CHALMERS

Collaboration and Knowledge Exchange Mediated by Technology

Master of Science Thesis in the Master's Programme
International Project Management

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GLOSSARY

Artefacts	Object or tool which assists to convey a message.
Boundary Object	An object which facilitates communication by reduction of boundaries.
Boundary Spanner	An individual which facilitates communication by reduction of boundaries.
Building Information Modelling (BIM)	A modern work process with the aim to connect stakeholders.
Coding	A structured approach to convert a message into code.
Concurrent Design	A modern work process which relies on a parallelisation of tasks to reduce boundaries of participants.
Explicit Knowledge	Knowledge which can be articulated with ease.
Knowledge Management	A variety of practices and strategies to enable the capturing and distribution of insights and experience.
Organisational Learning	Models and theories regarding organisational adaptation.
Project	A unique and time limited endeavour to produce change.
Project Knowledge Management	An adaptation of knowledge management set in the context of projects. Provides an connection between project management and knowledge management.
Project Management	A study field on how to manage projects and secure its deliverables.
Shadowing	An observation technique focused on a single individual.
Tacit Knowledge	Knowledge which is difficult to articulate.

PREFACE

Information technology has changed the modern business environment significantly. IT systems have gained much influence over the work process within organisations. The interaction is increasingly virtual as the project teams are no longer co-located, but can be shattered all around the globe.

The dispersion of project team members as well as project limited time frame forces organisations to rethink their process of identifying, capturing, containing and distributing knowledge. Knowledge has become a valuable resource which can be stored and transferred for the benefit of the organisation. Although, several studies have identified and evaluated critical success factors in knowledge management and collaboration the connection to modern IT systems is vague. The lacking connection between IT, boundary objects and knowledge management especially in operational research is limiting the applicability of the academic findings. Therefore, additional research has to be conducted regarding IT's influence and impact on the knowledge, collaboration and team development.

The dissertation purpose is to contribute to the understanding of IT's role in the modern business environments through the analysis of an organisation and its daily routines. A qualitative case study has consequently been performed in a Reinertsen, a consultant firm. The case study is divided into two different fields in order to ensure the findings broad applicability.

The research aims to answer the research question posed at the beginning of the introduction, namely:

How can project efficiency, such as time and cost, be improved through a better interaction, integration and utilisation of modern IT systems?

The research question limits the scope of the review to project efficiency and the three aspects of interaction, integration and utilisation. Therefore, the project efficiency has to be considered from each aspect in order to give a comprehensive conclusion.

In addition, the research aims to provide a guidance for further study of IT's impact on projects, both planning and execution.

Structured Abstract

Background:

There is a limited understanding of IT systems role in the knowledge management and organisational learning, especially in project-based organisations.

Objective:

To investigate the interaction, integration and utilisation across individuals and applications to improve project efficiency within the case study organisation and provide guidance for further research within the area.

Method:

Observations complemented by interviews and documentation from the case study organisation provide a qualitative basis from which patterns can be drawn. The case study organisation provided a context which enabled the review of two industries, namely construction and offshore. The findings were analysed and evaluated contra current research findings in order to develop recommendations.

Results:

The IT systems are appropriately integrated in the work process to ensure their utilisation. However, additional effort may be considered in order to gain the full potential of the potent yet expensive software licenses. The proper utilisation of the application mitigates and corrects potential issues at an early stage in projects.

Conclusions:

The research found that an overview of the current procedures would potentially be beneficial if properly applied. Both the construction and offshore industry can learn from each other in order to improve their routines and practices. Therefore, cross-disciplinary collaboration is suggested

Keywords:

Project Information Technology, Knowledge Management, Cross-Discipline, Collaboration, Communication, Construction, Offshore

ABSTRACT

There is an inadequate understanding of technologies role in collaboration and knowledge. However, as technology is quickly developing, it is a field which needs to be continuously reviewed, in order to avoid becoming obsolete. The aim is therefore to review, through a case study, the influence technology has on interactions. Furthermore, to understand technologies role, the current integration in work processes as well as its utilisation will be reviewed. The approach of reviewing interaction, integration and utilisation aims to provide a more comprehensive understanding, which can be used as a foundation for further research.

Reinertsen provided a setting which enabled a case study approach, reviewing two different industries work processes to gain a more general understanding. The data collection was qualitative and structured to have a strong foundation based on observations. Observations were coded and illustrated in graphs and social network matrixes. Interviews were used in order to bridge gaps in information and knowledge that was not present during the observations. Documentation provided additional depth regarding operational aspects, which were not sufficiently elaborated during observations and interviews.

Technology plays a crucial role in the facilitation of interactions, as the requirement of physically attending a meeting becomes obsolete. However, technology cannot replace the face-to-face meeting which may be necessary during certain events. Technology is adequately integrated in the work process to ensure its usage, however not sufficiently to extract its full potential. The utilisation is limited by the experience and knowledge base of the user, as the tools may provide flexibility which is not explored. Furthermore, proper utilisation may assist in mitigating emerging issues at an earlier stage.

The research found that several tasks were performed in order to improve and structure the effort within the case study organisation. However, the efforts are fragmented and would benefit greatly from an overarching instance ensuring collaboration between disciplines. There is potential to achieve synergy effects by reviewing different sectors to extract and distribute successful methods across the

organisation. In addition, these synergy effects may be obtained by closer cross-industry collaboration with the focus on improving routines and practice.

1 INTRODUCTION

This chapter serves as an introduction to the study. It begins by presenting the rationale for the commencing the study. The goal is to elaborate on the research question as well as the aim and objectives of the research. The research is built upon the importance of the factors, which is shown through an examination of core components within the chosen topic. Afterwards there is a description of the company participating in the study, followed by scope, method and limitations. Lastly, there is an elaboration of the dissertation structure.

1.1 RATIONALE OF THE STUDY

Communication and interaction is crucial in effective organisational structures. The rapidly changing global business environment has made communication and its quality essential on all levels. To achieve a competitive advantage, within the last decade, modern Information Technology (IT) systems have become integrated and an essential part in all industries. In the offshore industry IT, such as concurrent design, has become an integral mechanism to reduce the boundaries between project participants and promote effective communication. Concurrent design is a methodology based on the notion of several functions performing tasks concurrently, which is often enabled through IT systems (Anumba & Evbuomwan, 1997). In addition, IT has obtained a crucial role in the construction industry with tools such as Building Information Modelling (BIM) which supports and facilitates communication between project stakeholders (Eastman, 2011; Sebastian, 2011). BIM provides a platform with a visual representation to facilitate information exchange (Carmona & Irwin, 2007). Eastman (2011, p.1) states that "When completed, these computer-generated models contain precise geometry and data needed to support the construction, fabrication, and procurement activities through which the building is realized".

BIM works as a Boundary-Object as it bridges across disciplines and organisations (Di Marco, Alin & Taylor, 2012). Castagna (2008) states that the benefits of BIM for corporations and customers are several, such as the possibility of reducing problems during the implementation phase of the construction project, reduction in material

waste, and improving the early stages contribution towards projects sustainability goals. The benefits of BIM in comparison to traditional architecture, engineering and construction methods are pointed out by several researches (Carmona & Irwin, 2007; Daley, 2009; Di Marco, Alin & Taylor, 2012). However, the inherent requirement of compatible platforms among project participants hinders BIM from realising its potential (Daley, 2009). In addition, the applied knowledge of BIM is not adequate which hinders the realisation of its potential benefit (Sebastian, 2011). To investigate this further a review of how other industries have managed the inherent issue of compatibility among IT systems may hint towards a potential solution or assist with the mitigation of its impact in the construction industry.

It stands to reason that organisational knowledge exchange is not reliant on the field, but on the boundary and its objects bridging the gap, hence by examining the process corresponding to BIM in other industries, a greater understanding may be achieved and novel ideas may spout. Construction is a very traditional industry which in the past has gained much benefit from utilising development and adopting working methods, from other industries (Forbes & Ahmed, 2010). Critically examining different industries and their corresponding work methodology may contribute to further develop processes and procedures. Furthermore, it may assist academia to gain a more comprehensive understanding of IT systems role in project knowledge management.

1.2 RESEARCH AIM AND RESEARCH QUESTION

The aim of this dissertation is to review the impact of technology on collaboration and knowledge exchange. The research will touch both the emergent fields of Project Knowledge Management, by exploring the enabling and restricting nature of the applied IT solutions on the knowledge flow, and the traditional theory of collaboration and team dynamic. In order to gain validity and reduce uncertainty the research limits the case study to one company, Reinertsen. The core focus of the research is to explore potential cross-disciplinary collaboration in order to improve processes, procedures and gain a more comprehensive understanding of modern IT tools role in the current business environment.

1.2.1 GENERAL AIM AND RESEARCH QUESTION

The research conducted will focus on three pillars, which are 'Interaction, integration and utilisation', in order to break down the work procedures within the different industries. The first pillar 'interaction' involves the interaction both between participants as well as the interaction between participants and IT tools. Traditionally within industries, such as construction, a task has been distributed and solved before transferred and little interaction is established between parties involved, often illustrated with 'walls' between office desks. Clear and condensed information improves the communication flow and reduces the risk of mistakes due to inadequate communication. The second pillar 'integration' involves IT applications integration to the control system used to guide the project progression. In order to understand the IT systems role, its integration has to be established, as it reflects its importance within the host organisation. The third pillar 'utilisation' contains the depth of applications usage from the second pillar, as support functions only can be of assistance if sufficient time and investment is allocated. While the interaction and integration of modern effective tools often are positive, it only becomes beneficial with the appropriate utilisation (Gal, Lyytinen, & Yoo, 2008). Therefore, actions must be taken to ensure the creation of new and suitable work procedures in order to reap the profits.

To address the research aim, the ambition is to answer the following research question:

How can project efficiency, such as time and cost, be improved through a better interaction, integration and utilisation of modern IT systems?

1.2.2 RESEARCH AIM DISMANTLED

The research question can be broken down into areas of interest. These areas can in turn be voiced as subdivisions of the original research question. A few of these lower category research questions are listed:

Interaction

How is the current interpersonal interaction facilitated?

How is knowledge management reliant on interactions?

How does literature suggest communication to be facilitated in project environment?

What areas of improvement are there, and what benefit would it generate?

Integration

How is IT integrated in the current work process?

How does the IT integration enable knowledge exchange?

How does literature suggest that IT is integrated in project environments?

What areas of improvement are there, and what benefit would it generate?

Utilisation

How are the current IT systems utilised?

How can IT be utilised to improve knowledge creation and promote innovation?

How does literature suggest the IT utilisation to be established and facilitated?

What areas of improvement are there, and what benefit would it generate?

The sub questions established above illustrate the need of establishing the status quo within the organisation as well as in academia. The research therefore requires reviewing the status quo and comparing it to academia. This is achieved through the examination of the work flow, patterns and control mechanisms.

The research is based on the notion of knowledge management generating a competitive advantage within the business environment. The interaction, integration and utilisation aspects are connected to the context or level in which knowledge management operates.

Within the present business environment 'IT' is a broad and vague term, which incorporates a significant number of tools, spanning from simple applications, such as Microsoft Office, to complex IT based methodologies, such as Concurrent Design. However, in this dissertation the role of IT restricted to the main applications within the projects examined. This limitation is required and enforced due to the sheer mass of IT tools being utilised throughout the project life-cycle.

1.3 RESEARCH OBJECTIVES

Once the process and procedures have been dismantled, the core elements can be compared, and applications can be suggested as recommendation. However, it is important to acknowledge that due to the difference within fields of expertise, one solution may or may not be transferable as the goals might differentiate. Therefore, the objectives main aim is not the establishment of recommendations, but to gain a more comprehensive understanding of IT systems impact on the work process.

Furthermore, a more comprehensive understanding of IT systems impact in regard to its interaction, integration and utilisation may assist to further develop applied work methodologies established, such as BIM and Concurrent Design.

Presently, there is an uncertainty regarding IT systems and their impact on knowledge sharing and collaboration (Newell et al., 2009). There is an assumption that modern IT systems act as a boundary objects to facilitate the flow of knowledge, however there is little research within the area (Gal, Lyytinen & Yoo, 2008). Through examining control systems within different industries, such as construction and offshore, the integration of IT as well as its role is evaluated. Furthermore, potential relations between the systems is analysed, in order to explore the feasibility and prospective of such a connection.

The problem explored in this dissertation relates to the business environment being forced to increase efficiency and productivity, which is suggested in academia to be achieved through enhanced communication, which may potentially be facilitated through IT systems. This dissertation has the following research objectives:

- Examine and establish the status quo interaction pattern found in projects and theory.
- Dismantle and analyse the status quo work process to identify the integration of IT tools and relate it to recent academia.
- Scrutinise and compare the integration and utilisation of IT in different industries.
- Analyse the utilisation of the IT tools and factors enabling or hindering the process
- Evaluate synergy effects and improvement potential enabled by cross-industry collaboration.

1.4 SCOPE, METHOD AND LIMITATION OF RESEARCH

As projects often act in unstable environments, the sources of uncertainty are wide ranging with potential significant consequence on the project and its management (Atkinson, Crawford, & Ward, 2006). This is however not always aligned with the project stakeholders as Dinsmore & Cooke-Davies (2005, p.141) state that "The sponsor, however, may face conflicting demands. Initially, there is a need to express objectives as broadly as possible in order to maximise stakeholder buy-in. On the other hand, specificity of objectives is a key factor for tightening up the project scope and forecasting the proposed benefits". Therefore, limitations of the project scope are listed to provide certainty and restrict aspects of the dissertation.

The dissertation will review the impact of IT systems on the work flow in two projects through a case study in Reinertsen. The work flow is broken down into the aspects of interaction, integration and utilisation in order to structure the research. The two projects reviewed are from different industries, construction and offshore, in order to ensure a general view. In the construction industry BIM acts as a mechanism to ensure communication among project participants (Dossick & Neff, 2010). In the offshore industry Concurrent Design is used to facilitate quick and clear communication in order to reduce issues (Anumba & Evbuomwan, 1997). Therefore, it can be said that BIM and Concurrent Design are similar as they facilitate means to improve the processes and procedures through lowering the distance between involved parties and encourage questions. In addition, the conclusions are compared to project management literature.

The rationale for using a case study was a strategic decision which allows the use of a variety of methods depending on the situation. The project reviews are based on meeting observations, ad hoc interviews as well as documentation. During the meeting observation the communication pattern is gathered to be coded and analysed. Questions that arise during the meetings were written down and explored after the observations to reduce the potential interference. This was done as all interactions between researcher and participants may harm the data's validity (Biggam, 2008). Observations reduce the risk of variance of interpretation as it is only one researcher present doing the observations (Bell, 2005). The primary flaw with observations is the time-consumption which often extends beyond a fixed-time

Master's degree (Bell, 2005). In addition, the data may be skewed due to the researchers' interpretation (Biggam, 2008).

An alternative would be to adopt unstructured interviews, however that also has weaknesses, such as the interviewee 'romanticising' the past, experience replacing authenticity, and the interviewee not having the appropriate role or knowledge to judge the subject which can severely skew the results (Denscombe, 2010; Silverman, 2006). Another aspect would be to use several methods, referred to as triangulation, however this would become too time-consuming (Denscombe, 2010).

In order to reduce potential variances due to differences in corporate culture both projects will originate from the same company. The projects were chosen with similarities in mind, primarily regarding the project team, as it is assumed to give the best readily available approximation regarding the project match. Approximation related to project budget and time-frame was also considered, but rejected, as diverse industries have different cultures and norms. In addition, both projects are located within Scandinavia, as the culture, characteristics and legalisations are comparable between the nations.

1.5   DISSERTATION STRUCTURE

The dissertation structure is as follows. Chapter one is the introduction which provides the basis of the dissertation. Chapter two is the literature review divided into the following four topic areas:

- Knowledge Management
- Organisational Knowledge
- Facilitation of Knowledge Creation and Exchange
- Collaboration and Team Development

Each field is presented with recent concepts and academia in order to give comprehensive illustration of the present situation. Afterwards a brief literature conclusion condenses the current state and connects to the next chapter methodology. Chapter three describes the methodology used to investigate the research question. Chapter four is the data analysis and connects the findings to the research aim. Chapter five is the discussion following the data gathering and analysis. Chapter six

is the research conclusion and includes recommendations as well as a section regarding further research within the area. This is followed by references, and bibliography.

