchers preferred working in pilot projects (full-scale socio-technical experiments) in collaboration with other researchers and with industrial partners (practitioners). They also tended toward a normative and prescriptive research ideology to influence and underpin regulatory measures to support funding of large-scale development of energy technology. They saw themselves as the propagators of research-based knowledge beyond their own institutes to professional and practitioner communities. In this way they perceived that they contributed to societal and technological change. The discourse of the researchers tended to be couched in abstract concepts and technical jargon, e.g. passive housing, and their discourse was oriented toward future possibilities rather than day-to-day problems.

The practitioners reflected a short-term perspective on energy-efficient renovation of buildings, which some argued to be a result of their organisation's predominant concern for financial value, revenues and return-on-investments. This limited time perspective framed their view of energy efficiency as well as constrained their possibilities to argue for long-term investments in their day-to-day practices:

“What is really difficult to discuss in the company is saving over several years from now. These [future savings] have no value today.” (P4)

In the same way as for the researchers, pilot projects focused on energy efficiency were important for the practitioners, especially development projects carried out in their own organisations. These served as reference objects when communicating and explaining the concept of energy-efficient renovation. The practitioners tended to have a practice-oriented approach, in which energy-efficient renovation consisted mostly of fine-tuning existing systems and improving technical details. Key terms frequently used when explaining the notion of energy-efficient renovation were technical solution, reduced energy use and return on investment, which reflected a pragmatic

mindset oriented toward the present. For them, knowledge was a commodity, something to be acquired through cooperating with others, mainly their fellow practitioners.

Some of the practitioners were frustrated with the constraints imposed on them by their organisation's limited attitudes to energy efficiency and the lack of long-term commitment regarding social, environmental, and economic sustainability. What these practitioners had in common was a strong personal interest and commitment to sustainability issues. There were also some divergent views, within the group of researchers concerning energy-efficient renovation. Some demonstrated a broad societal interest and commitment while others seemed to be solidly entrenched in their specific field of technological expertise. These different outlooks within the same group gave rise to alliances across research/practitioner boundaries, but also to tensions.

Reasons for engagement in arena activities

From the interviews, the underlying motivation for the arena was a belief among researchers that practitioners needed expert knowledge to effectively take on the challenges of reducing energy use in building renovation. Therefore the researchers voiced irritation that many practitioners from municipal-housing companies hesitated to take active part in the knowledge arena. This was perceived by the researchers as lack of interest and even lack of concern for energy efficient-buildings.

“We have to chase people to make them show an interest, to find those who want to be engaged and involved [in the arena].” (R3)

This quote reflects some of the frustration among the researchers at the practitioners' lack of immediate involvement in what the researchers implicitly considered an initiative for the benefit of the practitioners. Conversely, most practitioners initially experienced the arena as a forum for the researchers rather than for joint activities and sharing of knowledge between researchers and practitioners. Even though interest in the arena gradually increased, the motivation was often ambiguous, such as being obliged to attend since their organisations was financial committed to the arena project; or having to stand in for a colleague. Yet others felt that

participation was required by their professional role and consistent with their duties within their own organisation. These could be reasons why the arena seminars were well attended, while there was little interest in the other joint activities. Other practitioners, who did have personal interests in energy-efficient renovation, were forced to de-prioritise this domain and the opportunities that the arena availed them due to their organisation's lack of interest.

Among the researchers, the reasons for participating in arena activities were more consistent. Many identified with the formulated ambitions of the arena. They sought opportunities to initiate pilot projects with practitioners and elicit feedback from these, on their research. They also saw themselves as repositories and disseminators of new knowledge to practice. The researcher group in the forum grew from an initial handful to 21 researchers, including fields such as installation engineering, building-energy technology, building physics, indoor climate, construction management, and architecture. Contrary to the practitioner group, the researchers shared a history as well as belonging to an umbrella scientific sub-community. Many had collaborated on research projects and were university colleagues or former fellow-students. Thus, the arena partly consisted of an already established researcher's network. These factors as well as the strong convictions manifested in the researchers' ways of expressing themselves could explain the practitioners' perceptions of the arena as predominantly a forum initiated by researchers for researchers. Reinforcing the practitioners' perception, was the lack of formal roles and hierarchical structures within the arena, i.e. the members participated as professional equals within their specific fields with equal opportunities to become involved and interact within the arena framework. For practitioners, this rather typical academic implicit structure could have generated impressions of lack of structure.

Joint activities for knowledge sharing

As formulated in the arena-project aims, joint activities formed the springboard for knowledge exchange between researchers and practitioners. These joint activities were pilot projects initiated by the practitioners, open seminars and arena meetings. Two arena pilot projects were carried out

within the arena, of which the first was launched at the same time as the arena in 2007 (hereafter called the pilot project). The second was launched in 2010 and only briefly dealt with in this article. Two arena seminars and numerous meetings in various constellations took place during the duration of this study.

Related to the pilot project, a workshop to discuss possible technical solutions' effects on the building exterior and on energy efficiency was held. The interviewees that had participated in this workshop had positive experiences of the activity. A critical factor for the success was the possibility of meeting face-to-face and spending time discussing one issue and its ramifications at length. Many researchers and practitioners found participating in the pilot projects self-developing. The researchers had been eager to collaborate both with each other and with practitioners in order to learn more from real-life situations. Practitioners felt that they had learnt from collaborating with the researchers on the pilot project, and that their membership in the arena community enabled them to test and evaluate technical solutions on site. The pilot project thus offered a space where individuals that had not been in contact before could interact. Through this interaction, researchers and practitioners gradually developed a common vocabulary which allowed them to contribute with their individual bits to 'the puzzle' as a whole. As a result the pilot project stimulated the creation of aggregated ideas for addressing the challenge of making buildings more energy efficient.

The arena seminars were organised around themes and topics related to problems encountered in the pilot project. The first seminar focused on technical solutions, where the practitioners and researchers involved in the pilot project gave presentations and initiated discussions. This seminar also included a field trip to the pilot project. Many practitioners stated that this first seminar and field trip enabled them to experience first hand what the arena was trying to achieve. They also claimed that they had been able to network with researchers, which they normally had little opportunity to do. These activities, they reported, had whetted their appetite for further and more active participation in the arena. Interviews also showed that practitioners used arena seminars as forums for discussions with peers

concerning critical matters such as how to run energy-efficient businesses. The arena thus also became a forum where practitioners could ventilate and obtain support for their frustrations and disillusionments or celebrate their successes with like-thinking peers facing similar situations.

The second arena seminar was well visited by both practitioners and researchers. Word had spread after the first seminar, and the topic of the seminar, rent setting to cover increasing costs for energy-efficient renovation, was highly relevant to the practitioners. The interviewees found that this seminar produced a common understanding of how economic cut-backs impacted possibilities of implementing far-reaching actions. Most of the interviewed practitioners stated that they initially participated in the seminars out of curiosity, to find out what other companies were doing within the domain. The interviewed researchers, on the other hand, saw the seminars as opportunities for obtaining information about practitioners' energy-efficiency practices and their perceived obstacles.

The interviews as well as the observations of arena activities indicate that the researchers and practitioners, through their discussions and dialogue, gradually developed a shared understanding of the challenges that needed to be overcome to achieve energy-efficient renovation of housing. Moreover, the arena participants became increasingly aware of the importance of joint activities as a driver of knowledge sharing, which can be corroborated by a stronger interest from municipal-housing companies in initiating pilot projects.

Although the practitioners' interest in the arena slowly increased, the researchers were dissatisfied in the practitioners' lack of active engagement in the activities and in their lack of initiative in availing themselves of the palette of expertise offered. The researchers had expected the practitioners to initiate more pilot projects than the two that were realised. For the practitioners, however, starting a pilot project was a cumbersome process; pros and cons, financing, resource allocation and most importantly the benefits for the company needed to be deliberated carefully, all of which are time-consuming activities. For a project with a three-year funding scheme, time is a scarce resource.

