THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Knowledge Sharing Across Professional Boundaries in Construction
Facilitators and Hindrances

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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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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
Johansson, Karin, in proceedings of International Conference on Organisational Learning, Knowledge and Capabilities (OLKC 2012), 25-27 April in Valencia, Spain, 2012.
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.

Table of contents

1. Introduction

In the ongoing debate on how to deal with climate change, the construction industry has been found to be significantly responsible for CO_2-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 Räisänen, 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 though 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.

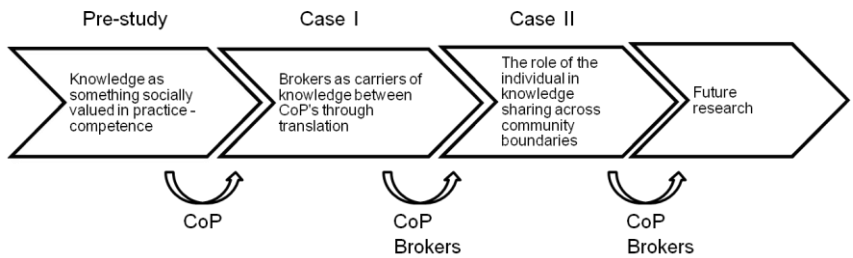

Figure 1: *The systematic combining processes of matching theory and reality leading to the evolvement of the analytical framework used in this thesis.*

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	8 interviews/9 respondents (at 1 interview 2 interviewees participated)	18 interviews/ 18 respondents	12 interviews/ 12 respondents (1 interviewee was also interviewed in the pre-study)
	Semi-structured interviews, audio recorded and iteratively summarised, resulting in a detailed list of quotes, phrases, concepts and key words	Semi-structured interviews, audio recorded and iteratively summarised, resulting in a detailed list of quotes, phrases, concepts and key words	Semi-structured interviews, audio recorded and fully transcribed
	1-2 hours/ interview	1-3 hours/ interview	1-2 hours/ interview
	7 middle managers (from 2 construction organisations) 2 technical consultant	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)	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)
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.

References

Ahmad, H. S. and An, M., (2008), 'Knowledge management implementation in construction projects: a KM model for Knowledge Creation, Collection and Updating (KCCU)', Int. J. Project Organisation and Management, Vol. 1, No. 2, pp. 133-166

Bishop, J., Bouchlaghem, D., Glass, J. & Matsumoto, I., (2008), 'Identifying and Implementing Management Best Practice for Communities of Practice', Architectural Engineering and Design Management, vol. 4, no. 3, pp. 160-175.

Bresnen, M., Edelman, L., Newell, S., Scarborough, H. and Swan, J., (2003), 'Social practices and the management of knowledge in project environments', International Journal of Project Management, vol. 21, no. 3, pp. 157–166.

Bresnen, M., Goussevskaia, A. and Swan, J., (2004). 'Embedding new management knowledge in project-based organizations', Organisation Studies, vol. 25, no. 9, pp. 1535-1555.

Bresnen, M., Edelman, L., Newell, S., Scarbrough, H. and Swan, J., (2005), 'Exploring social capital in the construction firm', Building Research and Information, vol. 33, no. 3, pp. 235-244.

Brown, J. S., and Duguid, P., (1991), 'Organizational learning and communites of practice: towards a unified view of working, learning and innovation', Organization Science, vol. 12, pp. 198-213

Brown, J. S., and Duguid, P., (1998), 'Organizing knowledge', California Management Review, vol. 40, on. 3, pp. 90-111.

Brown, J. S., and Duguid, P., (2001), 'Knowledge and Organization: A Social-practice Perspective', Organization studies, vol. 12, no. 2: 198-213.

Bryman, A. and Bell, E., (2007), Business research methods (2nd ed), Oxford University Press, Oxford, UK

Chan, P. and Räisänen, C., (2009), 'Editorial: informality and emergence in construction', Construction Management and Economics, vol. 2007, no. 10, pp. 907-912.