2 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will elaborate the historic and present academic view regarding knowledge management and team development, in order to ensure a comprehensive examination of the literature. The first sub-section will elaborate the concept of knowledge management, leading into the second regarding organisational knowledge creation. Afterwards, the notion of barriers hindering knowledge creation is examined and mitigating factors are briefly explored. Finally, collaboration and team development with a focus on communication is explored. As the subjects are connected the review will focus on the core aspects of each field in order to give a comprehensive analysis of the literature. In the end, there is a brief illustration of the connection between the topics, which explains the importance of considering both in this particular case. While knowledge can be considered philosophical in nature (Tsoukas, 2005), the topic within this dissertation will not dwell into the area of knowledge and instead focus towards traditional organisational strategy and theory. By narrowing the knowledge management topic the author intended to elaborate on organisations perception of 'managing knowledge'. For the sake of further structuring the literature review, the author will embrace Newell *et al.* (2009, p.5) definition of knowledge as "the ability to discriminate within and across contexts" which suggests that knowledge correlates with the capability to select appropriate solutions. In the context of this dissertation the collaboration and team development concepts heavily rely on the notion of organisational learning, which in turn connects to the knowledge management field.

2.2 KNOWLEDGE MANAGEMENT

Knowledge within this dissertation is devoid of 'truth' and solely focus on the ability to distinguish and categorise across contexts (Anand & Singh, 2011). In a practical perspective knowledge is the process of sense-making where parties involved interact within a specific context to produce a unified idea of a subject (Weick, 2006). Knowledge Management is a structured way of framing knowledge in order to develop it as a resource and distribute it within the organisation (Cilliers, 2005). According to Newell et al. (2009, p.14) knowledge is therefore 'equivocal, dynamic

and context-dependent'. Equivocal means that knowledge is subject to change as it is influenced by perspectives and interpretations. Dynamic means that knowledge is dependent on the context as well as the parties involved and may therefore change if the situation changes. Context-dependent relates to the notion that knowledge can never be entirely separated from its contextual origin. Consequently, knowledge may change when transferred due to context as well as the individuals experience (Anantatmula, 2010).

Theory of knowledge can assist in the development and attainment of insights beyond the traditional production and resource functions (Linderman, Schroeder, & Sanders, 2010; Spender, 1996). Several topics hold great value in the current business environment, however knowledge management has been heralded as crucial effort to gain a competitive advantage as well as enable a creative environment for future growth (Peng & Sutanto, 2012; Teece, 2000; Wang & Ellinger, 2011). The benefit is especially great in volatile business environments (Thomas, Sussman, & Henderson, 2001). However, in organisations knowledge management has at times been unsuccessful and failed to delivered expected outcomes (Scarbrough & Swan, 2001). The reason knowledge management fail to deliver the change can be traced to different reasons, such as a too narrow and general approach without adequate integration and consideration of contextual environment. Newell et al. (2009, p.2) stresses 'enabling context, purposes and processes' as three dimensions of knowledge management that has to be considered in order to ensure appropriate utilisation within the set environment.

Fundamentally, knowledge can be divided into either 'epistemology of possession' and 'epistemology of practice' (Cook & Brown, 1999, p.381). The view of possession is rooted in the notion that people have knowledge, while the view of practice relates to peoples actions contain knowledge. Each of these perceptions tends towards either explicit or tacit knowledge. Explicit knowledge is simple to articulate, while tacit knowledge may be nearly impossible, which is further explained later in this chapter. Those in favour of 'epistemology of possession' often describe knowledge as a hierarchy, illustrated by a pyramid as can be seen in Figure 2.1. (Newell et al., 2009)
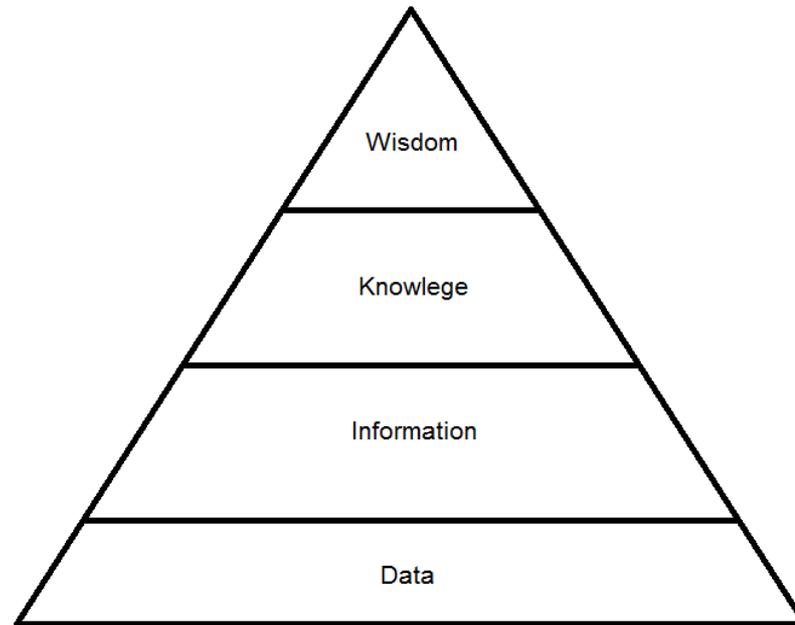
Figure 2.1: Knowledge hierarchy according to Rowley (2007, p.162).

While there are several different ways to illustrate the knowledge hierarchy pyramid its core remains the same with lower understandings in the bottom and higher in the top. In Rowley's (2007) model, data can be explained as unstructured information without an inherent value of its own. Information on the other hand has been structured in a suitable matter, which promotes its usefulness. Utility bills can be taken as an example of data, which hold little value until it is structured and thereby converted to information. However, even with a structure it is not guaranteed to be valuable as its structure has to stimulate its worth. Both data and information are physical entities that exist which can be stored and transferred (Newell et al., 2009). However, this is not the case for knowledge and wisdom located in the top of the pyramid. Knowledge and wisdom are according to the different epistemologies either contained in actions or experience and do therefore not consist of a physical entity (Anand & Singh, 2011).

Knowledge management is a two edged sword, which may obstruct and damper innovation as it often forces a specific procedure which frames and restricts creativity (Newell et al., 2009). Nonetheless, innovation heavy environment are commonly those with the most to gain from knowledge management and commonly

possess some degree of maturity within the subject to aid the creativity (Argote, 2012). Although, innovation is only obtained if a sufficient level of knowledge is being convoyed across organisational boundaries (Mitchell & Nicholas, 2006).

2.2.1   NATURE OF KNOWLEDGE

Knowledge is often a vague word which holds several different meanings as explained in the introduction. However, commonly knowledge is broken down to either tacit or explicit (Collins, 2010). Tacit knowledge is closely linked to an action or skill, making it inherently difficult to express (Wyatt, 2001). According to Collins (2010) tacit knowledge can in turn be divided into three categories of relational, somatic and collective tacit knowledge, relating to the strength of. An example of tacit knowledge often mentioned in academia is the ability to ride a bike. While riding a bike may be trivial for many, it can be considered nearly impossible to learn through theory (Newell et al., 2009). It is something that has to be experienced to be completely understood. Explicit knowledge is the opposite, being simple to confine and articulate (Wyatt, 2001), which is the reason it is viewed as more valuable in organisational learning (Zollo & Winter, 2002). Therefore, an organisation has to consider what aspect of knowledge that will be gathered and customise the procedure accordingly (Ajamal & Koskinen, 2008; Anumba, Egbu, & Carrillo, 2008; Newell et al., 2009).

2.2.2   KNOWLEDGE FRAMEWORKS

In order to organise the kinds of knowledge several frameworks have been established in order to gain a structure and overview. Three major frameworks will briefly be explained as it gives a greater understanding of knowledge management approaches in the current business environment (Newell et al., 2009).

One of the most common knowledge frameworks originates from Nonaka (1994) and is often referred to as the 'SECI' model. The 'SECI' model can be viewed in Figure 2.2 and explains knowledge creation as a spiralling process of interactions with both or either tacit and explicit nature.
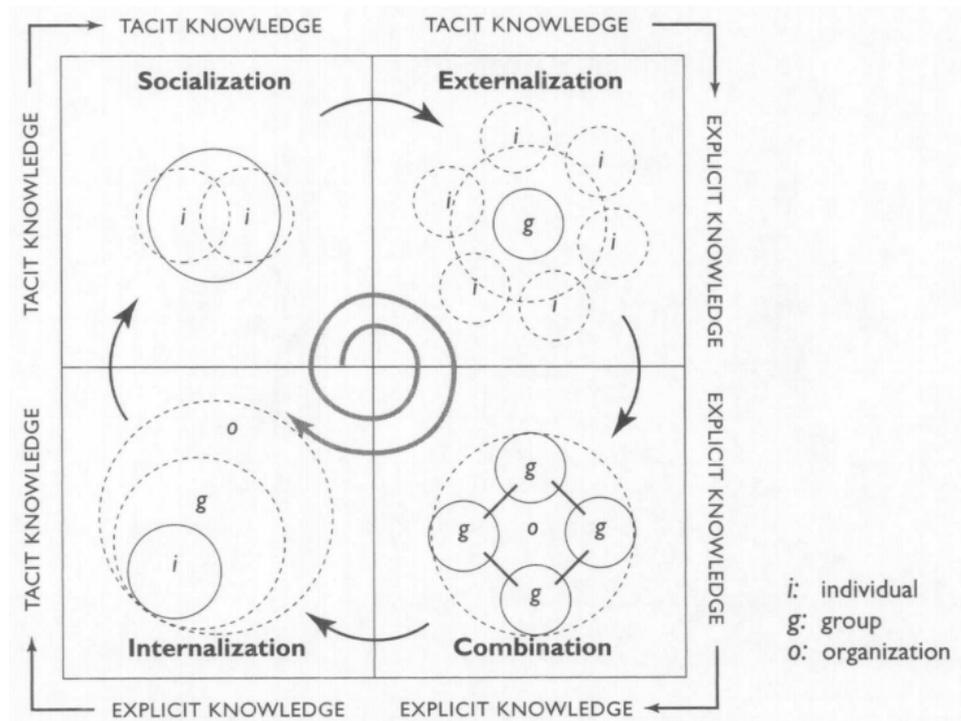
Figure 2.2: Spiral Evolution of Knowledge Conversion according to Nonaka and Konno (1998, p.43)

The model describes the knowledge creation being located in four conversion processes: socialization (tacit, tacit), externalization (tacit, explicit), combination (explicit, explicit) and internalization (explicit, tacit). Socialization is the sharing of knowledge across and between individuals through joint activities. Longer relationships enable parties to understand each other at a fundamental level. Only if the connection is achieved at the core certain tacit knowledge can be understood and transferred. In order to gather and extract tacit knowledge the processes are explored physically. In order to share knowledge directly a shared space (ba) must be established. Externalization is when tacit knowledge is articulated and communicated. Externalization is focused on two core aspects: Articulation of tacit knowledge and conversion of tacit knowledge to something comprehensible and communicable. This often is established by the individual being integrated in a group setting, which creates a shared space. Combination revolves around the translation of explicit knowledge to a structured and systematic approach. New knowledge is captured from previous stages, broken down to its basis and finally spread across the parties involved. The knowledge created is justified and agreed upon within the

organisation enabling groups to apply the results. Internalization is the process of taking the new knowledge and translating it to tacit group or organisational knowledge. Fundamentally, internalization is broken down into two approaches: the embodiment of explicit knowledge in actions and the embodied actions can be triggered. Essentially, the 'SECI' model is a structured process where explicit and tacit knowledge are blended in order to create and capture knowledge. (Gourlay, 2006; Nonaka & Konno, 1998; Nonaka, 1994)

The framework is built on the notion that knowledge creation originates from the individuals cognitive ability. It relies on the individual's contribution to the development of the collective knowledge. Therefore, according to Nonaka (1994) organisational learning evolves individuals and their capability. The central notion of knowledge solely subsists at the individual level differentiate it from other frameworks. The 'SECI' model was further developed by Nonaka and Konno (1998) where they added 'ba' which is a physical, virtual or mental place. While information resides in networks and media and is tangible, knowledge resides in 'ba' and is intangible. The concept of 'ba' was developed and mapped into four natures of knowledge conversions, illustrated in Figure 2.3 and more explained below.
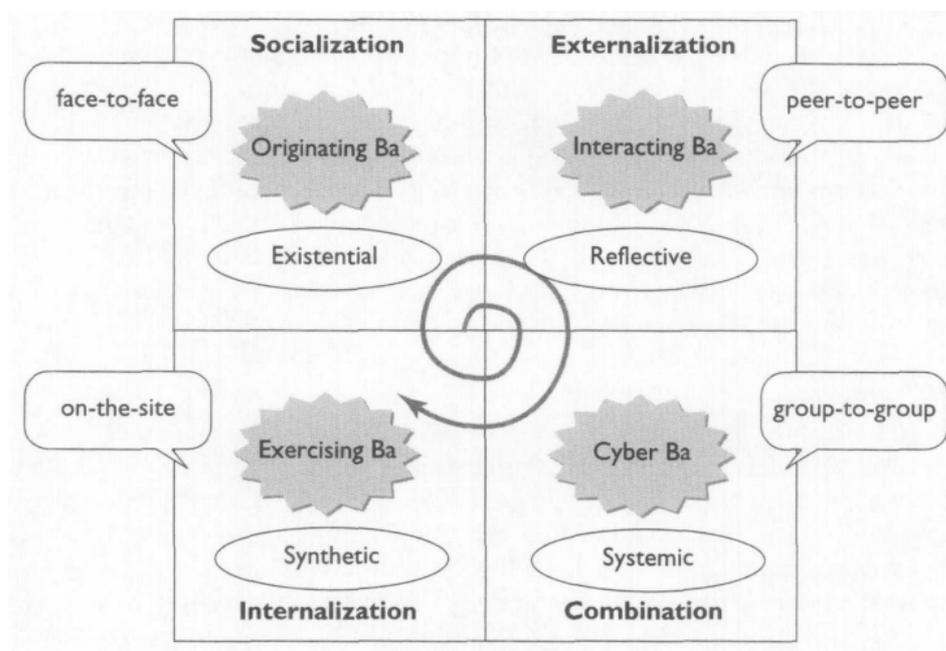
Figure 2.3: Concept of 'Ba' from Nonaka and Konno (1998, p.46)

Each nature of 'ba' relates and is respectively suited for a certain stage of the 'SECI' model. The notion is that each 'ba' supports a specific knowledge conversion processes resulting in higher effectively during the stage. Originating 'ba' is emotional connection between individuals as it enables a stage for deep emotional commitments, such as empathy, caring and loving. It is linked to the socialization stage and revolves around the interpersonal relations built on physical face to face experience. Interacting 'ba' is a forced connection, consciously constructed to enable a stage for development through a dialog. It is linked to the externalization stage and revolves around the group input for resolving issues. Cyber 'ba' is the virtual representation of interaction and represents the combination stage. It centres on a collaborative environment and is enabled by information communication technology, such as databases and online networks. Exercising 'ba' is the application of explicit knowledge into actions to create tacit knowledge and relies on the active participation. It corresponds to internalization enables an enhanced development due to the application of theory in practice. (Newell et al., 2009; Nonaka & Konno, 1998)

The 'SECI' model and 'ba' has much support but several critical voices have been expressed (Anuradha & Gopalan, 2007). The two main concerns raised by Newell *et al.* (2009) regarding the framework are the narrow and individual focused approach to knowledge and the restrained role of context such as difference in power, interest and political dynamic in competitive environments. Becerra-Fernandez and Sabherwal (2001) raised the concern that the different stages of the model requiring the participation of a specific characteristics. In addition, the model disregards the relation between task influences on the forms of learning (Poell & van der Krogt, 2003).

In contrast to Nonaka, Spenders (1996) framework relies on both the nature of knowledge and its containment. Spender's framework does originate from a different viewpoint which focuses on transactions and resources. Through the review of the epistemology (nature) of knowledge and the containment (ontology) the framework differentiates between social and individual knowledge, which is illustrated in

Figure 2.4.

	Individual	Social
Explicit	Conscious	Objectified
Implicit	Automatic	Collective

Figure 2.4: Forms of knowledge according to Spender (1996, p.52).

Spender suggests that the collective knowledge is generated through interactions of both tacit and explicit nature. While the framework does acknowledge the collective and social side of knowledge creation it primary focused on individuals. (Wickramasinghe & Lichtenstein, 2006)

Spender (1996) argues that the most valuable knowledge within an organisational setting is the collective as it is not as vulnerable to knowledge dispersion. Knowledge residing in the organisation is difficult to transfer to a new firm or context and does not rely solely on one individual. An organisation which structure allows and supports knowledge creation is therefore difficult to imitate, as a culture has to be established before the structure will gain acceptance. Therefore, competencies have advanced from a mere competitive advantage to a strategic necessity (Kang, Morris, & Snell, 2007; Newell et al., 2009; Wang & Ellinger, 2011).

Blackler's (1995) framework is a two by two grid, consisting of collective and individual contributions versus familiar and novel problems, and can be seen in Figure 2.5 below.