Mediators and mediating tools

Within the arena, a tool for calculating life cycle costs (LCC) was developed jointly by researchers and practitioners working in the pilot project. This tool was used in the pilot project in the selection of products and technical solutions. Interviews showed that the LCC-tool in this setting served as a mediating tool during discussions between researchers and practitioners, facilitating knowledge sharing regarding technical solutions to suit energy-efficiency demands and economic constraints. Nevertheless, some practitioners perceived that their influence on the design and choice of mediating tools had been limited. They suggested alternative mediating tools, for example an arena web-portal, to enhance communication and knowledge sharing between professional groups within the arena.

The findings indicate that researchers tended to interact mainly with researchers and practitioners with practitioners. This wasted opportunity for cross-disciplinary interaction may be the consequence of different knowledge and information-sharing practices. Researchers stated that they preferred to communicate and mediate information and knowledge through scientific texts and attending academic conferences. This preferred way of sharing knowledge was not that of the practitioners, who stated that they shared knowledge and learned through their day-to-day project practices. Additionally, previously established networks between the researchers rendered interaction between researchers easier than with practitioners.

Figure 1 presents a schematic of typical interaction in the arena, and is based on the analysis of the contact maps (communication paths) that all interviewees drew. The Figure illustrates the positions of the interviewed community members (R1-8, P1-10) within the arena community, as they saw themselves and as others saw them. The closer to the centre, the more influence the members had on activities carried out within the arena. The grey zones illustrate where frequent interaction occurred. One feature that stuck out was the prominent positions of certain individuals, namely the self-appointed leader in the researcher group and the project manager of the pilot project in the practitioner group. These were frequently referred to in all the interviews and seem to have been perceived as “figures of authority”.

In this respect, they may be seen as the main mediators in the shaping of the arena.

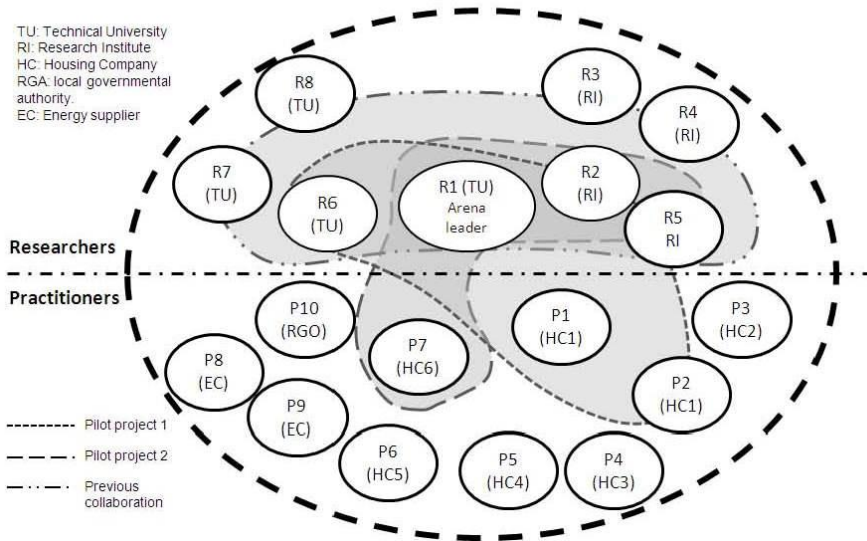


Figure 1: Extensive interaction within the arena community

The leader of the arena, in taking on that role, strongly influenced the framing and scoping of the arena. Reflected in the interviews is the image of an academic with a passionate interest in the subject and a strong belief in the arena project. His mediator sphere of influence, however, was limited to his own community of researchers much due to his inability to translate his vision into a language that the practitioners could readily understand. This is apparent in the interaction patterns (*Figure 1*), where it can be seen that the researchers mostly interacted amongst themselves, resulting in what can be presumed as an unintentional exclusion of practitioners. The result of this behaviour reified the conventional boundary between research and practice rather than relaxing it.

A second cluster of interaction evolved around the pilot project. Here the manager of the pilot project, a professional with a strong integrity and will as well as a passionate interest in the subject took on the main role of mediator, facilitating knowledge sharing not only in the practitioner group,

but across the arena. Words that recurred in all the interviewees' descriptions of her were: enthusiasm, encouraging, and motivating. She also seemed to provide the structure that the practitioners felt they lacked.

“It was she who encouraged us, she set up meetings like the workshop, presented a structured agenda and a plan, and it was a good plan. But, also her desire and motivation to do this pilot project.” (R6)

As the quote indicates, she also provided structure for the researchers. One explanation for the project leader's effective mediation within and across group boundaries was her sensitivity to the different mindsets and discourses of the two groups. Due to her genuine interest and deep commitment to sustainability and energy-efficient renovation, she sought information in the scientific literature and from researchers, thus learning and internalising their discourse. She was also able to translate research results and implications into a discourse that her peers could easily make sense of and were comfortable with. She was therefore capable of initiating dialogue across boundaries. A third cluster of strong interaction was found in relation to the second pilot project, initiated toward the end of our case study, and therefore not within the scope of this paper.

DISCUSSION

Knowledge sharing across professional groups and practices has been explored. By empirically highlighting facilitators as well as hindrances in the creation of a knowledge-sharing arena in cleaner production, this paper contributes to an enhanced understanding of how inter-disciplinary communication and collaborative knowledge sharing may take place across professional boundaries. As such the paper makes a contribution in developing the understanding of how energy-efficiency may be achieved in the context of a socio-technical approach.

The empirical data describing the shaping of a collaborative platform for knowledge sharing show both successes, such as the pilot project, and failures in that a many practitioners and some researchers remained indifferent and inactive in the arena. Through the lens of CoP theory, learning relies on participants' sharing a practice, common interest, visions

and goals, engagement and personal vested interest (Wenger, 1998). All these elements existed initially among the researchers, who were able to mobilise a few practitioners as collaborative partners at the grant-proposal stage. However, findings show that already at the outset of the development of the arena project, content focus and activities were biased toward the stronger group, the researchers, thus creating tensions that reified conventional borders rather than relaxing them. These borders were distinctly pronounced in the groups' divergently perceived arena objectives and in their framing of energy efficiency as a knowledge domain. Arena objectives were instrumental, prescriptive and normative for researchers, and imminently problem-solving for practitioners. The researchers had a long term view on renovation of buildings while the practitioners were constrained by the short-term response to contingencies set by their organisations. In the early phase of the arena project, little strategic effort was spent on the challenges of managing communication and alignment among the inhomogeneous prospective arena members. Instead an ad hoc trial and error approach was used until one individual was able to take on the role to mediate between the various professional groups. An initial effort to create a common and shared vision of the arena's objectives could have generated stronger participation during the early phase, e.g. by using reflective transition monitoring (Loorbach, 2010), visioning exercises (Vergragt and Brown, 2007) and/or participatory back-casting (Quist *et al.*, 2011).

The arena project's ambition was to create a learning space through strong participation and collaborative interaction among the professional groups, yet the way in which the arena was designed contradicted this ambition through its adherence to a 'learning by searching' approach based on the logic of the research community (Kamp *et al.*, 2004). This logic is built on a positivist technological paradigm in which a systematic and organised search for knowledge is guided by a (most often) extant theoretical and methodological framework based on pre-existent knowledge and experiments/experiences, and financing has been pre-allocated. In this world there are possibilities for trial and error as a means of learning. Thus, as propagators for research-based knowledge the core team of five researchers built the arena in line with what can be seen as a 'science-push' strategy

(Kamp *et al.*, 2004). The result, which may be compared to that of the Dutch wind-turbin innovation system explored by Kemp *et al.* (2004), was a mismatch between the intended role of an arena as a forum where several professional groups can interact and collectively learn from each other and the actual competencies and means in hand to implement the intention. In spite of the ambition to base knowledge sharing on joint activities, little attention was paid to the actual implications or consequences of the choice of activities. In addition, the deep-rooted assumption among the researchers that practitioners were in need of their knowledge, created an inherent status and power imbalance reflected in actors' choices, discourses and behaviours. On such a foundation it is difficult to build reciprocity.