Cole, R., (2011), ‘Editorial special issue: Motivating stakeholders to deliver environmental change’, Building Research & Information, vol. 39, no. 5, pp. 431-435.

Dalenbäck, J.-O., Mjörnell, M., (2011), ‘Milparena – a network project for knowledge enhancement regarding energy renovation of multi-family buildings in Sweden’ in proceedings of Ökosan 2011, Graz, Austria, September 28-30, 2011

Dubois, A., Gadde, L.-E., (2002), ‘Systematic combining: an abductive approach to case research’, Journal of Business Research, vol. 55, no. 5, pp. 553-560.

Elmualim, A., Govender, K., (2008), ‘Communities of Practice in UK Large Contracting Firms: Contrasting Application and Non-utilized Merits’ Architectural Engineering and Design Management, Vol. 4, No. 3-4, pp. 149-159.

Elliot, A. J. and Dweck, C. S., (2007), Handbook of competence and motivation, Guilford Press, New York, USA

E2Rebuild, 2012. Industrialised energy efficient retrofitting of residential buildings in cold climates. EeB PPP Project Review, July 2011.

Engwall, M., (2003), ’No project is an island: linking projects to history and context’, Research Policy, vol. 32, pp. 789–808.

Gherardi, S. and Nicolini, D, (2000), ‘To transfer is to transform: the circulation of safety knowledge’, Organization, vol. 7, pp. 329-348

Gherardi, S. and Nicolini, D, (2002), ‘Learning in a constellation of interconnected practices: Canon or Dissonance?´, Journal of Management Studies, vol. 39, no. 4, pp. 419-436

Gluch, P. and Räisänen, C., (2012), ‘What tensions obstruct an alignment between project and environmental management practices?’, Engineering, Construction and Architectural Management, vol. 19, no. 2, pp. 127-140

Glad, W., (2012), ‘Housing renovation and energy systems: the need for social learning’, Building Research & Information, vol. 40, pp 274-289.

Gold, R-L., (1958), ‘Roles in Sociological Field Observations’, Social Forces, vol. 36, No. 3, pp. 217-223.

Grisham, T. and Walker, D. H. T., (2006), ‘Nurturing a knowledge environment for international construction organizations through communities of practice’, Construction Innovation, vol. 6, no 4, pp. 217-231.

Johansson, K., (2010), ’Knowledge Management i byggindustrin: En förstudie med fokus på kunskapsbärare vid standardisering av produkter och processer i byggandet’, Chalmers Repro, Gothenburg, Sweden

Kamara, J.M., Augenbroe, G., Anumba, C.J. and Carrillo, P.M., (2002), ‘Knowledge management in the architecture, engineering and construction industry’, Construction Innovation, vol. 2, pp. 53-67.

Koch, C., (2002), ‘The Emergence of Second Generation Knowledge Management in Engineering Consulting’ in conference proceedings of CIB w78 conference, Aarhus School of Architecture, 12-14 June, 2002.

Love, P.E.D. and Ellis, J., (2009), ‘Knowledge sharing, learning and situated practice: communities of practice for projects’, in proceedings of European and Mediterranean Conference on Information Systems, July 13-14, Imzir, Turkey

Meyer, M., (2010), ‘The Rise of the Knowledge Broker’, Science Communication, vol. 32, no. 1, pp. 118-127.

Much, A. (2003), ‘Communities of Practice and Habitus: A Critique’, Organization Studies, vol. 23, no. 3, pp. 383-401.

Nicolini, D., Gherardi, S. and Yanow, D., (2003), Introduction: Toward a Practice-Based View of Knowing and Learning in Organizations in: Nicolini, D., Gherardi, S. and Yanow, D (Eds), *Knowing in Organizations: A Practice-Based Approach*, M.E. Sharpe Inc., New York, USA

Nicolini, D, (2011), ‘Practice as the site of knowing: Insights from the field of telemedicine’, Organization Science, vol. 22, no. 3, pp. 602-620

Pemsel, S. and Widén, K., (2011), 'Bridging boundaries between organizations in construction', Construction Management and Economics, vol. 29, no. 5, pp. 495-506.