	Focus on familiar issues	Focus on novel issues
Focus on collective endeavour	**Knowledge-Routinized:** Knowledge embedded in technology, rules and procedures. Hierarchical division of labour and control. Low skill requirement.	**Communication-Intensive:** Encultured knowledge and collective understanding. Communication and collaboration is the key process. Empowerment through integration.
Focus on Individual contribution	**Expert-Dependent:** Embodied competencies of core members. Input of specialist and experts are critical.	**Symbolic-Analyst-Dependent:** Embrained skills of core members. Entrepreneurial solving of issues. Status and power are linked to achievements.

Figure 2.5: Organisational knowledge types adapted from Blackler (1995, p.1030)

The framework is based on analysis of previous organisational knowledge and identifies different containments or types of knowledge, such as: embrained, embodied, enclutered, embedded and encoded. Embraind knowledge is based on abstract and cognitive abilities. Embodied knowledge is contained in the action itself and is therefore to a lesser extent explicit. Encultured knowledge is linked to the obtaining of a shared perspective, established by the contextual environment in an organisations culture. Embedded knowledge is contained in, often formal structured, routines and procedures. Encoded knowledge is contained in symbols and other forms, which can be located and transferred. (Blackler, 1995, pp.1024-1025)

Nonaka's (1994) framework contradicts Spender's (1996) and Blackler's (1995) frameworks and has therefore resulted in the fragmentation of knowledge theory. Each of the theories originate from different fields of knowledge theory, which may obscure the connection. Currently, the prevailing idea is the more integrative perspective of Blackler (1995) and Spender (1996) which considers both the individual as well as the collective (Newell et al., 2009). Although, the integration of encoded knowledge does advance the field as it depicts the idea of knowledge being to a varying degree explicit. One of the main ideas in Blackler's (1995) framework is the notion of different organisations are dominated by different knowledge types. The notion indicates that issues related to knowledge management have its roots in the key purpose of the organisation in question (Newell et al., 2009).

Love, Fong and Irani (2012) in turn propose a knowledge management cycle, which contains four phases: Creation, Administration, Dissemination and Utilisation. The creation is enabled through the gathering, combining and refining of previous knowledge. Administration is the framing and containing which enables the organisational distribution of knowledge. The dissemination is connected to the act of the distribution. Utilisation is when the knowledge is applied in processes and routines and thereby benefits are gained (Love, Fong, & Irani, 2012).

While a structure, such as a framework, provides a guidance to understanding knowledge it has been challenged, since it does not enable the understanding of the subjective and dynamic nature of knowledge (Newell et al., 2009). In addition, the structure exaggerates the differentiation of tacit and explicit knowledge (Gourlay, 2006). However, frameworks often view knowledge as a commodity that can be transferred just like other resources (Newell et al., 2009). Similar to other resources, knowledge is shared throughout the organisation as well as collected and accumulated in knowledge hubs, such as databases or communities of practice.

Knowledge sharing is an interaction in which entities exchange knowledge. The exchange is inherently limited by the parties involved, as certain may choose to hoard knowledge or obstruct the knowledge flow, in order to gain a specific benefit. In addition, knowledge is hindered by its own nature as obtaining knowledge does not always enable its use (Mukherjee, 2011; Newell et al., 2009). An example of the inherent nature of knowledge hindering the sharing can be seen in rapid

specialisation of both organisations and disciplines. This results in a limitation of parties which would be able to comprehend the knowledge and therefore benefit from the knowledge sharing (Carlile, 2002). Currently, there is an assumption that more knowledge equals increased profit, which can be questioned as there is no direct connection between knowledge and success (Newell et al., 2009).

2.2.3 KNOWLEDGE MANAGEMENT IN PROJECT-BASED ORGANISATIONS

Knowledge management has traditionally focused on stable organisations in order to optimise operations and efficiency. However, as projects gain a more prominent role in the daily operations within the business environment (Maylor, 2010), actions have to be taken to ensure that knowledge created within the time-limited project environments is not lost after its completion. This has forced the development of a sub-category within the field called project knowledge management (PKM), which acts as a link between project management (PM) and knowledge management (KM), illustrated in Figure 2.6 below (Hanisch, et al., 2009).
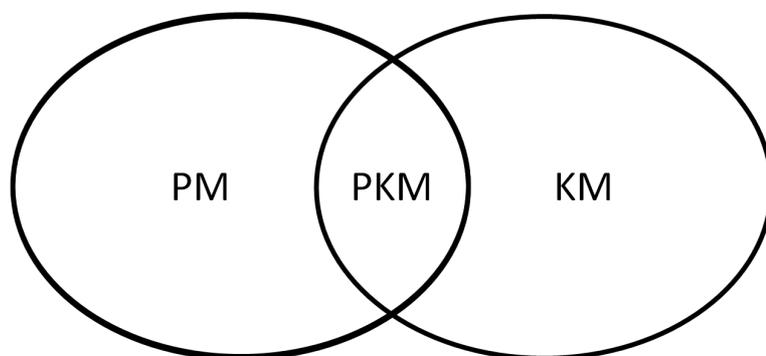
Figure 2.6: Project knowledge management as a link illustrated by the author.

One of the main issues with knowledge management in project-based organisation is the lack of established and structured processes required to capture, refine and distribute knowledge (Gasik, 2011; Hanisch et al., 2009). This is due to the inherent time-limited and unique nature of projects. In addition, the short-term orientation within a volatile and changing internal, such as work force, and external, such as

rules and regulations, environment conflicts with the long term benefit found in knowledge management (Hanisch et al., 2009).

The main benefit of project knowledge management according to Hanisch *et al.* (2009) can be broken down into five areas of improvement, namely: the reduction of duplicate work, learning through repetition, enabling innovation, standardisation and allocation of resources. The overall benefit is an improved project organisation through time and cost reduction (Hanisch et al., 2009).

2.2.4 INFORMATION TECHNOLOGY SYSTEMS AS A BRIDGE TO KNOWLEDGE

In the modern era, Information and communication technology (ICT) plays a crucial role in the distribution of knowledge (Newell et al., 2009). In industry the synergy from having a knowledge program enabled from the use of ICT is often promoted. However, the simplified idea of an integral positive reaction between ICT and knowledge management should be questioned as the previous notion of knowledge being highly dependent on context is considered. Modern IT era has impacted significantly on the organisational structure as the traditional bureaucratic hierarchy has become fragmented and decentralised (Newell et al., 2009). Furthermore, Newell *et al.* (2009) argues that one of the reasons knowledge management became fashionable was that it provided a remedy to some of the issues encountered in the new decentralised and fragmented organisational structures. However, even with assistance of modern ICT issues may be challenging due to personal aspects (Newell et al., 2009). The notion that knowledge management aim was to extract and cultivate the valuable knowledge assets located in the human resources independent of organisational structure.

2.3 ORGANISATIONAL KNOWLEDGE

In organisations a culture is developed which either assists or hinders the spreading of knowledge. The organisation becomes a container of set norms, behaviours, beliefs and customs which result in a shared understanding. Within the organisational context involved parties and artefacts yield results formed within its contained social structure (Argote, 2012; Newell et al., 2009).

2.3.1 ORGANISATIONAL LEARNING

Until recently there has been an argument whether organisational learning should be considered as a change in cognation or conduct. Currently, the definition of organisational learning relates to experience impacting on the shared internal knowledge (Argote, 2012). Organisational learning is the development of a framework as a set of norms to reach a shared understanding for the creation and distribution of valued knowledge within a certain environment (Antonoaie & Antonoaie, 2010; Newell et al., 2009; Wang & Ellinger, 2011). An organisations' success centres round the capacity to supply greater customer value within existing markets or the creation of new (Kang, Morris & Snell, 2007). One way to keep in pace with the rapidly changing business environment is organisational learning. However, organisational learning cannot guarantee success as it has its own weaknesses. Kang, Morris and Snell (2007) voiced their concern regarding the low success rate of organisational learning, while Levinthal and March (1993) argued that it may result in a decay of the organisations adaptive competencies over time.

The issue with quantifying knowledge has been extensively researched which resulted in a variety of alternatives. The approaches relate to different parameters, such as: cognition of organisational members (Huff & Jenkins, 2002), change in characteristics of performance (Argote & Epple, 1990), characteristics of product (Helfat & Raubitschek, 2000), range of patents (Alcácer & Gittelman, 2006) and embedded in routines or practices (Gherardi, 2009). Previously, the acquisition of knowledge has been rooted in the observable expectation of change. However, a corresponding change of behaviour is not required, instead researches have focused on the set range (Huber, 1991) or capacity (Pentland, 1992) of behaviours. The method best suited for the quantification of knowledge depends on the context and situation of the organisation going to be assessed (Argote, 2012). Each approach limits itself or is inherently limited due to the tacit nature of knowledge.

Similar to knowledge creation organisational learning acts within a context depending on both the macro and micro environment (Kazanjian, Drazin, & Glynn, 2000). In the macro environment, external factors such as clients, competitors, educational institutes and government resides. While the micro environment focuses on the internal barriers. All factors act within its situation and influence the development within the organisation. The factors are subject to several aspects,

which results in a variety of uncertainties (Argote, 2012). Although, certain factors may have a stronger impact on the overall direction it is important to recognise that each factor has influence. Organisational learning is rooted in individual learning, however requires a shared common space for the distribution (Argote, 2012).

2.3.2 LEARNING THROUGH EXPERIENCE

Organisational experience is an important factor when exploring learning. Experience can originate form a variety of sources which affects its categorisation, such as directness, novelty, success, ambiguity, location, timing and rarity. Experience can be acquired direct or indirect, however the relationship between is disputed, as researchers both claim it being negative (Schwab, 2007) and positive (Bresman, 2010). The experience can be gained from either a exploration (novel) or exploitative (familiar) actions which are independent of each other, however research suggests that utilising both improves the organisational learning (He & Wong, 2004; Lunnan & Barth, 2003). Researchers argue whether success or failure results in the most effective learning experience (Argote, 2012). Scott and Vessey (2000) claim that learning from success encourages exploitation while learning from failure encourages exploration. However, Kim, Kim, & Miner (2009) suggests that a synergy effect can be achieved when utilising both experience of success and failure. Experiences can be clear or ambiguous, which is when the connection between cause and effect is vague resulting in potentially wrong conclusions (Argote, 2012). The spatial location affects the organisations experience as the distribution and access of knowledge may be an issue, which relates to the lacking motivational and relational cohesion required for information exchange as suggested by Cramton (2001). The temporal aspect consisting of how recent and when in relation to the action the experience occurred. The experience may be gained before, during and after performing a task. Training or planning may generate experience before performing an activity. While after the activity experience can be gained through sense making. If sufficient base knowledge exists, an experience may result in a rapid development, however in contrast without the base knowledge experience may not assist in development. In addition, related to the timing of the experience, research has found that the validity and importance of experience decays over time (Benkard, 2000). This relates to the notion of sense making and how the cognitive capacity is crucial

when learning from experience. The learning from experience is limited to the occurrence of said experience, as its frequency greatly affects potential of interpretation (Lampel, Shamsie, & Shapira, 2009). Although, rare events hold great potential there is a risk of false interpretations (Heimeriks, 2010; Zollo, 2009). Experience may be simulated through means such as trainings, both before and after the target experience, and its' worth is determined by to what degree the integral features are integrated. The range and variance of experience is structured in means of heterogeneity. If given time a higher heterogeneity will produce enhanced organisational learning. The acquisition of experience may be continuous or in internals. If experience is gathered in intervals it may result in knowledge decay, however offers a prospect for knowledge exchange (Argote, 2012; Benkard, 2000).

2.4 FACILITATING KNOWLEDGE CREATION AND EXCHANGE

There are roles and tools which assist to mitigate the barriers hindering the knowledge creation (Carlile, 2002; Mitchell & Nicholas, 2006). The explicitness of barriers varies as it is dependent on the context of the business environment, which in turn is set by unspoken norms, beliefs, behaviours, customs and traditions. Although, organisations may co-exist and interact without clear structured and expressed boundaries, it may potentially become an issue as challenges arise. Organisational interfaces clash as they interact with other actors in the environment. Therefore, boundary spanners and objects guide the interactions by providing a pattern acknowledge by all parties involved (Gal et al., 2008).

2.4.1 BOUNDARY SPANNERS

Within each organisation there is a myriad of networks intertwining those contained or in contact with the environment. These networks connect both across individuals within and outside the organisation. As business becomes more specialised the boundaries become increasingly explicit, resulting in involved parties gathering to avoid fragmentation (Akkerman & Bakker, 2011). Cillier (2005) claims that boundaries are necessary and research should therefore focus on its enabling rather than restraining aspects. Those employees who facilitate the information and knowledge exchange by bridging boundaries are referred to as 'boundary spanners'

(Hoe, 2006; Newell et al., 2009; Peng & Sutanto, 2012). However, boundary spanners have had several different titles and descriptions, such as linking-pin (Organ, 1971), gatekeepers (Pettigrew, 1972) and coordinators (Katz & Tushman, 1979). Boundary spanners can be appointed, however within some settings the role will naturally emerge (Di Marco, Taylor, & Alin, 2010; Newell et al., 2009).

Presently, within organisations there is frequently a difference between the vague and visionary viewpoint of the organisations top-line management compared to the narrow and focused field of view within teams and individuals (Newell et al., 2009). Boundary spanners assist the knowledge sharing and thereby provide a competitive advantage through the facilitation of knowledge exchange (Peng & Sutanto, 2012). Shantz, Latham and Wright (2011) break down the role of the boundary spanner into three core tasks:

- Improving organisational efficacy by supplying information from external sources.
- Representation of ideas and perceptions across boundaries ensure engaged and committed stakeholders.
- Value creation by establishing knowledge exchange between parties.

In practice, boundary spanning enables a quicker and more direct form of collaboration which increases the organisation or team efficiency (Di Marco, Taylor & Alin, 2010). In addition, through the integration of a cross-functional groups, knowledge gaps can be worked around achieving a more comprehensive solution (Mitchell & Nicholas, 2006). The concept of organisational learning ties into the knowledge creation aspects of boundary spanning and the related boundary objects, which is examined later in this chapter. Through establishing a connection between the topics a more comprehensive understanding of organisational knowledge flow can be acquired (Hoe, 2006).

The organisational boundaries do restrict the knowledge flow as they frame the limits of teams and departments. In order to overcome the barriers hindering the knowledge flow boundary spanners assist by reducing the barriers both internally and externally (Hoe, 2006; Peng & Sutanto, 2012). Within organisations there is a sub-conscious pressure to limit the novel knowledge creation, which can be mitigated through the integration of a diverse selection of knowledge areas (Mitchell & Nicholas, 2006).

Boundary spanners role is focused on the reduction of resistance, such as environmental constrains and organisational policy, through strategic decisions (Aldrich & Herker, 1977). Knowledge sharing is a core aspect within organisational learning and therefore boundary spanners have a crucial role to stress the subject (Newell et al., 2009). However, there are negative aspects of boundary spanning, such as the inherent change of knowledge when it is transferred, misrepresentation of information, the vulnerability of centralising the communication and the potential abuse of influence and power (Isbell, 2010). Adler, Black and Loveland (2003) claim that organisations need to adapt by establishing frameworks to capture and process the value generated through boundary spanning before the involved parties leave the organisation.

2.4.2 BOUNDARY OBJECTS

The concept of boundary object relates to the artefacts, such as documentation, tools and stories, both conceptual or physical, enabling interaction across boundaries. The artefacts succeed as an interface by providing a flexible environment containing several understandings, while remaining sufficiently robust to offer a mutual reference point (Carlile, 2002; Gal, Lyytinen, & Yoo, 2008). These artefacts assist with bridging the intersecting functions by providing each part with the tool to interact (Akkerman & Bakker, 2011). Crossing boundaries provide an opportunity to learn which supports the notion of improved organisational learning and experience within mixed teams. Boundary objects can be found embedded in the information infrastructure as they are used by personnel to bridge the barriers when engaging in standardised routines and practices.