In the same way as a community of practice (Wenger, 1998), the arena was intended to grow from a common strong interest and commitment to sustainability and energy-efficient renovations; the activities that the arena would generate were seen as developing out of this interest. The open seminars did show potential signs of serving as, what Wenger (1998) refers to as drivers for active engagement in the surrounding environment. The arena seminars indeed provided a platform where different professional groups could meet, interact and problematise energy-efficient renovation. As such the seminars offered a space where actors representing a range of interpretive frames and competencies could engage in interactions around a shared issue (Vergragt and Brown, 2007). These interactions and exchanges of experience and knowledge did lead to a gradual development of the arena. However, creating spaces for knowledge sharing takes time, as does building an arena or a CoP. Some people drop out, others join, which means that the 'drivers' of an arena need to have sufficient space and the necessary conditions to be able to stimulate an interactive innovation process (Loorbach, 2010). Three years, as in the arena case is not enough time to create a common language and understanding that could enable cross-organisational knowledge sharing. So in spite of beneficial pre-conditions in the form of funding, a need and enthusiasm, the creation of an arena community for sharing knowledge to generate sustainable and energy-efficient solutions for the renovation of buildings experienced problems in taking off and becoming what was hoped for, i.e. a driver of sustainability innovation. The social interaction that took place within the arena

community was simply not durable enough to enhance sharing of knowledge to any larger extent.

Learning in boundary-crossing communities, such as the arena project, is dependent on overlaps in the interpretive frameworks and practices held by the participants (Brown and Vergragt, 2008). This points at another observation made in the study regarding the imperative to consider the choice and appropriateness of the mediating objects and tools used (e.g. Bresnen *et al.* 2003; Räisänen and Linde, 2004). As emphasised by Heiskanen *et al.* (2010), mediating objects serve an important role within the social construction process in that they help bridge differences in viewpoints thus increasing the potential for cooperation between actors. For example, data on the LCC-tool and its use in our study showed that it provided both practitioners and researchers in the pilot project as well as practitioners within the same municipal-housing company common information, and served as a foundation for discussions. It was shared by cooperating parties and was viewed as a common referent, even though it differed in its initial contents. Thus, the LCC tool is a typical example of a mediating object which can travel across community boundaries (Räisänen and Linde, 2004).

With a stronger participatory approach (Loorbach, 2010; Quist *et al.*, 2011; Vergragt and Brown, 2007) at the outset of the arena project, the interaction in the arena might have looked different. Instead, as observed, it was not until the pilot project that interaction between different professional groups took place to the extent that knowledge could be said to have been shared and incorporated into participants' personal stock of knowledge and thereby posing a potential challenge to established, taken for granted interpretive frames and practice. Similarly to Kamps' *et al.* (2004) study of learning between researchers and practitioners, the pilot project proved to be the most efficient means for knowledge sharing and implementation of energy-efficient technology. Opportunities for learning were facilitated in the pilot project by what Wenger (1998) and Brown and Duguid (2001) refer to as a broker. The researchers originally prescribed the broker role in the arena goals failed to realise it; however, the project manager of the pilot project, through her efforts to align with both researchers and practitioners and her

sensitivity to both parties, succeeded in becoming a ‘competent’ mediator (Heiskanen *et al.*, 2010; Wenger, 1998). Her success was largely due to her ability to translate the discourses of the two parties and enabling mutual sensemaking. Once the participants had developed a shared language, it also opened up for a dialogue on how to overcome barriers, such as counteracting regulations and cost constraints for energy-efficient renovation in housing. The arena project thus provided practitioners with a space where they could ventilate and obtain support for their frustrations and disillusionments and celebrate successes with like-thinking peers facing similar situations. It also offered an opportunity to discuss these constraints outside the municipal-housing community.

The pilot projects were the main facilitators for knowledge sharing and learning in the arena. However, we found an interesting paradox: although practitioners stated that learning occurred in pilot projects, they neither wanted to contribute with nor participate in pilot projects framed by the researchers. This is most likely a consequence of the researchers’ inability to mediate the joint benefits of pilot projects. Instead the practitioners interpreted the pilot projects as reflecting the researchers’ own self-fulfilment. Their reluctance may also, have been a consequence of the short-term and limited view on energy efficiency of buildings held by the municipal-housing companies. Consequently, the participants’ engagement in the arena was limited due to contradicting organisational regimes and practices, such as norms, revenues, return of investments and budget frames. This point at the importance of also involving top-level managers in such arena endeavours (Quist *et al.*, 2011).

CONCLUSIONS

This paper has shown that the ways in which information was interpreted and acted upon by arena participants was dependent on the local context, the worldviews as well as also the role, and persuasive force of human mediators to change prevalent interpretive frames (cf. Gluch and Räsänen, 2009). What happened within the pilot project supports the assumption made by Heiskanen *et al.* (2010) that interrelationships between people arise from engagement in practice and not from an idealised view of what a community should be. Therefore, as argued by Brown and Duguid (2001),

for future attempts at creating knowledge-sharing spaces, careful attention needs to be paid to the actual practices within which the knowledge is to be shared, e.g. cleaner production.

We conclude that although the arena cannot be characterised as a community of practice, it showed potential for facilitating knowledge sharing and learning. It was also found that social interaction around a special interest allowed for learning among individuals with various backgrounds. Moreover, collaborative work in small-scale socio-technical experiments (Brown and Vergragt, 2008; Brown *et al.*, 2003; Kamp *et al.*, 2004), e.g. pilot projects, seem to be an efficient strategy to facilitate knowledge sharing and learning across organisational and professional boundaries.

In future attempts to stimulate knowledge sharing across professional boundaries in cleaner production, to enhance learning and to improve communication, semiotic tools such as the discourse, genres and platforms need to be adapted to the practices of the communities involved, rather than the other way around. The communication culture and the choice of learning approach as well as mediating tools need to be reflected upon by the actors at an early stage. Moreover, for the realisation of a knowledge arena a self-appointed leader might be necessary, but might not be self-evident once the arena has been launched. Our study showed the need to mobilise the “right” partners from the start and to promote the arena in their respective community using the appropriate discourse. The study also highlights time and space as important factors that need to be considered if interactive innovation processes are sought.

The research approach, where in-depth interviews have been combined with field studies and observations of arena activities, has enabled an opportunity to examine the informality of the interaction and knowledge sharing between different professional groups and practices. In addition, the time-span of the study has created an opportunity to closely follow the development of a collaborative knowledge-sharing forum for energy efficient renovation of buildings, opening a window that allows connecting a local and situational context to a wider societal discourse on sustainability.

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PAPER II

The Role of the Individual in Sharing of Knowledge in Project-based Organisations

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THE ROLE OF THE INDIVIDUAL IN SHARING OF KNOWLEDGE IN PROJECT-BASED ORGANISATIONS

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ABSTRACT

This paper explores how individuals develop and create activities that facilitate social interaction and knowledge sharing across professional and organisational boundaries within a project based settings. Data was collected through a case study approach in the setting of the highly projectified construction industry. By applying Wenger's conceptual framework of communities of practice the role of the individual as a knowledge mediator was highlighted. Findings showed sharing of knowledge in this setting to be dependent on individuals' possibility to act as translators of knowledge through creation of trust, allocation of time and money and the freedom to innovate.