Polanyi, M. (1983), The tacit dimension, Doubleday & Company Inc., USA

Roberts, J., (2006), 'Limits to Communities of practice', Journal of management Studies, vol. 43, pp. 623-639.

Rubino, B. ; Edén, M. ; Femenias, P., (2007), 'Towards a Sustainable Building Approach: arenas of enactment, models of diffusion and the meaning of demonstration projects for change', in proceedings of CIB World Building Congress "Construction for development" 2007, Cape Town, South Africa

Ruuska, I. and Teigland, R. (2009), 'Ensuring Project Success through Collective Competence and Creative Conflict in Public-Private Partnerships – A Case Study of Bygga Villa, a Swedish Triple Helix e-government Initiative', International Journal of Project Management, vol. 27, pp. 323-334.

Schenkel, A., Teigland, R., and Borgatti, S. P., (2001), 'Theorizing Structural Properties of Communities of Practice: A Social Network Approach', paper presented at the Academy of Management Conference, Organization and Management Division, Washington DC,

Schenkel, A. and Teigland, R., (2008), 'Improved organizational performance through communities of practice', Journal of Knowledge Management, vol. 12, no. 1, pp. 106-118.

Sense, A. J., (2009), 'The social learning character of projects and project Teams', International Journal of Knowledge Management Studies, vol. 3, no:s ¾, pp. 195-208.

Sense, A. J., (2011), 'The project workplace for organizational learning development', International Journal of Project Management, vol. 29, pp. 986–993.

Sexton, M. and Lu, S.-L., (2009), 'The challenges of creating actionable knowledge: an action research perspective', Construction Management and Economics, vol. 27, no. 7, pp. 683-694.

Strati, A. (2003), Knowing in Practice: Aestethic Understanding and Tacit Knowledge in: Nicolini, D., Gherardi, S. and Yanow, D. (Eds) Knowing in Organizations: A Parxtice-Based Approach, M.E. Sharpe Inc., New York, USA

Styhre, A., Josephson, P.-J. and Knauseder, I., (2004), 'Learning capabilities in organizational networks: case studies of six construction projects', Construction Management and Economics, vol. 22, no. 9, pp. 957-966.

Styhre, A., (2009), 'Tacit knowledge in rock construction work: a study and a critique of the use of the term', Construction Management and Economics, vol. 27, no. 10, pp. 995-1003

Sverrisson, Á., (2001), 'Translation Networks, Knowledge Broker and Novelty Construction: Pragmatic Environmentalism in Sweden', Acta Sociologica, vol. 44, no. 4, pp. 313-327.

Wenger, E. C., (1998), Communities of Practice – Learning, Meaning, and Identity, Cambridge University Press, New York, USA

Wenger, E. C., (2000), 'Communities of Practice and Social Learning Systems', Organization, vol.7, no. 2, pp. 225-246.

Wenger, E.C. and Snyder, W.M., (2000), 'Communities of Practice: The Organizational Frontier', Harward Busniess Review, vol. Jan-Feb.

Wenger, E. C., McDermott, R. and Snyder W., (2002), Cultivating communities of practice: a guide to managing knowledge, Harvard Business School Press, Cambridge, USA

Whyte, J., Sexton, M., (2011), 'Motivations for innovation in the built environment: new directions for research', Building Research & Information vol. 39, pp. 473-482.

Yanow, D., (2004), 'Translating Local Knowledge at Organizational Peripheries', British Journal of Management, vol. 15, pp. 9-25.

Yu, W., Chang P., Yao, S.-H. and Liu S.-J., (2009), 'KVAM: model for measuring knowledge management performance of engineering community of practice', Construction Management and Economics, vol. 27, no. 8, pp. 733-747.