Star and Griesmer (1989) introduced the concept of boundary objects and it has since then been applied to a variety of organisational or environmental contexts (Gal et al., 2008). However, as the context changes, so must the boundary object in order to retain its role in assisting the interaction between interfaces (Carlile, 2002). As the concept has been further developed it has moved from the focus on the object to the interaction its enables and notion of shared identity (Levina & Vaast, 2005). However, the idea of the boundary object has also been expanded as Garrety and Badham (2000) introduced primary and secondary boundary objects which related to

the influence on interactions. Gal, Lyytinen and Yoo (2008) proposed a model, see Figure 2.7, which aimed to illustrate the entangled nature of boundary objects, information infrastructure and organisational identities.
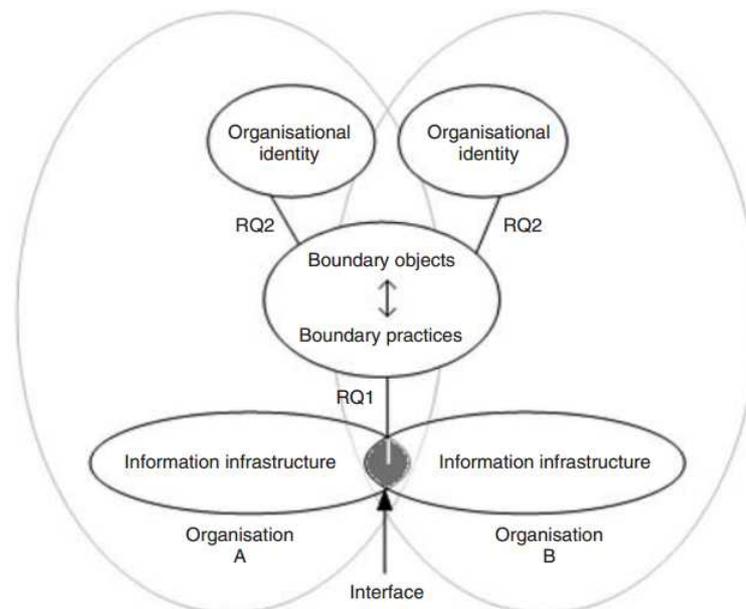
Figure 2.7: The relationship between boundary objects, information infrastructure and organisational identities (Gal, Lyytinen & Yoo, 2008, p.293)

The model is a simplified visualisation of the pure ideal relationship within mutual interaction. The interaction shapes both the actions and identities of the involved parties (Gal et al., 2008).

2.4.3 IT SYSTEMS AS ENABLING ARTEFACTS

There is a vast variety of IT systems acting as boundary objects within business by assisting the information sharing across heterogeneous settings. In order to utilise the tools a shared understanding has to be established (Gal et al., 2008). Research has stressed boundary objects enabling effect on inter-organisational collaboration and knowledge exchange (Carlile, 2002). However, IT may provide a challenge as the

transitions to and between IT systems often is problematic and littered with implications (Gal et al., 2008). An organisations practices, routines and communicative patterns influence form the IT based boundary objects. Project teams become increasingly dispersed, as IT systems reduce the impact distance has on work efficiency (Adenfelt & Lagerström, 2006). IT has emerged as a substitute for the traditional face to face interaction (Adenfelt & Lagerström, 2006). However, the main issue relates to the virtual teams inability to efficiently create trust as it limits the readiness knowledge exchange among team members (Anantatmula, 2010). Furthermore, there are integral restrictions with the knowledge exchange through IT systems, as they are to some degree limited. While the explicit knowledge exchange is unrestricted, the tacit may require social interaction on a personal level (Sandhu & Naaranoja, 2009), which is not yet possible in the common IT environment.

2.5   COLLABORATION AND TEAM DEVELOPMENT

Efficient collaboration and team development is a blend of a variety of factors, such as clear and consistent communication, adaptable conflict resolution and understanding of group dynamics. Collaboration and team development literature is connected to knowledge theory, as can be seen with the emphasis on the generation of trust and the establishment of a shared space. Furthermore, knowledge, collaboration and team development theory is based on the notion of enhanced interactions to develop employees or organisation for future benefit (Hitt, Black & Porter, 2011). Collaboration is a crucial factor when achieving the maximum potential of the limited resources available within the competitive business environment (Rogers, 2009).

2.5.1   COMMUNICATION ENABLING COLLABORATION

Communication is a broad word, which incorporates several meanings, which is why we limit the definition within this dissertation to 'the act of conveying data, such as ideas, facts and figures' (Hitt, Black & Porter, 2011). The interaction can be either intentionally or unintentionally, which may reflect upon the receiver. The quality can vary significantly, rendering the results inadequate, both due to internal and external factors (Clegg, Kornberger, & Pitsis, 2011). Internal factors are such as issues with

the interpretation, context or medium, while external factors could be the availability of communication tools and noise (Hitt, Black, & Porter, 2011). Hitt, Black and Porter (2011, p.304) examines communication by disassembling the process into four actions and five components as can be seen in

Table 2.1 below.

Actions	Components
Encoding	Sender
Sending	Message
Receiving	Medium
Decoding	Noise
	Receiver

Table 2.1: Communication broken down to actions and components according to Hitt, Black and Porter (2011, p.304)

The notion is that by combining these basic actions and components transfer of meaning is facilitated (Hughes, Ginnett, & Curphy, 2011). The process of communication can be explained as: *Sender* generates *message* to be *sent*, by *encoding* information and containing it in a *medium*. The *message* contained in the *medium* is *received* through the *decoding* by the *receiver*. However, due to an issue (*Noise*) only half of the *message* is received. The interference of communication is called noise, which leads to misinterpretations, misconceptions and confusion. However, though the utilisation of a verification of feedback system the potential issues can be mitigated. Communication heavily relies on a shared understanding, therefore even though the basic elements remains the same, dimensions such as cultural, personal and organisational contexts may greatly affect the nature and focus of the communication. (Hitt, Black & Porter, 2011)

The interference may occur either at the sender or receiver on an interpersonal, organisational or cultural level. At the interpersonal level, factors originate from

emotions, language, selective perception, frame of references, individual differences and non-verbal cues which affects both individual and group reception. At the organisational level factors originate from hierarchical barriers due to prearranged structures and functional barriers due to issues across departments which affect individuals and groups within and across organisations. At the cultural level, factors originate from language, context, stereotyping, ethnocentrism and cultural distance which affect individuals and groups from different or diverse national and organisational culture. Therefore, in order to achieve the best outcome communication need to be tailored to fit the need of the situation (Hitt, Black & Porter, 2011). Communication can be broken down in verbal and non-verbal. Verbal does include both oral and written communication. There is a myriad of methods to interact, however, each has their strengths and weaknesses which are vital to acknowledge. Hitt, Black and Porter (2011, p.305) elaborated on common methods found in practice and listed associated general advantages and disadvantages, which can be seen in Table 2.2 below.

	Verbal (Oral)	Verbal (Written)	Non-verbal
Examples	Conversation Speeches Phone Calls Video conferences	E-mail Letters Reports Faxes	Gestures Facial Expression Speech Intonation Wearing
Advantages	Vivid Stimulating Commands Attention Flexible Adaptive	Interpretation	Supplement to presentation Emphasis meaning
Disadvantage	Potential Misinterpretation Transitory	Simplified in translation Inflexible Easy to ignore	Meaning is not universal

Table 2.2: Advantages and disadvantages of communication methods adapted from Hitt, Black and Porter (2011, p.305)

According to Sandhu and Naaranoja (2009) the majority of knowledge is transferred through social interactions. Other research has found that individuals generally prefer to direct verbal communication, as it is perceived as the most efficient method (Adenfelt & Lagerström, 2006; Anantatmula, 2010; Sandhu & Naaranoja, 2009).

2.5.2 COMMUNITIES OF PRACTICE

In order to facilitate collaboration and knowledge sharing communities of practice are established (Newell et al., 2009). Communities of practice are a collection of individuals which share a common field of expertise and purpose. Members are enabled to share and enhance their own knowledge through the collaboration with peers (Wenger, McDermott, & Snyder, 2002) without the crippling restrictions workgroups and teams encounter due to deadlines and deliverables. Fundamentally, communities of practice facilitate an interface which enables collaboration across projects and organisations within a predefined context (Hasanali et al., 2002).

The whole notion of communities of practice links to organisational learning, through an improved intra-organisational collaboration. Through the gathering of professional members, within a shared setting, further development is enabled through the utilisation of informal or semi-formal networks. Communities of practice have shown to give a significant benefit to the knowledge creation, in settings with scarce or rapidly shifting human resources (Boh, 2007). The idea is that the informal nature will lead to trust which results in a supportive culture enhancing the knowledge exchange (Hara, 2009).

The potential development of local to global communities of practice through the utilisation of modern information communication technology systems has been promoted by research. However, extending the communities of practice through virtual communication tools may imperil the sense of bound among participants and therefore a sensitive approach, considering all organisational and technical issues (Hara & Kling, 2002). However, while IT solutions may not solve issues related to disperse communities of practice, it is suggested by Brown and Duguid (1996) to improve local communities of practice. In Hara and Kling's (2002) research a clear connection between the bound among members of the community and the amount of interactions enabled by IT systems could not be established. However, weaker ties

among members were found in settings with high IT proclamation, which is contradicting previous research on IT systems impact on relationship and bounding (Hara & Kling, 2002). This supports Hara's (2009) claim of the field requiring additional empirical studies to develop a more comprehensive understanding of the subject.

Communities of practice have negative aspects, such as the risk of hoarding knowledge and the hampering of innovation. Wenger, McDermott and Snyder (2002) promote a categorisation of the weaknesses according to its manifestation, as can be seen in Table 2.3.

Manifestation	Issue	Description
Single Communities	Temptation of ownership	Pride and arrogance may induce a feeling of ownership, which results in a missing understanding of other perspectives. It often results in hoarding of knowledge, which may damage the organisation.
	Too much of of a good thing	The community may become incapacitate from the calm and pleasant atmosphere resulting in the members ending their active exploration of external input.
	Liabilities of competence	The inherent expertise may restrict the communication with external parties. The interactions get tainted by the common procedure within the community.
Constellation of Communities	Managing boundaries	Knowledge may become difficult to transfer to parties outside the community, however flow easily within the practice.

Organisations	Organisational Barriers	Organisational barriers consist of settings imposed by the host organisation, such as: irrational policies, short term focus and anti-learning culture. Communities of practice cannot by itself influence these factors and therefore needs the support of other functions, such as senior management.
	Rigidity and agility	The community of practice may not have the influence to impact on the organisation or vice versa.
	Managing complexity	Communities of practice introduce a higher level of complexity, which requires effort to sustain as else the community may risk losing its adaptable and agile nature.

Table 2.3: Flaws of communities of practice (Wenger, McDermott & Snyder, 2002)

As communities of practice act in an informal and uncontrollable manner there is no guaranteed procedure to avoid internal and external issues. However, being aware of the flaws may assist on mitigating the potential damage (Wenger, McDermott & Snyder, 2002).

2.5.3 CONFLICTS IN COLLABORATION

In all collaborations there is potentially conflicts arising. Conflicts may spark from a variety of reasons such as lacking communication due to misinterpretation. However, conflicts should not be considered as an issue but as an opportunity to improve. Through the knowledge of conflict management models, such as the 'dual concerns model' (Forsyth, 2009; Gabrielidis et al., 1997; Sorenson, Morse, & Savage, 1999), the most suitable conflict resolution technique can be utilised to mitigate damage and gain potential knowledge.

One of the most common conflict models is called 'dual concern' which breaks down conflict management into five different styles. In the 'Dual concern model' the vertical axis is the concern for others, while the horizontal represents the concern for self (Forsyth, 2009; Rhoades & Carnevale, 1999; Sorenson et al., 1999), and each style is further explained in the Table 2.4.

Dual Concerns model further explained	
Smoothing	• Focused on relationship • Goals are secondary
Problem-Solving	• Values both goals and relationships • Initiates negotiations through problem-solving • Focused on solutions resolving tensions and negative feelings • Risk accepting • Time is of less importance
Withdrawing	• Avoids conflicts if possible • Changes subjects in order to avoid irritation
Forcing	• Uses authority or power to subdue opponents • Goal oriented • Views negotiations as competition
Compromising	• Concerned about both goals and relationships • Compromises to move on • Time is important • Utilised in time restricted situations

Table 2.4: A brief explanation of 'Dual concern model' adapted from Sorenson *et al.* (1999, p.27)

When dealing with conflicts within a group it is crucial to avoid it escalating and endangering the delicate group cohesion. Mapping the origin of the conflict may help to quickly subdue the conflict and mitigate the issue. Group conflicts can commonly be mapped to task, differences in ideas and developments of the actions, processes,

differences in views regarding procedures to achieve goals, and relationships, interpersonal disputes inside the group. Task and processes include the ambiguities in tasks, actual or perceived scarcity of resources and dissimilarities in goals, objectives and perspectives. The relationship oriented conflicts include differences in group composition, interpersonal styles and values (Hitt, Black & Porter, 2011, p.291).

2.5.4 Stages of Group Development

In response to the demand within industry to become quicker, more adaptive and innovative organisations have flattened and slimmed their ranks. An emphasis on operation effectiveness has forced the development and management of teams whether its been public or private sector. There has to be a development from individual group work to collaborative team work to remain competitive within the business environment. While groups may not pose the most effective method the increasingly global market has forced the collaboration across and within networks (Hitt, Black & Porter, 2011).

In order to understand the development and potential gains, it is crucial to separate groups and teams. Groups are commonly a set number of people interacting towards a shared objective, which is illustrated in Figure 2.8 below.
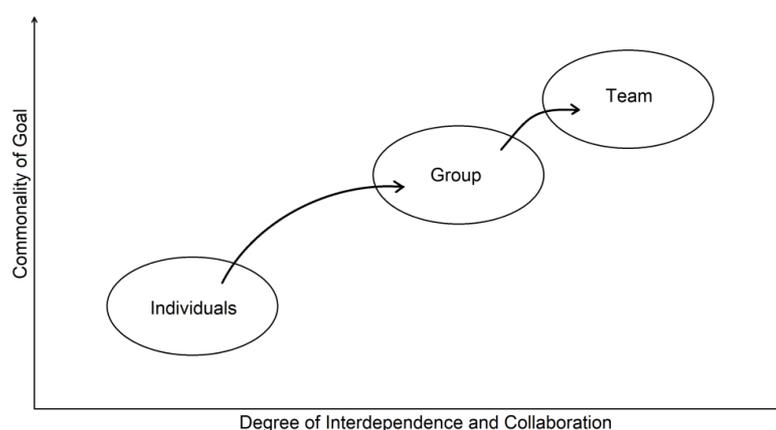
Figure 2.8: Team development continuum (Hitt, Black & Porter, 2011, p.271)

However, a team is an advanced group which in addition has a high degree of interdependent and coordinated interactions. Furthermore, a team has a strong internal connection between the members and a feeling of responsibility for the produced results (Hitt, Black & Porter, 2011).

A group does follow a distinct pattern of development stages whether it has been formed by an organisation or ad hoc. One of the most common group development models, which was introduced by Tuckman (2001), breaks it down into four phases, namely: forming, storming, norming and performing. Forming is the first phase characterised by politeness and caution. This is a socialisation phase which lets the members become acquaintances. Storming is the second phase which is characterised by chaos and disrespectful behaviour. The phase arises when wills and opinions clash. Norming is the third phase which is characterised by the development of group coherence and consensus. This phase is obtained when the second phase is over due to the establishment of norms within the crowd. Performing is the fourth and final phase which is characterised by the improved collaboration and effectiveness. The last phase arises when the norms has been established to a sufficient degree without restricting the work process. However, groups may revert to previous stages of the group development due to both internal and external factors, such as the introduction of new members or laws. (Hitt, Black & Porter, 2011; Tuckman & Jensen, 2010; Tuckman, 2001).

2.6 LITERATURE CONCLUSION

The assessment of the literature gives a broad yet comprehensive view of the current situation, which ties in well with the research aim and question. The fields of knowledge management, collaboration and team development are closely interlinked, which can be seen as several of the issues are resolved by similar aspects.

The creation of trust is highlighted as a primary factor for the successful implementation of the different processes. The notion of knowledge containment in individuals and collective is supported by the boundary spanners and objects. Interactions are required for the knowledge creation which is ensured by the facilitation through boundary spanners, and the integration of boundary objects ensure efficient work processes. The spiral of knowledge creation (Nonaka & Konno,

1998; Nonaka, 1994) which is enabled by the establishment of a 'shared space' corresponds to the group development theory of Tuckman (2001). In addition, it reveals how further advancement may be facilitated through a more comprehensive outlook on the issue (Newell et al., 2009).

The literature review elucidates that the topics are large and mature yet cross field research has gained little impact, which may suggest an inability to accept and adopt other viewpoints. Therefore, the research proposes a methodology which takes an overview of the relevant areas within each topic influencing knowledge, collaboration and team development.

The critical evaluation of the data collected is ensured by the rigorous nature of the methodology. Credibility of the research is warranted by the articulation and transparency of the research methodology (Biggam, 2008).

3 METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss the reasoning behind choosing the selected methodology as well as its benefit in pursuit of the research question. Several different methods and approaches have been evaluated, such as interviews, questionnaires and observations. The methodology and tools are presented through an overview, in order to expose both the strengths and weaknesses of the method selected. At the end, research ethics and ethical considerations are presented which warrants respectable research practice.