Keywords: *communities of practice, energy efficiency of housing, translators, construction industry, standardised building systems*

INTRODUCTION

Although knowledge is seen as the property of the individual, it is also a product of social interaction within groups. Since the turn of the millennium, researchers and practitioners within the field of knowledge management have begun to focus on these tightly knit groups called community of practice, and how they interact and share their knowledge

(e.g. Brown and Duguid, 1998; Wenger, 1998) across organisational boundaries (Wenger *et al*, 2002). Although Wenger's concept of community of practice describes the sharing of knowledge and learning as a social process that takes place when people meet and interact around a shared interest and/or task, the concept has in recent years been proposed by researchers and practitioners as a tool to facilitate and manage these communities. Scholars have described this perspective on the concept of communities of practice as the new generation of knowledge management, and it is explored as a means of creating competitive advantage (e.g. Wenger and Snyder, 2000; Wenger *et al*, 2002; Koch, 2002; Grisham and Walker, 2006; Bishop *et al*, 2008; Probst and Borzillo, 2008). This new generation of knowledge management notion highlights the role of the individual within the community of practice (Fontaine, 2001; Borzillo *et al*, 2011) and his/her possibilities to share knowledge across boundaries (e.g. Handley *et al*, 2006; Kimbel *et al*, 2010). However, the need to understand what happens inside as well as outside these communities and what part individuals' play in the sharing of knowledge across community boundaries still exists.

Using the example of the highly-projectified construction industry, researchers in organisational learning have explored the learning possibilities in these settings, focusing on social practices (e.g. Scarborough *et al*, 2004; Bresnen *et al*, 2005). Scholars have found that firms in the construction industry operate on the basis of a high degree of tacit knowledge (e.g. Bishop *et al*, 2008; Styhre, 2009) and are therefore highly dependent on face-to-face interaction in their endeavours to create and sustain knowledge sharing and learning (e.g. Styhre *et al*, 2004; Grisham and Walker, 2006). Though strong learning capabilities have been found within projects (e.g. Anheim, 2003; Schenkel and Teigland, 2008), mechanisms of knowledge sharing between project settings are lacking (e.g. Prencipe and Tell, 2001; Styhre *et al* 2004; Sense, 2011). Several studies within construction organisations indicate that communities of practice should be nurtured and supported in order to achieve best practice and competitive advantage (Scarborough *et al*, 2004; Bresnen *et al*, 2005; Bishop *et al*, 2008; Elmualim and Govender, 2008). However, few studies have focused on how individuals share and mediate knowledge between communities in project-based settings.

Facing the challenges presented by energy efficiency of buildings as well as increased standardisation within the industry opens up research opportunities into how knowledge is shared and mediated within and between such communities in form of professional groups and organisations. By applying the theoretical lens of Wenger's communities of practice this paper contributes to research on knowledge sharing and learning in a project-based settings. Using a case study approach, knowledge sharing is explored during the development process of a standardised building system for energy-efficient housing within a construction group based in Sweden. The aim of the paper is to explore how individuals development and creation of activities may facilitate social interaction and knowledge sharing across professional and organisational boundaries.

The paper begins by giving an introduction to the concept of communities of practice and its application in research on project-based organisations. Next, the research approach taken and tools used for collecting data are outlined. The subsequent sections present the results, i.e. the organisational setting of the case study, the development process of the standardised building system and how individuals belonging to different professional groups interacted during this process. The paper concludes with a discussion and conclusions on how individuals' may facilitate social interaction and knowledge sharing across professional and organisational boundaries.

KNOWLEDGE SHARING AND LEARNING

For the individual, learning takes place when she/he engages in and contributes to a community's practice. For the community, learning occurs when a group of individuals negotiate meaning, and by doing so develop their common practice (Brown and Duguid, 2001). Learning in organisations entails sustaining the connections between the communities of practice that exist within the organisation. These social groups constitute and encompass what the organisation knows and how it is perceived since individual and environment cannot be separated (Brown and Duguid, 2001; Wenger *et al*, 2002).

The conceptual framework of communities of practice

Communities of practice are as diverse as the situations they accommodate: they can vary in size; have short or long life spans; consist of members situated in close proximity or widely distributed over organisational and/or geographical boundaries; and consist of people from the same or multiple disciplines. They may coalesce from spontaneous interaction or be formed intentionally and they may be institutionalised or organic (Wenger *et al*, 2002). In short, communities of practice are everywhere and, just by participating in everyday life: e.g. at work, through family and sports, we belong to several simultaneously (Wenger, 1998; Wenger *et al*, 2002). Most formal organisations can be seen as a hybrid of groups, organisational entities and official and unofficial networks, overlapping each other as interdependent communities (Brown and Duguid, 1998).

Communities of practice can be characterised by how new members are admitted. Membership can be open to anyone who is interested in the community's area of interest, or it can be limited to those who the community wants as members (Wenger and Snyder, 2000; Dubé *et al*, 2006). Open membership, then, corresponds to the thought of sharing knowledge in organisations. Dubé *et al* (2006) argue that admitting only those who match a certain profile allows for more control of the community of practice and thus facilitates its management. Further, enrolment in a community of practice can take various forms: voluntary (open membership), management induced (encouraged by management) or compulsory (Dubé *et al*, 2006; Borzillo *et al*, 2011). In any case, individuals may themselves select which communities of practice they wish to join. The choice may be based on what knowledge the individual desires to gain and on their need for the knowledge.

Sharing knowledge across community and organisational boundaries

Communities of practice are not isolated. To thrive they need outside influence. As communities of practice focus on their interests and/or tasks, they inevitably create boundaries (Wenger, 1998; Wenger *et al*, 2002). The boundaries of a practice are informal, and often even unarticulated. Nevertheless, they are real and can be identified through variations in use of

language, vocabulary, artefacts, sets of experiences and ways of performing a task. However, knowledge both ‘sticks’ within as well as ‘leaks’ across boundaries (Brown and Duguid, 1998).

The ‘leaking’ of knowledge across boundaries requires mediators. Brown and Duguid (1998) called these persons translators or knowledge brokers depending on the context, Wenger (1998; 2000) simply called them brokers whereas Sverrisson (2001) saw them as entrepreneurs. The individuals referred to are ‘importers-exporters’ of knowledge between communities of practice. These knowledge brokers or mediators have central roles at the interface between different communities of practice facilitating the dialogue between them as translators of vocabulary, symbols and tools (Wenger, 1998; Wenger *et al*, 2002; Yanow, 2004; Meyer, 2010). As the role of these persons is to mediate knowledge they should not erect walls or create boundaries around their own practice (Meyer, 2010).

One distinction between translators and knowledge brokers is how they mediate knowledge under different circumstances, i.e. between organisations seen as communities (translator) or within a firm (broker) (Brown and Duguid, 1998). A translator has to be knowledgeable about both communities’ practices in order to be able to negotiate meaning and gain trust within and between the two. Gaining the trust of both communities of practice as she/he negotiates meaning within both communities while simultaneously taking into consideration the interest of the other community was found to be essential (Brown and Duguid, 1998). The role of the knowledge broker on the other hand is that she/he belongs to the communities of practice she/he in turn mediates knowledge between, e.g. this person is a member of an organisation (as a community of practice) and also several sub-communities in the form of workgroups or projects (Wenger, 1998). This type of brokering of knowledge requires concurrent membership in the communities of practice between which knowledge is shared. As a consequence, trust is here of a lesser importance (Brown and Duguid, 1998).