Data gathering is an often difficult endeavour which optimal methodology heavily relies upon the case at hand, and the data which is supposed to be collected (Silverman, 2006). Furthermore, it is important to recognise that the research may endanger the parties involved directly or indirectly due to the information, and therefore sensitivity and discretion is advised (Rogers, 1987). Research within a company context is favourably done through case study, as it may permit the researcher to include specific situations in a suitable format (Bell, 2010). Striking the balance regarding exposing research details is important in order to craft a good dissertation, which is done through analysing the value of the information to use an appropriate amount to validate the research (Biggam, 2008).

3.2 RESEARCH APPROACH

There are numerous way of collecting data, such as interviews, questionnaires and observation, however the core elements is whether it is a quantitative or qualitative approach. The quantitative data gathering can be said to answer the 'how' question of the research while the qualitative answers the 'why' (Biggam, 2008). Quantitative research is based on quantities and measurements which are evaluated in search of statistically significant patterns. As stated by Bryman and Bell (2007, p.28) "Thus, qualitative research can be construed as a research strategy that emphasizes quantification in the collection and analysis of data". The counterpart qualitative research connects to the scrutinising and expanding in-depth exploration of a hypothesis. Bryman and Bell (2007, p.28) claimed that qualitative research "usually

emphasizes word rather than quantification in the collection and analysis of data". However, it should be noted that it is not the research strategy that determines the methodologies quantitative or qualitative orientation, which is a common mistake according to Biggam (2008). The research strategy bundled with the data collection method and objectives assists finding the nature of the research. Commonly, qualitative data is collected through interviews and observation while quantitative relies on surveys (Bell, 2005).

Research may utilise both quantitative and qualitative methods exploring the subject, which is referred to as 'mixed-methods'. The mixed-method methodology is considered in academia as the most prominent research method as it has an inherent corrective element that strengthens the credibility of the research (Basu, 2010). Utilising a mixed method approach does not limit the researcher, as it allows for both parallel and supplementary data collection. For example, mixed methods can be used to improve the selection of data, through an initial sample being scoped into a more focused research. Basu (2010) claims that mixed method is often a preferred solution due to its inherent self-correcting nature, if properly applied. However, other researchers (Denzin, 2012; Ma & Norwich, 2007) highlight its' main flaws time-consumption as well as the risk of data corruption, which makes it not always a viable option. Furthermore, mixed method is only as strong as its weakest component, and therefore is best suited in environments that enable a balanced review of both qualitative and quantitative facets (Moehle, 2011). This is, however, refuted by Basu (2010) as he claims that in spite of one method being weaker, it is complemented by the strength of the other. Mixed method could have been an appropriate strategy for the case study, however the author perceived the additional time-consumption (Abowitz & Toole, 2010; Denzin, 2012; Ma & Norwich, 2007) beyond the scope of a Masters dissertation. In addition, the qualitative and quantitative aspects were unbalanced due to the qualitative nature of the research question, which may have skewed the research and thereby corrupted the research validity.

The data gathering during the research will primarily rely on meeting observations, as the methods shortcomings can be mitigated with the research setting and therefore pure rich data may be collected. However, in order to enrich the data gathered supplementary ad hoc interviews as well as internal documentation review were

performed in order to expand on areas which did not get sufficient exposure during the observations. Therefore, the data collection phase utilised a triangulation approach in order to improve the validity and credibility of the data gathered. In addition, the observations were coded and structured in a quantitative manner, in order to expose the social and interpersonal networks found within meetings. Although, as mixed method research has become diluted, as the term has been "used, abused and misinterpreted" according to Denzin (2012, p.85), the author assumes that the benefit of complementary interviews as well as internal documentation review provides an opportunity to confirm or reject discoveries from the observations. Nonetheless, the author was cautious regarding the connections as the interviews and internal documentation review are minor yet valuable parts of the data collection and thereby may reduce the validity of research if extensively promoted.

Commonly the qualitative and quantitative approaches are linked to different minds-sets regarding three key aspects as can be seen in Table 3.1.

Principal Orientation	Quantitative	Qualitative
Relation to Theory	Deductive	Inductive
Epistemological Orientation	Natural science model, in particular positivism	Interpretivism
Ontological Orientation	Objectivism	Constructionism

Table 3.1: Core difference between quantitative and qualitative research strategies according to Bryman and Bell (2007, p.28)

Quantitative research is deductive due to its focus consists of the testing of theories, while qualitative emphasis is commonly placed on the generation and establishment of theories. From this the author concluded that qualitative research is best suited to answer the research question. The motive is linked to the inherent difficulty in measuring factors involved with knowledge management and collaboration. As both knowledge exchange and collaboration is heavily based on interactions which can be explored through observations by an objective researcher. The essence of the

dissertation is an inductive study, breaking down current interaction, integration and utilisation of modern IT systems to offer areas of improvement.

3.3 RESEARCH STRATEGY

The research strategy exploits the possibility of reviewing procedures from different fields, which increases the comprehensiveness of the conclusions and their validity. When researching different industrial fields the studies may be subject to uncertainty due to different working environments which is mitigated by the fact that the case studies are contained within one company. The case study is broken down into three sub-sections, which each consists of a separate project and project team, as can be seen in Figure 3.1.

```
                    ┌─────────────────┐
                    │    Reinertsen   │
                    │    Case Study   │
                    │   Organisaiton  │
                    └─────────────────┘
              ┌──────────────┴──────────────┐
    ┌─────────────────┐           ┌─────────────────┐
    │     Project     │           │     Project     │
    │   Construction  │           │     Offshore    │
    │ Norwegian Branch│           │  Swedish Branch │
    └─────────────────┘           └─────────────────┘
```
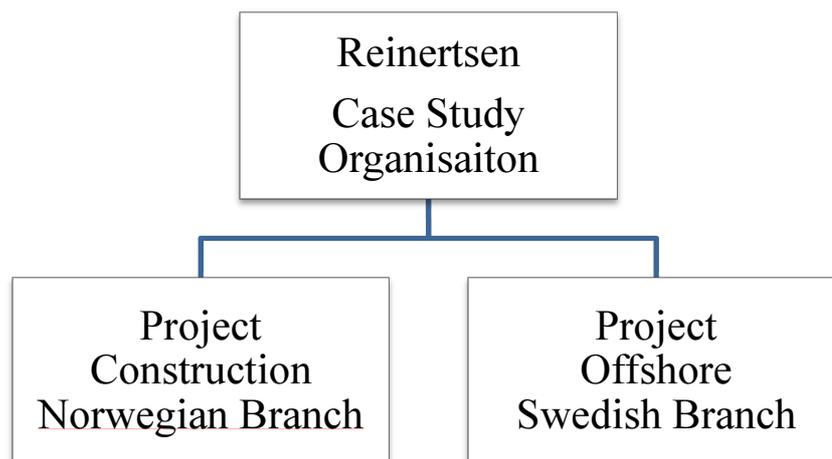
Figure 3.1: The Case Study broken down.

A case study enables the researcher to explore the current environment, connecting theory to practice (Levine, 1996). The subtle interaction between parties involve which else may be lost are caught through the eyes of the researcher (Lipson, 2007). Case studies have gained popularity due to their inherent focus on one or part of an organisation (Biggam, 2008). Furthermore, there is rarely a mixture of data collection techniques which simplifies the approach (Biggam, 2008). Lipson (2007,

p.100) suggests that before using case studies a researcher must answer two questions:

- Why use cases at all?
- Why use these particular ones?

The first question is related to the opportunity the case study supplies. In this dissertation the case study provides an interface to observe the research objective in a current business environment. The nature of the data collected is enabled through the case study to give a raw and unaltered view on the present situation (Lipson, 2007). The second question is answered by the research cross-industry aspect, which enables the researcher to explore a general perspective opposed to the potentially narrow view of one industry.

While in this case study, the data collection does heavily rely on observations, there is aspects of both document review as well as ad hoc and unstructured interviews. The documentation and interviews act as a complement to the observations and may assist in shedding light on areas that are not properly presented during the observations. Research can be based on single or multiple case studies. However, when dealing with multiple case studies it is crucial to apply the same research approach throughout each case study, as it may else complicate the comparison and devalue the research findings (Biggam, 2008).

3.4 SELECTING THE CASE STUDY

As the business environment is volatile and ruthless, many companies are hesitant to supply sufficient access to projects which may restrict or skew the data collection. While the researcher should act in a sensible matter participants may feel anxious as their work process gets scrutinised. Therefore, it is crucial both for the researcher as well as the participants that a high moral and ethical ground is taken when researching in business environments, which is secured through the participant form where the researcher provides an opportunity for the participants to review the background of the research and list requirements for their partaking. Finding suitable cases to explore, which allow sufficient interaction with processes and personnel to answer the research aim may pose an issue.

The case study organisation, Reinertsen, is a consultant firm, working mainly within construction, infrastructure, energy and offshore. In this dissertation, the construction and offshore fields are explored. The firm is rapidly growing, approximately 10-20% annually and has currently approximately 2300 employees. It is common within the firm to have cross-disciplinary teams as well as cross-industry exchange in order to gain a competitive advantage within the often ruthless business environment. While the company is mainly located in Scandinavia there are offices both in Poland and Russia. The company profiles themselves as cutting edge consultant firm. This can be seen through the adoption of BIM within construction and infrastructure, as well as concurrent design in offshore.

The company was selected as it enabled the review of different industrial sectors in a fast paced and international environment. There is a demand within the firm to strengthen their collaboration through a more structured and efficient utilisation of IT solutions. Therefore, the company provided an excellent platform for the research within the area of knowledge management and collaboration.

As illustrated previously in Figure 3.1, this research case study consists of two major project reviews and one complementary to potentially expand on the conclusions. The projects were selected in collaboration with a company contact. As suggested in the literature review, an emphasis was put on the heterogeneity of the projects, which is why different industrial fields and functions were explored. The main part of the data is collected during observations. The researcher did attend and observe meetings from both the construction and offshore industry. In addition, ad hoc interviews with key personnel were held throughout the visit to each office. Furthermore, shadowing is performed on boundary spanning individuals, which are selected by their formal or informal role of project knowledge hub. This is done to ensure the deductions from the meetings are valid and unbiased. Throughout the observation and interviews documentation is reviewed and explored in order to gain an understanding of the current use of the provided assisting documentation.

3.5 DATA COLLECTION

The process of data collection is a set of interrelated activates which Creswell (2006; 2009) claimed to be best described as a 'circle' which include: locating site or

individual, gaining access and making report, purposefully sampling, collecting data, recording information, resolving field issues and storing data. These steps are claimed by Creswell (2006; 2009) to be necessary in order to collect good qualitative data. The research is founded on a strong data collection provided by the observations which are complemented by the interviews and internal documentation review to gain a more comprehensive research conclusion. The data collection is illustrated in Figure 3.2 below.
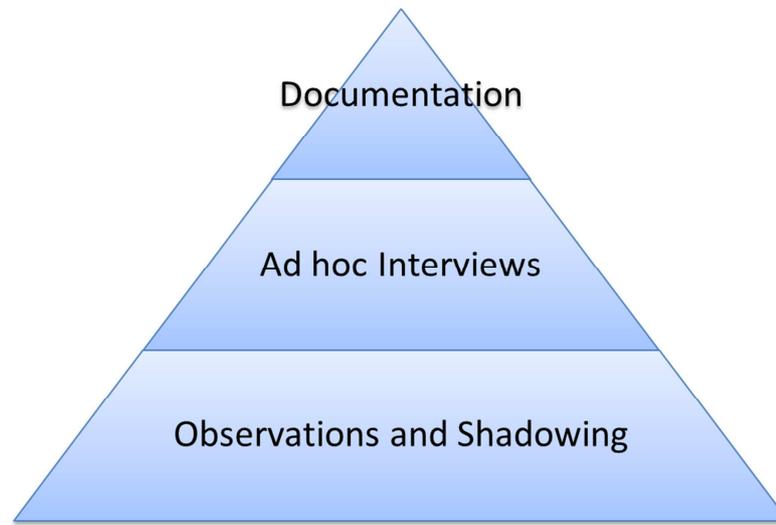
Figure 3.2: Illustration of the data collection.

3.5.1 OBSERVATION AND SHADOWING

According to Malik (2006) translated and cited by Nothhaft (2010), observations are the sole scientific process to obtain significant insights when exploring managers actions and agendas. Nothhaft (2010) states that there are merits of other methods, however there being a tendency of managers wanting to be perceived as up-to-date regarding current research development but the integration is questionable.

This dissertation takes influence from previous dissertations written at the Reinertsen to assist with the establishment of status quo as well to improve the utilisation of the qualitative observations. Observations need to be structured in order to be fruitful (Biggam, 2008). The preparation assists to improve the data collection resulting in an enhanced collection of rich data. According to Farenga *et al.* (2003) observations is an attempt to identify patterns. Observation is an empirical process directly based on

the researchers' prior knowledge. Furthermore, it has to be understood that observations cannot be truly unbiased (Biggam, 2008).

According to Farenga *et al.* (2003) there are reoccurring components within good scientific observing, as can be seen in Table 3.2.

Component	Description
Plan	Use a plan to guide the observations.
Senses	Use all senses to gather clear and extensive information.
Measurements	Make important variables measureable to supplement observations if needed.
Changes	Observe natural changes occurring, but whenever appropriate make deliberate alterations and observe the response to change.
Questions	Keep an open mind, however alert to discrepancies. Raise questions when needed, as they may lead to new information

Table 3.2: Components of good scientific observations (Farenga et al., 2003, p.57)

As the observations are conducted with professionals in on-going projects the sample pool may be limited due to external factors. In order to mitigate the restriction scarce data would pose additional reports and documentations are used to build the research foundation. The observations of each project will take place during two days, which will enable the researcher to gather sufficient insight in the work process. There was both meeting observations as well as shadowing of project participants during the appointment. Additional information was extracted by documentation. This scheme will enable gaps within the rich data gathered from observations to be compensated by the additional information gathered from documentation. The importance of collecting rich data originates from its ability to go beneath the surface which may open up the research to new aspects. (Charmaz, 2006)

3.5.2 SHADOWING AS STRUCTURED OBSERVATIONS

Shadowing is a sub-category to observations linked to a certain observation technique and focused on qualitative research (Bartkowiak-Theron & Sappey, 2012; McDonald, 2005). It originates from Mintzberg's (1973) study "The Nature of Managerial Work", where he followed five CEOs during a week each. Mintzberg labelled it as 'structured observations' or 'shadowing'. According to McDonald (2005) shadowing is rarely used and discussed in social science literature. Shadowing has been used in important management studies, such as Mintzberg (1973) mentioned previously, however has not managed to translate to the modern management research (McDonald, 2005). Although, there are exceptions such as Bonazzi (1998), Perlow (1998) and Smith, Dufour and Erakovic (2011). However, the research lacks the distinctive scrutiny required to further develop the methodology. The critical examination is vague which has resulted in a dilution of an already niche approach (McDonald, 2005). In practice 'shadowing' is the act of a researcher closely following a person for a set time period, while collecting data regarding the specific roles day to day actions and activities as they occur. The benefit of the methodology is related to the potential greater understanding of the individuals' motivations fuelling its actions (Bartkowiak-Theron & Sappey, 2012). The technique enables the collection of insights both related to the fulfilment of functions but also the role in the day-to-day operations. The aim is to answer the behaviours related "what", while exploring its connection to "why" it occurs (Bartkowiak-Theron & Sappey, 2012).

3.5.3 SUPPLEMENTING INTERVIEWS AND INTERNAL DOCUMENTATION REVIEW

The interviews were held in an unstructured (open-ended) and ad hoc manner in order to secure rich data without the interference of the researcher. Bryman and Bell (2011) claim that interviews in qualitative research commonly have a flexible structure allowing the topic to be explored in a suitable manner, as the interviewee elaborates within its' own industrial context as well as their interpretations of the subject at hand. The notion is that this may provide a suitable platform complementing the data collected during observations by filling in potential gaps in knowledge and experience. Although, in order to ensure that the three core concepts of the dissertation gets explored the researcher will mention the notion of interaction,

integration and utilisation at the beginning of the interview in order to phase in the concept into the discussion. This ensures a predefined arrangement without limiting the interviewee.

The weaknesses associated with interviews are such as the interviewee 'romanticising' the past, experience replacing authenticity and not having suitable role or knowledge to comment (Denscombe, 2010; Silverman, 2006). Furthermore, the data collected may potentially be corrupted due to the interviewee vanity and intelligence (Charmaz, 2006). The interviews were held with professionals in on-going project environments, which limit the potential participants pool, however this is mitigated by the sheer amount of project team members available across the organisation.

The data collected during the interviews was briefly condensed and structured to be utilised as a complement to the observations.

The internal documentation will explore the control systems provided within the firm, in order to gain a better understanding of the normal procedure. It will explore the perceived benefits, as well as the potential issues associated with the established tool. While the internal documentation mainly will assist in improving the researchers understanding of the current environment it may provide a great yet untapped asset, which is further elaborated in the following chapters. As can be seen in Figure 3.2, documentation is the least explored data collection method, and mainly utilised to gain a more comprehensive conclusion and recommendation chapter.

3.6 DATA ANALYSIS

The method of analysing qualitative data within academia varies greatly. However, there are a few acknowledged and established guidelines (Bryman & Bell, 2011). Traditionally, the data is collected, evaluated and structured in an iterative manner. This enables the interviews to be tailored, if required, to incorporate important factors discovered during the observations.

The data analysis is built up on a chain of actions, which to part run parallel. The observations are structured through the usage of a template, in order to list the interaction occurred through the meetings. The interactions are structured in self,

incoming and initiated. Self contains statements, callouts and interactions not directed to a specific individual. Incoming contains the interactions directed to the person in question, such as direct questions. Initiated contains the interactions initiated by one individual and directed to one or two participants. These notes were transcribed into interactions committed by the attending participants. From the transcribed interactions graphs were created using Microsoft Excel. Furthermore the transcribed interactions were used to construct social network matrixes using Gephi 0.8.2, in order to visualise interaction patterns Gephi 0.8.2 creates the social network matrix by using nodes and edges. Nodes are the entities within the network matrix, such as the project leader. Edges are the interactions between nodes or to itself, such as the interaction between the project leader and the planner. The edges are weighted by the number of interactions between the involved parties, in order to gain a visual representation of the connection. The layout of the pattern was selected to be 'Fruchterman Reingold' as it provided the best overview without modifications. If patterns emerge within the interaction then conclusions can be drawn and explored within the interviews and documentation review. In addition, the boundary spanners encountered was shadowed between meetings. After each interview a short condensed paragraph of the interview was written which incorporates the main points and key words from the interview. The goal is to let the interviews supplement and not suffocate the deductions from the observations. The interviews were done in an ad hoc manner as the environment did not let a time schedule be established prior to the events. Although, this may have lowered the quality of said interviews it is assumed by the researcher to have increased the richness of the data collected. In addition, internal documentation bridged knowledge gaps encountered during the interviews.

The observations, interviews and documentation review assist to create an understanding of the current situation as well as the direction of the firm which is necessary in order to accurately identify potential areas of improvement. The author compared the theoretical knowledge explored in chapter 2 to the current situation to establish potential improvement areas. Once the improvement areas were selected the recommendations were tailored to fit within the company which was done by the researcher evaluating the solutions applicability within the current business environment. The recommendations are presented in the conclusion and are focused

on the improved time and cost efficiency within the case study organisation. In order to ensure the relevance of the recommendation they were cross referenced to the keywords expressed during the interviews.

3.6.1 ETHICAL CONSIDERATIONS

Data is collected through observations and documentation from the case study organisation and other parties involve which have agreed to participate in the dissertation. All individuals involved are anonymous and therefore not mentioned with name in the dissertation. If a party explicitly requests to be listed with name a written request will need to be filed, which is reviewed according to the applicable rules and regulations of both Northumbria University and Chalmers Technical University. In addition, a written approval is requested from both Universities enlisted supervisors. The projects which were reviewed are structured by industrial origin in order to create a clear separation without endangering any parties involved.

Due to the nature of case studies, confidential information may be encountered. However, it will be excluded from the final dissertation and observational notes. This is ensured through a review copy being supplied to responsible parties sufficiently ahead of deadline. Confidential information is a persistent issue in business environment, however it is suggested that difficulties can be avoided through an open dialog between the researcher and the parties involved.

As the data gathered may be sensitive out of a personal or corporate perspective the storage needs to be carefully selected in order to reflect the importance. The gathered data recorded is stored on a cloud-service with a Secure Sockets Layer (SSL) and AES-256 bit encryption, to ensure its security. All documentation gathered is collected and stored by the researcher, and supplied to Northumbria University or kept within a bank deposit until the information can be considered obsolete, when it will be destroyed.

4 DATA FINDINGS AND ANALYSIS

As previously explained, the data collection was done in a manner which incorporates methods as observation, shadowing, interviews and documentation review. The results are presented by first establishing the current situation leading into the observations of the case study. The analysis of the observations discovers factors which were explored during the interviews assisted by the internal documentation review. This enables the evaluation of the research objectives which answers the overall research question. The dissertation is built on the idea of interaction, integration and utilisation. The interaction is data is explored in section 4.2 and 4.3 while integration and utilisation can be found in section 4.4.

4.1 CURRENT SITUATION AND STRUCTURE

The current business environment is briefly explored in this section in order to give an introduction to the analysis and results of the data gathered. The different industries have specific work procedures and values. Therefore, there is a slight difference in aims of objectives. Offshore projects are commonly more front heavy, which means more resources are allocated to the initial phases, in comparison to building and infrastructure projects.

The participants physically attending a meeting are given a number based on the succession of their arrival. Those participants which participate through video conference are labelled with 'ext' and number. Two meetings were observed of each project. In addition, ad hoc interviews were held in connection to the observations as well as documentation was reviewed. The interactions were sorted in the following manner:

- Self: Statements, callouts for everyone and interactions not directed to one specific. This includes interactions such as project leader brief summaries, callouts and non-directed statements.
- Incoming: Interactions directed to the person in question. Not initiated. This mainly consists of questions.
- Initiated: Interactions initiated. This includes all questions asked that are directed to one or two specific persons. As the meeting only had 5

participants the initiated was limited to 2 persons at most. If more were asked with one question it was considered a statement and categorised as 'Self'.

4.2 CASE STUDY CONSTRUCTION PROJECT

The in-house project organisation is co-located within a dedicated office space located in the Oslo main branch facility. The deliverable is a 7 floor housing complex, with a total of 83 2, 3 and 4 room apartments. The building will be constructed in a classical area of Oslo, within close proximity to the Ekeberg park. This poses an integral challenge in the project, as the surrounding stakeholders may potentially become an issue if not tended. The building has been designed by an external architect, which is present throughout projects life-time as changes may be required to the initial plan.

4.2.1 THE TRADITIONAL DESIGN MEETING

The first meeting was a traditional design meeting with only a few attendees. Those that participated were all responsible of vital parts of the project. The meeting lasted for approximately 75 minutes. A total of 185 interactions were collected over the cause of the meeting. The following Figure 4.1 illustrates the interactions during the traditional design meeting.
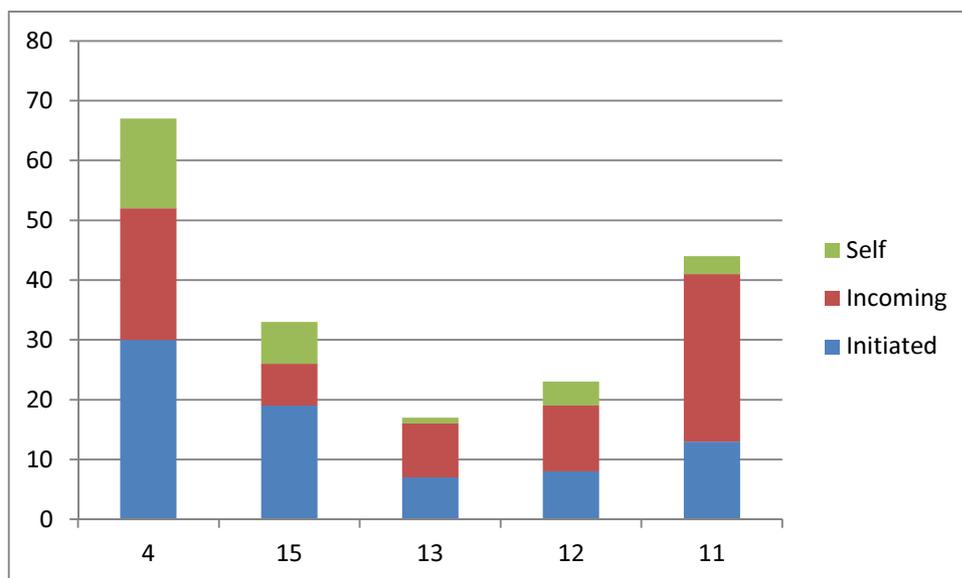

Figure 4.1: Diagram of the interactions during the first meeting.

As can be seen in the diagrams number 4 and 15 initiated vastly more interactions than receiving. 11 receive vastly more interactions than initiated. 12 and 13 have about equal incoming and outgoing interactions. Number 4 had the most self and initiated interactions. However, number 11 had the most incoming interactions. Therefore, additional diagrams were created to explore the interactions of these two participants. The initiated and incoming interactions of number 4 and 11 can be seen in Figure 4.2 respectively Figure 4.3.
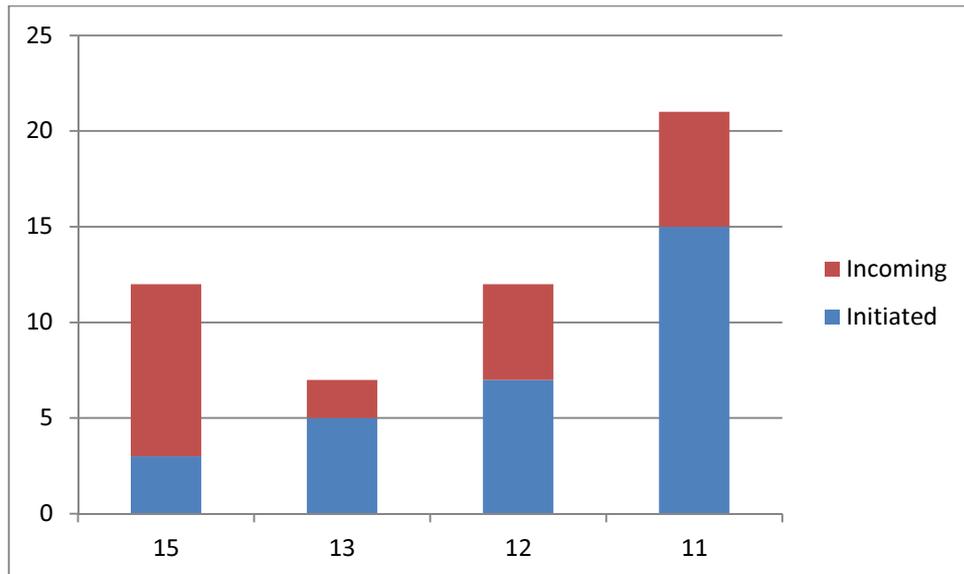

Figure 4.2: Interactions initiated by and incoming to number 4.

It can be seen that number 4 had a broad spread of interactions. Several of the interactions had the sole objective to bridge the gaps which could endanger the projects outcome. The review of the interactions of the project leader reveals that the whole group was able to participate to some degree within the meeting.
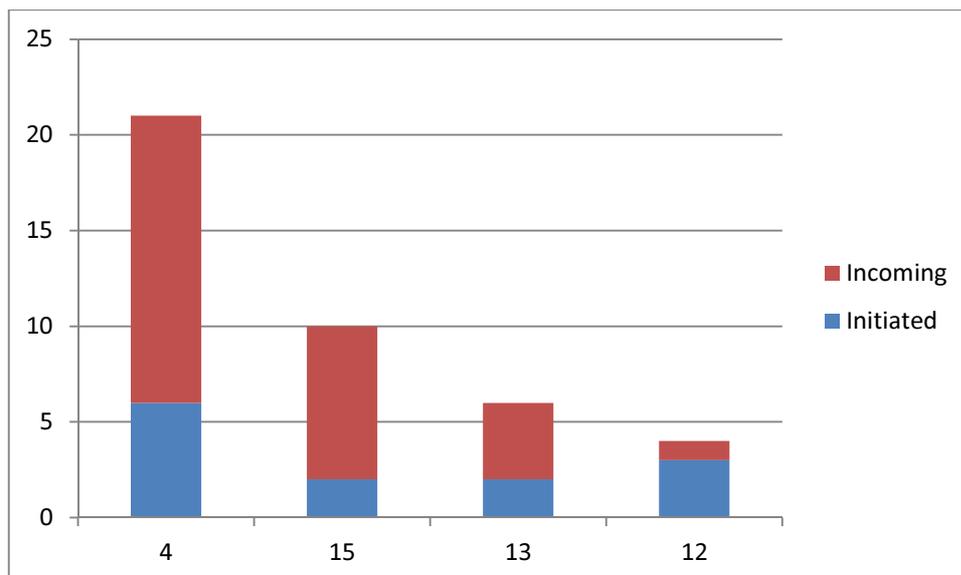
Figure 4.3: Interactions initiated by and incoming to number 11.

It can be seen that the majority of number 11 interactions originated or targeted number 4. This may be explained due to number 4s role of the project leader, while number 11 was an external source. In addition, number 11 received several questions from 15, mainly tied to potential upcoming issues in the current phase of the project.

In order to gain a better understanding of the interactions a social network matrix was created using Gephi version 0.8.2. The social network matrix consist of 5 nodes, 19 edges and 185 interactions. The social network matrix was structured through the usage of the 'Fruchterman Reingold' layout, provided within the application. The social network matrix can be seen in Figure 4.4, below.
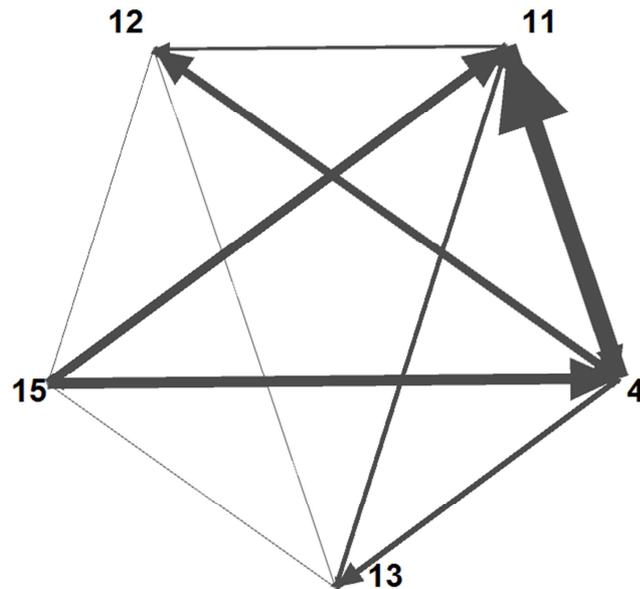
Figure 4.4: Social network matrix of the traditional design meeting.

The social network matrix clearly illustrates the main interaction of the meeting was between 4 and 11. All participants had some interaction among each other.

The traditional design meeting had no real interaction with IT systems. The meeting did not involve any computers or other IT tools supporting the meeting. Prior to the meeting the meeting agenda as well as the invitation was sent by electronic mail (email).

4.2.2 COLLISION CONTROL MEETING

The second meeting was a collision control meeting with more attendees. Those that participated were representing each part of the BIM model constructed in the project. The meeting lasted for approximately 75 minutes. A total of 150 interactions were collected over the cause of the meeting. The interactions were sorted in the same manner as previously explained in Section 4.2.1.

The following Figure 4.5 illustrates the interactions during the collision control meeting.
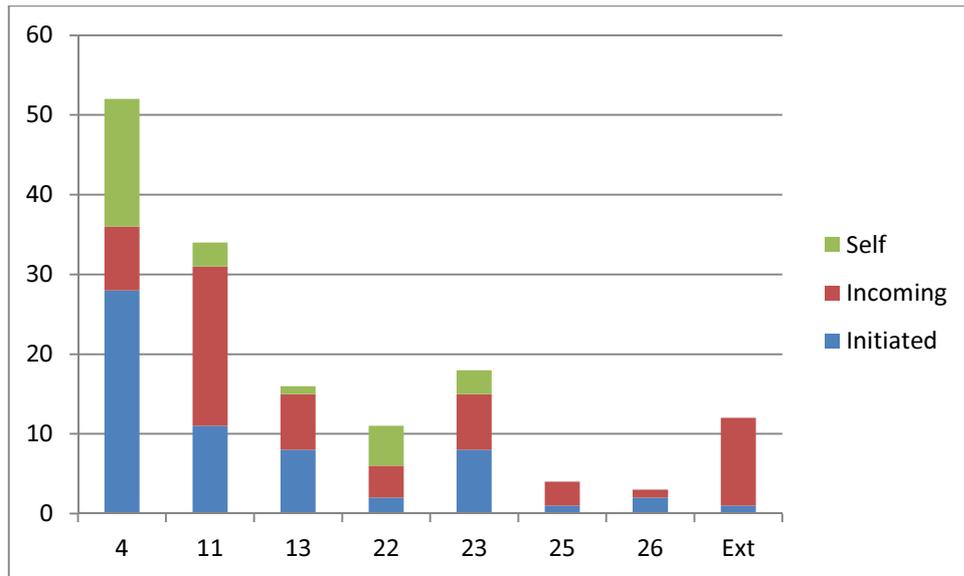
Figure 4.5: Diagram of the interactions during the second meeting.