Supporting tools and communication technologies are usually used to mediate knowledge between professional and organisational groups. Scholars investigating the use of these mediating objects in the construction

industry context have found that these need to be aligned with the organisation and its social groups in order for knowledge to be effectively mediated (Bishop *et al*, 2008; Styhre and Gluch, 2010). Similar, capturing knowledge and mediating it across organisational boundaries has been found to be dependent on roles that support and connect projects and organisations (Bresnen *et al*, 2003; Gluch *et al*, forthcoming). These roles could even themselves be seen as knowledge management mechanisms in these project-based organisational settings (Bresnen *et al*, 2003). Moreover, mediating knowledge is often associated with support functions and domain experts who have been found to rely heavily on personal contacts within and across organisational boundaries in order to be able to do their work (Bresnen *et al*, 2003; 2005).

Conditions for social interaction and sharing of knowledge in the construction industry

The construction industry is a project-based industry relying on a variety of professional groups such as private or public builders, contractors, architects and several specialised technical consultants. Being project based, the construction process is often described as a loosely connected chain of activities, a relay race, where each phase of realising a building system is de-coupled from the previous and the following (Prencipe and Tell, 2001; Dubois and Gadde, 2002; Kamara *et al*, 2002). Each project is seen as unique (Bresnen *et al*, 2003) where human resources from various professional groups are coordinated by artefacts such as drawings and other documents to attain a common goal (Ruuska and Teigland, 2009). This demands a high degree of social interaction which is dependent on face-to-face communication (e.g. Styhre, 2008; Gluch and Räsänen, 2009) to create a tight coupling within the project environment (Dubois and Gadde, 2002).

In order to address criticism of being an inefficient and fragmented industry (the Strategic Forum for Construction, 1998; SOU 2002:115) and to avoid 'reinventing the wheel' in each project, several construction companies in Sweden have chosen to develop standardised building systems (Gerth, 2008). These building systems address the one-off nature of construction projects, and in doing so challenges the traditional construction process and the way professional and organisational groups are used to interact when

realising construction projects. Another challenge that the industry currently faces is the increased focus on energy efficiency of buildings (Thuvander *et al*, 2011). This originates from the raised awareness of the ongoing debate on climate change and the strengthening of legislative measures regarding the energy efficiency of buildings. To meet this new demand for new knowledge on environmental performance, organisations have introduced new support functions in the form of environmental specialists (Gluch, 2009).

RESEARCH APPROACH

Over a three year period, data were collected from a Swedish construction group using such case study methods as: interviews, document studies, observations and informal conversations. The data were collected in two cases: the first case in 2009 (7 interviews) exploring knowledge management in the construction industry by focusing on knowledge brokering related to standardised building systems and processes, and the second case in 2011 (12 interviews) focusing on the individuals' role in facilitating interaction and knowledge sharing between organisations and professional groups in project-based settings. Data for the two cases were collected in the same organisation and one person, the manager of division for technical innovations, was interviewed in both cases. Both studies investigated the intersection between knowledge management and increased standardisation of building systems.

The interviews were carried out face-to-face, the one exception was the first case where the interview was carried out as a telephone conference. All interviews lasted between 1-2 hours and were all recorded except for one in the second case where notes were taken. The number of interviewees, their position and organisational belonging within the construction group and when they were interviewed (first or second case) can be seen in Table 1. Each interviewee has been given a reference number (C1-9; H1-3; TC1-4 and A1-2) to facilitate indexing in the result section.

The first case, interviewees were selected to provide a broad picture of how knowledge sharing within the company took place and how standardised building systems were developed and used within the construction group.

The second case was done in two stages, where interviewees in the first stage (7 interviewees) were selected to allow an investigation of the development process of a standardised building system for energy efficient housing. After an initial analysis of these interviews, the researcher decided to conduct 5 more interviews with persons identified in the first stage as furthering the understanding of individuals' actions to facilitate knowledge sharing. Out of the 5 interviews done in the second stage, 2 interviewees worked in an external architecture firm (see *Table 1*).

The interview guide used in the first case focused on how knowledge was shared within the organisation; how standardised building systems were developed; for what purpose and how they were used within the organisation; and what barriers the interviewees perceived in knowledge sharing within the organisation. Questions were designed so that the interviewees could elaborate to some extent.

For the second case, the interview guide was designed to focus on preferred ways of individual learning and sharing of knowledge; with whom knowledge was shared and how; how the development process of the standardised building system proceed; who had participated in this process; what their contributions were and how these were made.

In the first case, recorded interviews were listened to and summarised iteratively, resulting in a detailed list of quotes, phrases, concepts and key words pertaining to the themes in focus.

Case	Position (interview No)/ Area of expertise	Organisation (No interviews)
First case	Environmental manager (C1)/ structuring of environmental issues	Construction organisation (10 interviews)
	Head of R&D organisation (C2)/risk management	
	Manager of division for technical innovations (C3)/market strategy	
	Manager at division for purchase and competence division (C4)/property development, international purchasing	
	Head of division for product development (C5)/ property development	
	Manager at division of production of buildings (C6)/ utilise standardised building systems	
Second case	Manager at division for standardised building systems (C7)/ structuring of quality issues, Life Cycle Costing, Life Cycle Analysis	
	Manager of division for technical innovations (C3)/market strategy	
	Planning manager (for the pilot project) (C8)/civil engineer, production of buildings, economy, project management	
	Site manager for the pilot project (C9)/ carpenter, production of buildings, project management	
Second case	Environmental coordinator (H1)/ environmentally adapted product development, structuring of environmental issues	Housing development organisation (3 interviews)
	Project manager for pilot project (pilot project) (H2)/ standardisation of the building process, project management	
	Manager of a geographic housing development division (H3)/ market strategies	
First case	Consultant on structural engineering (hired to develop standardised building system) (TC1)/ civil engineer	Technical consultancy firm (4 interviews)
Second case	Consultant on energy efficiency of buildings (hired to develop standardises building system) (TC2)/ civil engineer, energy efficiency of buildings	
	Consultant on production efficiency in construction (project leader of the development project of the standardised building system for energy efficient housing) (TC3)/ civil engineer, production of buildings, project management	
	Consultant on energy efficiency of buildings (TC4)/ energy and environmental engineer, environmental communication	
Second case	Architect (A1)/ architect, utilise standardised building systems	Architectural office (2 interviews)
	Planning manager (A2)/ civil engineer, project management	

Table 1: show the number of interviewees, where in the construction group they worked, their role/position in the company and during which part of the study they were interviewed. Each interviewee has been given a reference number to facilitate citation indexing in the results section.

The data collected through the interviews in the second case were transcribed and then analysed by iteratively listening to the interviews and reading the transcripts, drawing charts of interaction patterns and making detailed lists of quotes and phrases highlighting the themes in focus. All interviews were first analysed on their own and later in different combinations (e.g. organisational belonging, project participation, according to expressed interests, and/or profession) to map individual actions facilitating the forming of social groups and patterns for sharing/retaining knowledge. Findings in the interviews were compared with the collected documents, such as meeting protocols, information leaflets and the descriptions and blueprints that the standardised building system consisted of.

CASE DESCRIPTION

The organisation studied is a large construction group based in Sweden, but also active on an international market. Being a typical actor within the Swedish construction industry, the construction group offers services ranging from production of housing to R&D in projects. (See *Figure 1* showing organisational chart.) Parts of the organisation under study are the construction organisation (contractor), the housing development organisation (builder) and the technical consultants (in-house consultancy firm). The R&D, process development and standardised building systems divisions all belong to the construction organisation.