As can be seen in the diagram number 4 initiated vastly more interactions than receiving. Number 11, 25 and Ext receive vastly more interactions than initiated. The interactions seem unstructured and skewed in comparison to the previous meeting with only a few participants interacting. Therefore, the initiated and incoming interactions of number 4 and 11 are explored further in Figure 4.6 and Figure 4.7.
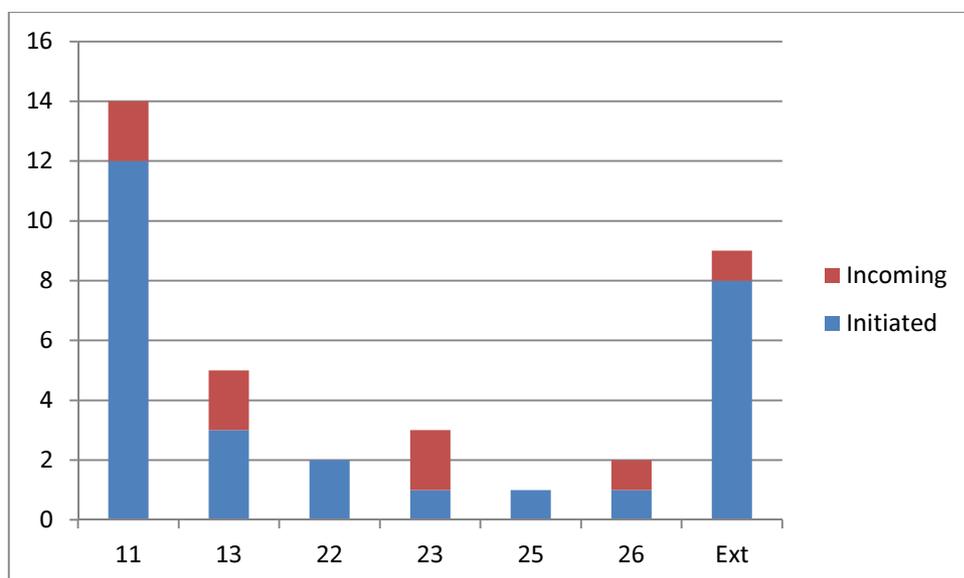
Figure 4.6: Interactions initiated by and incoming to number 4.

It can be seen that the majority of the interactions initiated by number 4 was targeting external participants as number 11 and Ext. This could be as the communication within the in-house project organisation works well, however the connection to

external participants is proving to be a challenge. It can be said that the in-house project team members allow the project leader to be their champion within the meeting by channelling their questions. The project leader provided an interface between the employees and the external participants.
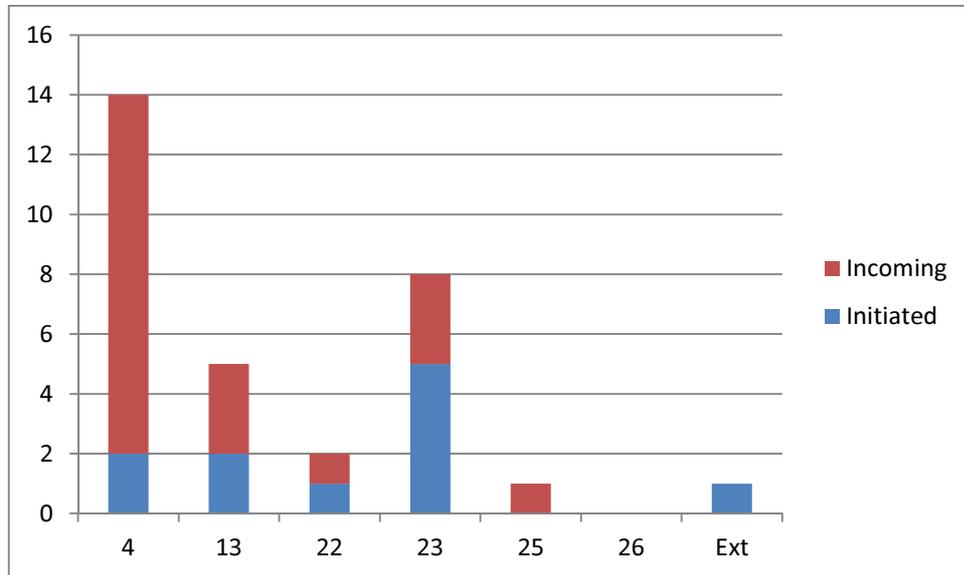
Figure 4.7: Interactions initiated by and incoming to number 11.

The interactions of number 11 can be broken down into three primary targets, namely number 4, 13 and 23. This is as some collisions between the different participants were detected and the discussion and questions took up a the majority of the meeting. It can be seen that number 11 directs the majority of the questions directly to the project leader, which could be seen as a sign of number 11 acknowledging the authority of number 4.

In order to gain a better understanding of the interactions a social network matrix was created using Gephi version 0.8.2. The social network matrix consist of 8 nodes, 31 edges and 150 interactions. The social network matrix was structured through the usage of the 'Fruchterman Reingold' layout, provided within the application. The social network matrix can be seen in Figure 4.8, below.
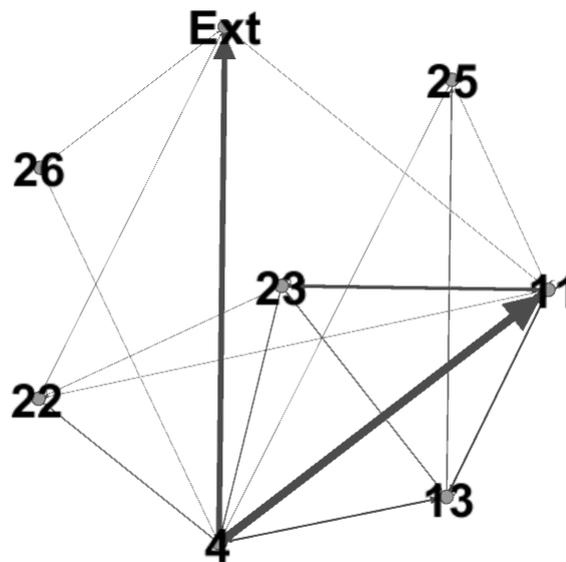
Figure 4.8: Social network matrix of the collision control meeting.

The social network matrix clearly illustrates the main interaction of the meeting was between 4 and 11. In addition, it visualises that not all participants interacted among the group.

The collision control meeting substantially relied on the IT systems in order to visualise issues and structure the meeting. Email was used to organise the meeting. Prior to the meeting an assembled BIM model was constructed and the collisions encountered were extracted. These collisions were then filtered by the project leader (4), as well as the BIM expert (22) before distributed to the participants through email, in order to provide guidance to the issues which would be dealt with during the meeting. Video conferencing on a separate screen was used as all participants were not co-located. During the meeting the BIM expert (22) was dedicated to handle the computer. As the meeting was dedicated to solve collisions encountered in the assembled BIM model, the majority of time was spent with it. However, documentation and blue prints were shown when required to reduce anxiety and confusion.

4.3 CASE STUDY PROJECT OFFSHORE

The in-house project organisation is located across the whole office and has no dedicated office space allocated. The deliverable is a modification for a large client in Norway. The project has not been officially confirmed by the client beside an initial request of rough cost estimation. However, as there have been similar projects previous experience is drawn upon in order to quickly give an estimation and prepare for the project specification from the client.

It was one meeting that was observed, however it was separated into two phases with a pause and relocation. The initial phase was a rough estimation meeting with the client attending and most of the in-house project organisation attending. The second phase of the meeting was relocated to a computer room in order to facilitate a concurrent approach, which means the parallelization of tasks according to Anumba & Evbuomwan (1997) . While the meeting was on paper considered as one, it is treated as two separate meetings due to its difference in participants, time and location. In addition, ad hoc interviews were held in connection to the observations.

4.3.1 THE ROUGH ESTIMATION MEETING

The first meeting was a rough estimation meeting, in order to present an initial project tender, with more attendees. Those that participated were representing all fields of expertise required to satisfy the potential requirements of the project. The meeting lasted for approximately one and a half hour. A total of 145 interactions were collected over the cause of the meeting. The interactions were sorted in the same manner as previously explained in Section 4.2.1.

The following Figure 4.9 illustrates the interactions during the collision control meeting.
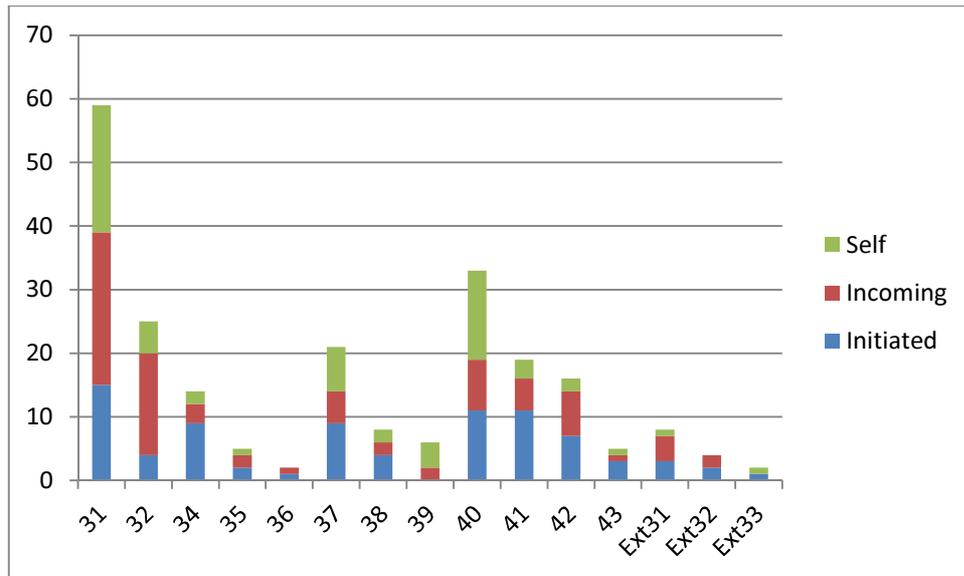
Figure 4.9: Diagram of the interactions during the first meeting.

As can be seen in the diagram the majority of the participants did not interact. The interaction was mainly held by number 31, 32 and 40. 32 participated only in the beginning of the meeting, while the number 40 interaction mainly is made in the planning part at the end of the meeting. The interactions are explained as number 31 was the project leader, 32 had extensive knowledge of similar project and 40 was the project planner. As the interactions of number 32 and 40 were mainly related to one task or topic they will not be further explored. The interaction of 31 is explored in Figure 4.10. 8 out of 15 participants had less than 10 total interactions in total.
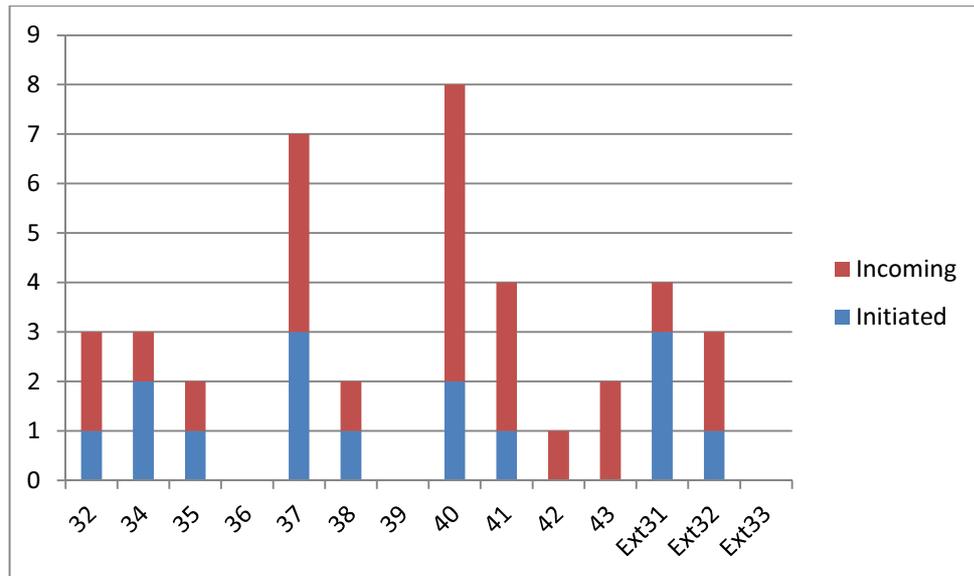
Figure 4.10: Interactions initiated by and incoming to number 31.

It can be seen that the interaction was focused on number 37 and 40. Number 37 recently got promoted, which resulted in answering questions directed to two different fields of expertise, linked to both the old and new responsibilities. As planning is crucial in the initial stages of a project, the interaction with number 40 ensured a verified and suitable project plan.

In order to gain a better understanding of the interactions a social network matrix was created using Gephi version 0.8.2. The social network matrix consist of 15 nodes, 65 edges and 145 interactions. The social network matrix was structured through the usage of the 'Fruchterman Reingold' layout, provided within the application. The social network matrix can be seen in Figure 4.11.
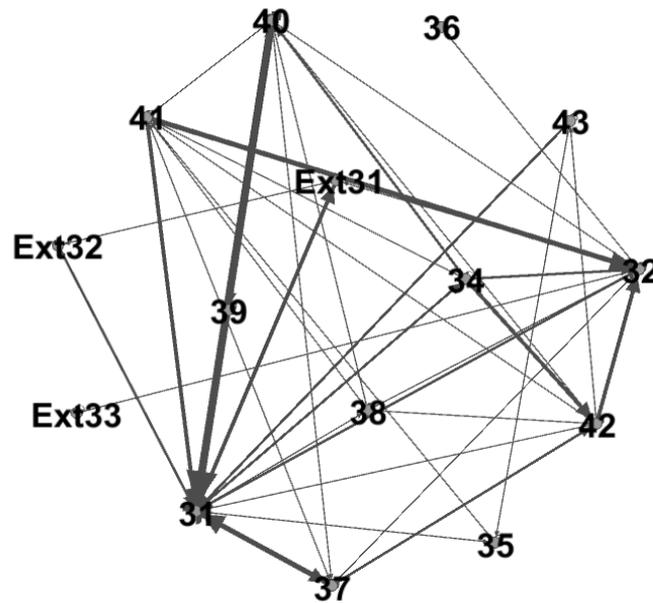
Figure 4.11: Social network matrix of the first phase.

The social network matrix clearly illustrates the main interaction of the meeting was between 31 and 40. In addition, it visualises that not all participants interacted among the group.

The rough estimation meeting used IT systems to facilitate the meeting, as the client participated over a video conference link. The majority of the in-house personnel did all participate in the meeting. Email was used to organise the meeting. As there was a slight confusion in why the client requested a meeting, only minor information was provided in advance. At one screen the video conference was placed, while the other displayed documentation and blue prints of previous projects resembling the new. The option of having a video conference allowed the meeting to be held shortly after the request from the client, which would not have been possible if physical participation was required. During the meeting the Project leader (31) was handling the IT systems. As the meeting was dedicated to establish and confirm the specifications of the requested projects, the focus was on the information provided by the client, such as time schedule and cost budget.

4.3.2 THE CONCURRENT DESIGN MEETING

The second phase of the meeting was the held in a concurrent design manner. Only few of the initial attendees did fully participate in the second phase. Most attendees preferred to work from their own office space. The meeting lasted for approximately 2 hours. A total of 39 interactions were collected over the cause of the meeting. The interactions were sorted in the same manner as previously explained in Section 4.2.1.

The following Figure 4.12 illustrates the interactions during the collision control meeting.
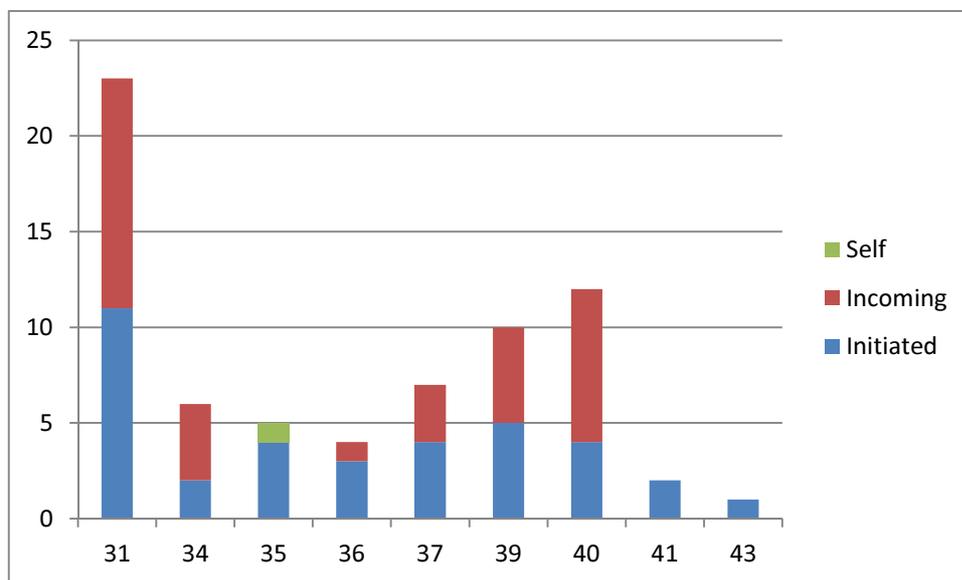
Figure 4.12: Diagram of the interactions during the second meeting.