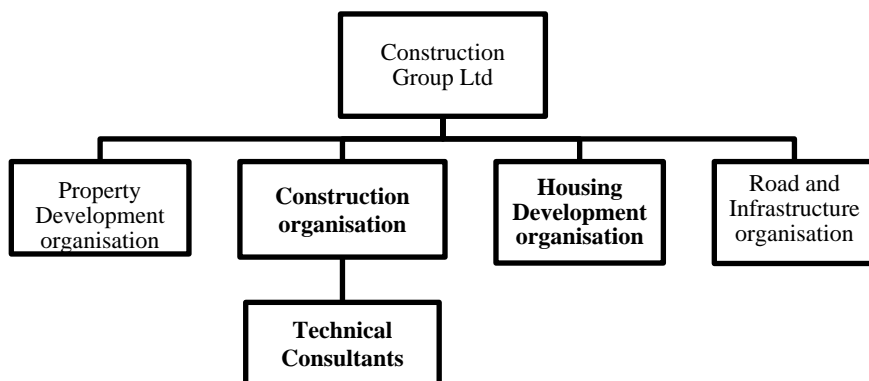


Figure 1: Structure of the Swedish organisation in the Construction group.

The construction group has recently refocused from considering time, cost and efficiency to include environmental considerations such as energy efficiency. To meet this new demand for knowledge on environmental performance, the construction group has introduced new support functions and in-house consultants on environmental issues and energy efficiency.

The construction group has previously worked with standardised building systems which have been managed by the standardised building systems division in the construction organisation aided by the technical consultants (henceforward, when appropriate, referred to as in-house consultants). Seen as a competitive advantage, these standardised systems were developed to coordinate purchases and collect best practice in order to raise the efficiency and quality of the production of housing and infrastructure (Gerth, 2008). Sharing knowledge between projects was not the primary reason for introducing these standardised building systems.

Since parts of the development process of the standardised building system took place during the pilot project, other relevant professional groups, such as the architects were included in the study.

KNOWLEDGE SHARING IN THE DEVELOPMENT OF A STANDARDISED BUILDING SYSTEM

Focus in this section will be on how knowledge and knowledge sharing was viewed and took place within the project-based settings of the construction group. How individuals' actions influenced the development process, and what their contributions were towards the developed standardised building system for energy efficient multi-family housing.

Knowledge and skills

The term competence was frequently used by members of the construction group when describing an individual's knowledge, when they assessed whether someone was knowledgeable. Competence was considered to be dependent on the social environment, i.e. to be skilled in a particular context. Competence was described as knowledge obtained through practical experience.

In this context, when required by the projects, specialists' knowledge could be mediated by individuals employed within and/or outside the organisation. In this sense, specialists were seen as individuals with a certain type of knowledge that 'did not exist' within, but was acquired from outside the social setting of the project group. Curiosity was seen as a prerequisite in the construction group for retrieving knowledge. Resistance could be detected against seeking or incorporating the knowledge provided by specialists or a professional group that the receiver did not belong to nor had had a previous personal relationship with.

Knowledge sharing in project-based settings

Within the construction group it was seen as important to know whom to contact to resolve problems that may arise in projects. Therefore, continuous efforts were made to connect employees to create knowledge capital in the construction group, as the quote below describes.

“The collective wisdom of the company is entirely dependent on how good we are at connecting people's knowledge. The knowledge of each individual is worth a lot, but we must ensure that we can build a network and a [knowledge] capital in the company.” Interviewee C3

To facilitate exchange of experience, formal horizontal networks were established in the organisation between different specialists and for the planning and staff functions. One example of this was the environmental coordinator's network led by the environmental manager of the construction company, within which participants from the housing development and construction organisations and in-house consultants on environmental issues of the technical consultancy firm were members.

The large flow of information within the construction group caused the employees to only take in and process information that was provided exactly at the time they felt they needed it. Time constraints were seen to have a large impact on information processing and also seen as the main reason for not seeking knowledge, for example in databases, including documents, or by contacting subject specialists or support functions.

Barriers to sharing knowledge were associated with time constraints and the fact that personnel left the project in various phases of the construction process and did not follow the project to its completion. In addition leadership was found to influence knowledge sharing as it guided, allowed for, or hindered the time-consuming social process of knowledge sharing.

No incentives to sharing knowledge or bridging these barriers were in place within the construction group. Instead, sharing knowledge with peers could be seen as a disadvantage when unique, prestigious and complex projects, where for instance new technique was tested, were to be manned.

The pilot project for energy efficient housing

In the autumn of 2007, to meet market demand, the housing development organisation made the strategic decision to set up one energy-efficient housing project in each of its four geographic regions. The decision was a result of the lobbying by the environmental coordinator in the housing development organisation.

The environmental coordinator, also a member of the cross-organisational environmental coordinator's network, saw the change in market demands and decided to lobby from the inside of her own organisation in order to drive the strategic decision for energy efficient housing. To facilitate the strategic decision made by the management of the housing development organisation she had data collated by in-house specialists on energy efficient housing, who could calculate energy savings and monetary expenditures for the different geographic areas and climates. She also had a market survey made by an institute of public opinion investigating clients' interest in energy efficient products and what these would be willing to pay for this type of housing. The environmental coordinator's efforts to get the strategic decision in place are illustrated in the quote below.

“To make decisions about the levels for energy use in housing, I took the help of [in-house specialists] to investigate where do we stand today. What kinds of measures are necessary for us to take in order to upgrade our standards? So, with the groundwork from [the consultancy firm], [like] the cost estimates on what better windows cost, and that, [then] the management team was ready to take a decision like that, so to speak. But, it was I who pushed [it]

through and presented the groundwork to the housing management team.” Interviewee H1

Her actions made the initiation of the pilot project possible. *Figure 2* shows the timeline of pilot project where activities and development of artefacts, such as drawings, descriptive documents and information leaflets can be seen.

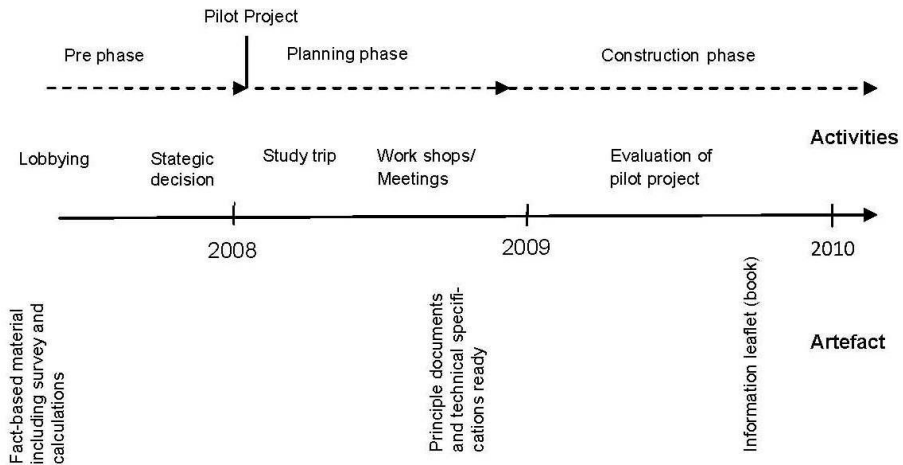


Figure 2: *The timeline of the pilot project where activities and artefacts created are shown.*

The pilot project itself was initiated by a manager of one of the geographical housing development divisions with the purpose to learn how to construct these types of buildings. He saw the potential of obtaining market advantages over competitors by learning more about constructing these types of housing. In his decision of creating a pilot project, the manager of the housing development division made two things: he appointed a project manager with previous experience in using standardised building systems and he contacted the environmental coordinator in order to get knowledge on how to design and build an energy efficient building. The contact with the environmental coordinator was taken by the manager as he thought it a part of her role to mediate knowledge to projects within the housing development organisation concerning these issues. Being contacted in expectation to help out in designing an energy efficient building, the environmental coordinator realised she had limited knowledge herself on

how to design an energy efficient housing. She therefore put the manager of the housing development division in contact with the in-house consultant she previously used for putting together the lobbying material.

The architect was included in the planning group as he showed interest in the energy efficiency of buildings. Together the group planned and arranged a study trip to ongoing and completed energy efficient housing projects. The trip took place early in 2008 and was made in order to learn and create a common view within the planning group on how to plan and design energy efficient housing. The planning group had by this time grown to include an external planning manager from the same architectural firm as the architect with the responsibility to coordinate the consultants, two external consultants on installations and electricity, two in-house consultants on installations and structural engineering, and a contract manager from the construction organisation. The project manager of the planning group facilitated interaction between the different professional groups. Her actions as project manager enhanced negotiation of meaning among planning-group members. How the members of the planning group viewed this process can be seen in the quote below from an information leaflet co-written by the architect, the environmental coordinator and the manager of the housing development division.

“All parties in the formed [planning group] had just as much - or rather as little - experience of building energy efficient housing and together we explored what it would mean for the buildings we were designing to meet the criteria [of energy efficient housing]. The group was imprinted by a common understanding and curiosity [for energy efficiency of housing] and worked in the first phase under workshop-like forms to find the appropriate solutions for both the system selection as well as the design. [...] This gave the group a common frame of reference and objectives to strive towards.”

As the quote demonstrates, the planning group together took on the challenge of designing and constructing something that was new to them.

As the economic recession hit in the autumn of 2008 the project was delayed four months allowing the group time to reach a common understanding of energy efficient technology and its implications for the

construction of these types of buildings during joint evaluations of solutions at meetings and workshops. The knowledge they gained during these meetings and workshops was used to draw up the principle documents and technical specifications for the project.

On moving into the construction phase, the project was handed over to the construction organisation and a hand-over to an internal planning manager was made. This procedure was in line with the construction group's policy for constructing buildings when using the housing development organisation as builder. In addition, the architect's services were no longer needed so he left the planning group, but kept in contact with the project and site managers through jointly arranging guided tours and seminars on site. On these occasions the project and site managers as well as the architect described how they devised technical solutions and designed for energy efficiency in order to comply with the official demands on energy efficiency of housing.

As the pilot project moved into the construction phase, the decision was made by the environmental manager of the construction organisation to classify the pilot project according to a Swedish environmental classification system. Although the decision was taken by the construction organisation, the environmental coordinator had raised the possibility of classification during the planning phase, as the subject of environmental classification had been discussed for some time in the environmental coordinators network.

The construction organisation needed the help of the environmental coordinator of the housing organisation to manage the classification process. As the quotes below illustrates, the environmental coordinator engaged the some of the members in the planning group in the classification process during workshops. Negotiation of how to classify the pilot project became a part of the discussions during these occasions. Moreover, the site manager of the pilot project chose to gather a group on site in order to handle the new demands regarding choice of material and technical solutions needed to meet the demands of the classification system. The planning group considered that the dedication of one person, a true enthusiast, was necessary to drive development and innovation; the site manager considered

that the power of individuals joining together in solving a problem to be more compelling.

“But, it came up, we talked about it, during our workshops on environmental classification in [the pilot project], that a person is needed who pursues issues in projects, which will exhilarate and drive [things forward].” Interviewee H1

“We were supposed to environmentally classify these houses and I had no idea how to do this, so I formed a small group [on site]. It's important to pick the right people. It is not easy. Sometimes I have to tell someone ‘you have to go’, for it must have the right composition. That when you get a giant motor! We solved a lot of problems in this environmental group.” Interviewee C9

Even though the site manager emphasised the advantage of working in a group, he also highlighted the importance of appointing the right individuals to that group. During these on-site group meetings where the negotiations on how to interpret and accommodate the classification system were carried out, the site manager made frequent use of both the environmental coordinator's and the in-house consultant on energy efficiency's knowledge. The site manager's practical experience was an additional asset to the planning group in the discussions on, for example, the architect's design of fitted sun screens for the windows and the project manager on different technical, installation and structural solutions. The site manager became an asset to the in-house consultant leading the development project of the standardised building system as this project leader made frequent visits on site to discuss issues related to construction practice. These projects ran in parallel during the construction phase, which made it possible for the in-house consultant leading the development project of the standardised building system to document the structural and installation solutions used in the pilot project. Many of the solutions utilised in the pilot project ended up in the standardised building system as the quote below indicates.

“[The standardised building system] is a copy of what we planned and constructed in [the pilot project] as there was no [standardised building system], or yes, it was under construction, but a lot of what is incorporated we planned and constructed in the [the pilot project].” Interviewee C8

As the concept of constructing energy-efficient housing was new to all the members of the pilot project, the initial lack of knowledge on how to construct such a building made its participants more open to collaboration. Working together in projects was a way of learning and developing individually as the quote below indicates.

“The people who worked on this project continued on to new projects, talking about what they had done [in the previous project], [...] We are constantly trying to summarise projects after they are completed, what we had been good at, what we missed, what was less good, what customers told us, and we try to absorb it. It's hard, everything is very bounded to the person. All the people who worked in the projects learned from it. That's where the knowledge is.” Interviewee H2

As indicated above, when the pilot project was handed over to the construction organisation, the architect felt a need to write down experiences made in the pilot project in an information leaflet in form of a book. He contacted the environmental coordinator and the manager of the geographic housing development division proposing a joint writing of the book. The book was thus co-authored by the architect, the environmental coordinator and the manager of the housing division in order to share their experiences and lessons learned outside their respective organisations.

The development project of a standardised building system

Early in 2008, after the strategic decisions to realise one energy efficient housing project per geographical region had been taken, the housing development organisation initiated cooperation with the construction organisation through a cross-organisational interest group. As the construction organisation was predominantly interested in the technical aspects of construction and in making the production of housing as cost and time-efficient as possible, the initiative to cooperate on energy efficiency of housing resulted in a decision to develop a standardised building system for this type of buildings.

The environmental coordinator of the housing organisation was appointed project leader of a pre-phase of the development project by the cross-

organisational interest group where information was collected on how to build energy efficient housing. At her disposal she had a work group consisting of seven in-house consultants who helped her calculate costs and identify risks of different technical solutions. Among the work group participants as an in-house consultant on production efficiency in construction who later was appointed project leader of the development project. The project group used workshops and meetings to coordinate its work, which resulted in drawings, calculations and risk assessments on how to build energy efficient housing. Even though not used later on in the development process, these documents included the knowledge of many individuals.

During the pre-phase, a study trip was made abroad by a selected group consisting of representatives from the housing and construction organisations, the technical consultancy firm and an architectural firm (not part of the actual development process). The purpose of the trip was to collect information on how to build energy efficient housing from countries where these types of buildings had been constructed for some time. The timeline for activities during the development project can be seen in *Figure 3*.

After the trip, a joint document, called a 'knowledge document' was compiled, where each professional group documented their impressions from the trip. The document enabled the group to create a common language around what they had experienced during the study trip. However, this document was not utilised later on in the development process, even though it contained valuable information on the participants' joint experiences. The process of putting it together was in itself perceived as a learning process by the participants in the study trip.

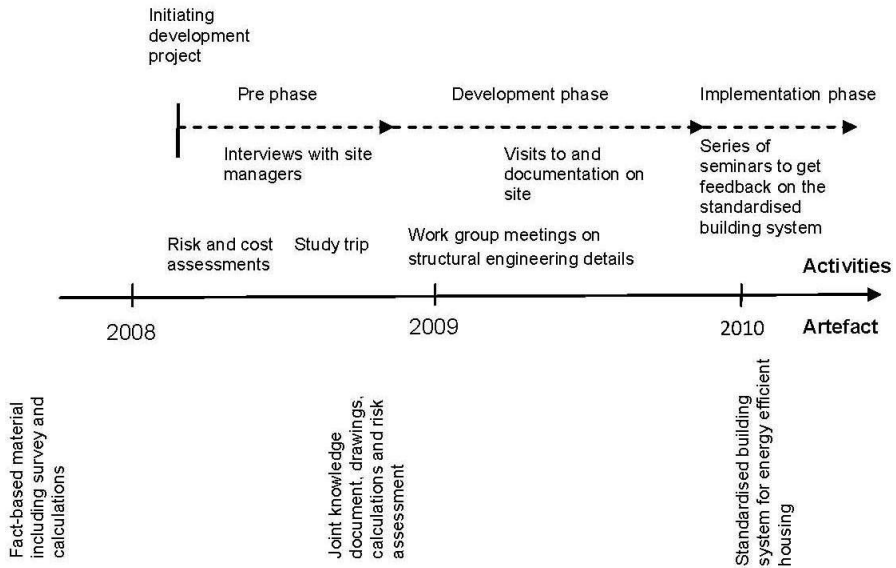


Figure 3: The timeline of the development project where activities and artefacts created are shown.

Parallel to the planning of the study trip, the in-house consultant on production efficiency in construction was also hired by the construction organisation to perform interviews with site managers. These site managers had previously constructed energy-efficient housing for external clients. As the in-house consultant on production efficiency in construction was appointed as project leader in the next phase of the development project, the site managers' accounts were used to inspire and guide the development process during workshops and meetings.

Although the project leader of the development project had participated in the study trip and in compiling the joint 'knowledge document' as well as drawings, calculations and risk assessments, he chose to use an already existing standardised building system for housing when continuing the development process of the standardised building system. Based on this platform the in-house consultant decided to gather a team of in-house consultants on structural engineering. In his choice he left out the in-house consultants on installation as he considered the development process to be of a structural engineering nature. He thought these in-house consultants'

contributions to be of less importance at this stage of the development process as is shown in the quote below.

“[...] we tried to cover the areas we thought were of concern. Well, we were pressed for time [...], so, even if I found it a bit wrong, [...] we decided to work on what was new. [The in-house consultants specialised on installations] had certainly been able to contribute with something, but it is not their role, as the installation part of the [standardised building system] had to undergo limited changes to what we normally build. So, we separated our meetings. This was more cost efficient too.” Interviewee TC3

The pressure the in-house consultant felt to deliver the project limited his abilities to administer a larger team of in-house specialists. He saw himself and his role as an information seeker, however, the information he sought under these circumstances was related to his interest in production efficiency. As a result, the installation solutions in the standardised building system were instead discussed and developed in the planning group during the planning phase of the pilot project. These solutions ended up in the standardised building system due to previous acquaintance between the site manager of the pilot project and the project leader. The already existing relation between these two individuals based on a common interest in production efficiency facilitated the project leader's frequent visits on the construction site of the pilot project. During these visits the project leader and the site manager discussed practical installation solutions made on site and these solutions were documented and incorporated into the standardised building system. Moreover, as the in-house consultant did not share the environmental coordinator's interest in environmental issues he found the classification system too comprehensive to be included in the documents and descriptions that constituted the standardised building system.

DISCUSSION AND CONCLUSIONS

The purpose of this paper has been to explore how individuals develop and create activities that facilitate social interaction and knowledge sharing across professional and organisational boundaries. By highlighting the role of the individual as a knowledge mediator in the development process of a

standardised building system, this paper adds to the understanding of how knowledge may be shared across organisational and professional boundaries in project-based organisations

Sharing of knowledge has in this paper been found to be highly dependent on personal relationships, where trust in the source of information was of importance for its acceptance and internalisation. By applying Wenger's (1998) conceptual framework of communities of practice and Brown and Duguid's (1998) application of the framework onto organisations, each organisational entity, professional group, project and network discussed can be seen as a community when similarities and differences in strategic goals, focus areas driving work, symbols and language used to communicate are reflected.

What facilitated the development process of a standardised building system possible were the vision and actions of the environmental coordinator on how the housing organisation could accommodate the evolving housing market through environmental and energy-efficient housing. Taking on the role of a trusted translator between the network for environmental coordinators and the management of the housing organisation, as described by Brown and Duguid (1998), she enabled the pilot project. The trust needed to become a translator in this situation was created through the presentation of facts using vocabulary and symbols, such as statistics and calculations that the housing organisation was used to and could digest. Trust was also shown by the cross-organisational interest group by making her the project leader of the pre-phase of the development project. And trust was displayed by the manager of a geographic housing division when he invited her to participate in the planning of the pilot project.

Similarly, the environmental coordinator guided the pilot project, not just on site, through the environmental classification of the energy-efficient housing by taking on the role of both translator and broker simultaneously at the interface of the different professional groups, i.e. the architect, the housing development and construction organisations as well as the in-house and external consultants, as suggested Brown and Duguid's (1998). Also, she made her knowledge available to the personnel on site by accepting the site manager's invitation to participate in group discussions on environmental

classification of housing which in itself is a sign of trust in her knowledge and abilities. But, what more than the use of vocabulary and symbols makes an individual a trusted translator or broker within and between communities? Would it be possible for any individual to mediate knowledge outside her/his area of interest and thus body of expertise?

In viewing knowledge as a competence and as being highly dependent on the social context and on personal relationships rather than as knowledge in its own right the construction group risked undervaluing or overlooking it. This was confirmed by the actions taken by individuals during the development process of the standardised building system. By comparing the actions and artefacts produced in the different projects (*Figures 2 and 3*) it becomes evident that social interaction lead to facilitation of knowledge sharing, here manifested in the documentation from the study trip and in the co-authored information leaflet, but also that sharing of knowledge within and between these project communities were dependent on individuals' actions.

The addition of time made available as a result of the recession and the actions of the project manager of the planning group enabled communication and interaction between individuals belonging to various organisational entities and professional groups where they freely negotiated meaning around a shared interest and task in workshops and meetings. Meanwhile, the feeling of operating under scarce resources made the project leader in the development project take actions in a way Meyer (2010) refers to as creating boundaries which resulted in limited membership in that project group hampering knowledge sharing across professional groups.

The limitation in membership in the development project group was found not only to be linked with the feeling of operating under scarce resources, but also to the project leaders focus of interest in production efficiency. However, as argued by Dubé *et al* (2006), admitting only those who match a certain profile allows for more control of the group and thus facilitates its management which is convenient during resource constraints. More, the feeling of scarce resources may well have affected the sharing of knowledge between the two projects. Here, knowledge was mediated through the interactions between the project leader of the development project and the

site manager of the pilot project with whom the project leader shared the interest in production efficiency. The trust to share knowledge was seemingly gained through these individuals' shared interest and vocabulary. However, as little other social interaction took place between the two development projects, the project manager's knowledge of standardisation of the building process was not sought and incorporated into the standardised building system.

The actions taken by individuals having the formal roles of subject experts, support functions and project managers facilitated social interaction and knowledge sharing across professional and organisational boundaries and can be seen as knowledge management mechanisms as discussed by Bresnen *et al* (2003; 2005). In the study presented in this paper, these individuals were offered the possibility to act as brokers and translators if personal contacts, skills and allocation of resources, such as time, were made available. But, can any member of an organisation take on the role of a broker or translator and become a knowledge management mechanism? And can organisations in this case support and facilitate such actions taken by individuals?

The research approach taken when performing this study has allowed the author to explore how knowledge sharing between professional groups and organisations can be facilitated and stimulated. However, it has been beyond the scope of this study to examine how the developed standardised building system was received and put into practice in other projects, i.e. how these individuals' explicit knowledge was mediated through the use of the standardised building system as previously studied by for instance Styhre and Gluch (2010). It is the conclusion of this paper that further research is needed into the sharing and mediating of knowledge across organisational and professional groups in project-based settings. For instance, what actions and personal traits make an individual trusted as a translator or mediator of knowledge?

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