As can be seen in the diagram number 31 initiate vastly more interactions than the other attendees. Number 39 and 40 interacted closely together, as 39 is supposed to replace 40 in the project planning role. The interaction can be seen as a mentoring session. The interactions are fewer yet longer as the topics are explained and elaborated in-depth. Number 31 interactions are further explored in Figure 4.13 below.
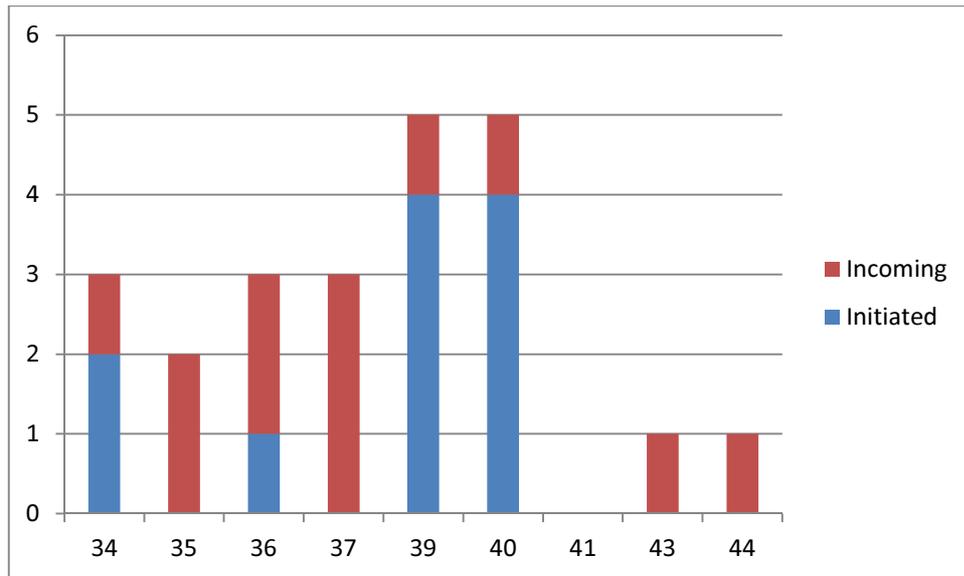
Figure 4.13: Interactions initiated by and incoming to number 31.

It can be seen that number 31 facilitates the meetings to distributing word and contacts across and between participants. The participants do come and go several times during the meeting, which indicates that the actual physical participation was lacking and posed a challenge within the meeting setting. Those which only pose 'incoming' communication targeted at number 31 are individuals which only briefly visited the meeting before going back to their office space. However, this illustrates how important the face to face contact can be when conveying knowledge. It links back to the tacit and explicit nature of knowledge and the social aspect needed when transferring tacit knowledge.

In order to gain a better understanding of the interactions a social network matrix was created using Gephi version 0.8.2. The social network matrix consists of 10 nodes, 25 edges and 39 interactions. The social network matrix was structured through the usage of the 'Fruchterman Reingold' layout, provided within the application. The social network matrix can be seen in Figure 4.14, below.
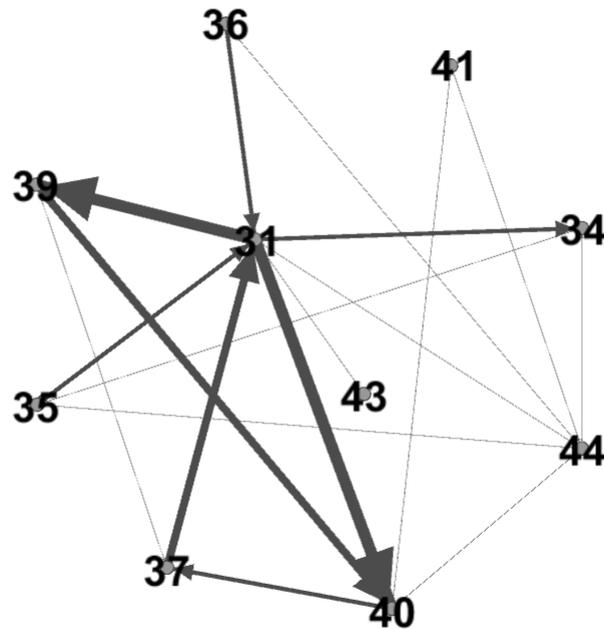
Figure 4.14: Social network matrix of the concurrent design meeting.

The social network matrix clearly illustrates the interaction are focused to number 31. It also shows that there was a tight collaboration between number 39 and 40. In addition, it visualises that not all participants interacted among the group.

The concurrent design meeting is being facilitated by the use of IT systems. The concurrent work process involves the participants to temporary co-locate in order to reduce boundaries between participants and thereby improve the information and knowledge exchange. The improvement is supposed to lead to a quicker communication and mitigation of issues encountered throughout the project life-cycle. The meeting room provides the possibility to display one screen on one of three projectors. This enables the involvement of the required participants in a swift manner. The enhanced work process reduces the risk of facing unforeseen challenges in current and later phases of the project. During the concurrent design meeting the projector mainly displayed the project leaders (31) computer, however, as project planner assistant had questions the projection was changed and the participants

assisted to solve the issue. As additional questions arose, the project leader used the IT systems to call the client to ensure that the details were correct.

4.4 THE AD HOC INTERVIEWS

The ad hoc interviews are presented in brief unstructured recaps, with a focus on the core theme elaborated. The author wrote down keywords as well as sentences during the interviews, which were afterwards briefly recapped. The interviews were held in a language which the interviewee was comfortable with, in order to ensure clear and concise communication. The aim of the interviews was the establishment of the employees view regarding integration and utilisation of IT tools. The employees did originate form a variety of fields, functions and locations in order to secure an overarching understanding of the current situation.

4.4.1 EMPLOYEES PERSPECTIVE IT SYSTEMS

BIM as a tool can be used to improve communication between stakeholders. However, currently BIMs main utilisation is connected to collision control during the planning phase there are other applications gaining momentum. According to the *site engineer* BIM is of great benefit, however at the current stage it is too rough and not detailed enough to provide sufficient information. In addition, the integration does result in issues as network and information technology is not always available on site. Network cables can often be cut, which may potentially put a hold on the project execution resulting in severe costs. The *site engineer* is currently using BIM models as a complement to current tools. However, this may change as new applications such as VICO Office are introduced efficiently linking the new and old applications.

According to the *BIM coordinator* the integration and utilisation of BIM has rapidly grown, since it was introduced in the consultant firm two to three years ago. The mismatch between applications and methodologies, such as BIM and MAP, has however interfered with some of the potential benefit. The *BIM coordinator* describes the possibilities in the initial phases as Figure 4.15 below.
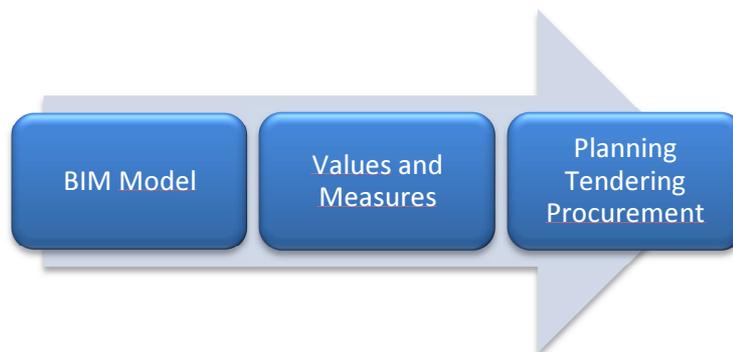
Figure 4.15: Opportunities of BIM according to employee.

There are alternative interfaces that offer a linkage between BIM and economic, planning and construction tools, such as MAP. However, MAP does not enable that communication. It is mentioned that while MAP is a great tool, the lacking feature will result in no comprehensive and fully utilised BIM environment. At this stage there are projects that have been previewing alternatives to MAP for use in pilot projects. However, no decision has been made.

According to the *project planner* Microsoft Excel as one of the most useful tools, due to its ease of use, however several tasks are monotonous and repeated between disciplines. There is currently a development towards tools which can directly auto-generate procurement documentation which would in turn reduce time cost and remove double work. The *project planner* stated that the main benefit is related to the time-cost of man-hours. In addition, there may be times where tasks are performed double due to the weak interaction between parties involved. If the task gets more automated it may result in the issue being forgotten. A stronger collaboration between disciplines will assist in the reduction of repeated work.

The *project economist* has dwelled deeper within MAP than other disciplines within the case study organisation and claims that there is a great potential benefit if suitable integration and utilisation can be established. Currently, the primary tool used is Microsoft Excel, however due to a recent completion of a pilot project utilising MAP it has become an integrated part in commenced projects. Microsoft Excel is used as a basic stage with filters, lists and formulas being applied. Through the utilisation of MAP a close collaboration between Construction, Planning and Economic can be

achieved, which potentially may reduce issues and shorten the time-consumption of the different tasks. Although, the quick integration of MAP has exposed issues related to the insufficient knowledge and experience. The *project economist* states that "An application is only as useful as it is utilised". Therefore, focused training in the application as well as a local expert, would assist to promote and develop the work force as skill development is time-consuming and fragmented. However, there are efforts being made in improving the knowledge development within the area through the establishment of communities of practice. The *project economist* states that MAP will not be able to replace all the functions of Microsoft Excel, however it can become a complement improving project effectively through increased collaboration between disciplines and reduction of monotonic activities.

During an interview with a *senior project leader* within offshore the notion of trust was a constant theme. The establishment of an environment which supports the employees was suggested to improve the collaboration and thereby reduce the risk of implications. Furthermore, the *senior project manager* proposed that there was a link between attendance and experience. The different project teams have a variety of work experience within the concurrent methodology. Once the employees have accepted and embraced the work process the attendance raises. The interpersonal work environment is more constricted in projects which have adopted a concurrent design process compared to normal projects. Therefore, conflicts within the project team have to be handled more quickly as it may derail the whole project team. A good project manager knows to adapt the conflict resolution style appropriately to mitigate damage.

During several of the interviews the restricted IT environment in the corporate network was raised as a potential concern. It was clearly understood that the restrictions are there in order to avoid malicious use, however it likewise restricts positive intentions. As example, the application JAVA is commonly utilised on web-based support functions, however due to the restrictions it is not available for use.

When working in a small team that is co-located it reduces the difficulty of arranging the work-tasks. However, at times the project planner and economic are working on similar tasks. If the communication would improve over the disciplinary boundaries

it may result in a better collaboration. Traditionally there has been a wall between the disciplines.

5 DISCUSSION

In order to structure the discussion it is separated in the three aspects interaction, integration and utilisation, with a brief closure of the discussion afterwards The structure is selected in order to link back to the research aim and the literature review which provides the foundation of the study.

5.1 INTERACTION

The interactions during the meetings show clear signs of project leader taking a boundary spanning role as explained by (Aldrich & Herker, 1977; Levina & Vaast, 2005). Furthermore, it was seen that the boundary spanner acted as a knowledge hub, distributing the in-house experience as was necessary which was suggested by Newell *et al.* (2009). The majority of interactions with external parties are handled by the project leader, with the assistance of the experts when required which links to knowledge exchange across boundaries (Newell et al., 2009) as well as organisational learning (Argote, 2012). However, likewise during in-house meetings the behaviour can be seen as the project leader acts as a facilitator of communication by reducing the noise and misconception interfering with the message, which links back to Hitt, Black and Porters (2011) notion of communication. The verbal communications disadvantages suggested by Hitt, Black and Porter (2011), such as misinterpretation, was apparent during several meetings, which forced the project leader to take a more active role, bridging the communicational. This bridging of communication connects to the role of the boundary spanner as suggested by Di Marco *et al.* (2010).

In the interviews the ease of access to concerned parties was voiced as one of the most important aspects of interaction, which connects to several of the topics explored in the literature review, such as organisational learning (Argote, 2012), knowledge creation (Newell et al., 2009), shared knowledge space (Nonaka & Konno, 1998) and communities of practice (Wenger, McDermott & Snyder, 2002). Communication was said to rarely be an issue, which was contradicted both in the observations, as two meetings displayed the language barrier, and in the literature which suggested miscommunication to be one of the primary reasons for tasks running over time and budget (Hitt, Black & Porter, 2011). The communication was

held in the native tounge of the participants and therefore the meetings contained a mix of Norwegian and Swedish, however, when the communication was failing the language used was switched to English to ensure the clarity of the message.

In Reinertsen technology has been implemented to ease the interaction between employees, however the project leader still plays a crucial role in facilitating the communication by distributing the contacts. It would suggest that even with technology taking the role of boundary objects (Akkerman & Bakker, 2011; Carlile, 2002; Gal, Lyytinen and Yoo, 2008), the interpersonal connection facilitated by the boundary spanner (Hoe, 2006; Isbell, 2010) remains crucial. Project management literature suggests that language is one of the primary factors for ensuring project success which connects to the previous findings (Maylor, 2010).

5.2 INTEGRATION

The BIM methodology (Eastman, 2011; Sebastian, 2011) develops quickly, however there are several areas, which need improvement. Projects with BIM do facilitate BIM meetings, where collision between disciplines are reviewed and resolved. These, while beneficial, could become more valuable through utilisation of methods such as concurrent design. At this stage, changes are discussed and decided. However, if they would be to be implemented directly, it would remove the delay and thereby improve efficiency. The current BIM knowledge platform is likewise an area which could be improved, as there is no effective and centralised educational and knowledge exchange, which is suggested by Newell *et al.* (2009) to ensure the potential benefit being obtained. BIM does however have a visible and knowledgeable 'Champion' within the Oslo branch office, which helps to push the agenda, as well as overcome challenges. The 'Champion' provides a focal point for the creation of a shared space (Nonaka & Konno, 1998) as well as communicties of practie (Hasanali et al., 2002). Finally, as BIM is fairly new, it still needs to establish its unspoken norms, routines and standards within the workplace, which is suggested in group development theory (Tuckman & Jensen, 2010). All individual respectively have to scrutinise and re-evaluate their own work procedure to fully utilise BIMs, boundary objects, potential. The full benefit of boundary objects can only be

achieved through the proper utilisation throughout the whole work process (Adenfelt & Lagerström, 2006).

Concurrent design (Anumba & Evbuomwan, 1997) has been used in the offshore industry due to the limitation in accessing the sites. The concurrent work process allows collaboration despite current location. However, there are difficulties, associated with the work process. Conflicts can quickly derail meetings and progression halts, as the conflicts engulf all participants instead of being isolated to those involved. This makes the solving of the issues extremely crucial to ensure development. The choosen conflict resolution style has to reflect the context in which the issue emerges, as suggested by Forsyth (2009). This was brought up by a senior project leader, which felt that to ensure successful concurrent meetings conflicts have to be dealt with efficiently at an early stage. The notion of selecting a suitable conflict style was mentioned, as the tight work process forces may not allow the time required for a compromise. This connects to the building of norms and trusts in group development (Tuckman & Jensen, 2010). In addition, it connects to the notion of 'ba' from Nonaka and Konno (1998) and the creation of a shared space. Reinertsen has been rapidly expanding in recent years, which results in a lowering of average experience, and may reflect negatively when utilising work processes which are not common within the field, such as concurrent design. The participants of the concurrent meeting observation included several individuals who recently have been recruited and therefore were not confident and comfortable with the work methodology, which reflected negatively on the rate of attendance. It would suggest that the group had not established itself within the new setting with the appropriate norms, beliefs and work methodology suggested by Tuckman and Jensen (2010). However, rate of attendance is crucial in order to gain the full potential of the concurrent meetings (Anumba & Evbuomwan, 1997). A suggestion was raised that a more experienced team gained more from the process than an unproven team. Although, this does to some extent contrast the idea of heterogeneity enhancing individuals (Gal, Lyytinen & Yoo, 2008) and groups (Argote, 2012).

5.3 UTILISATION

The IT systems are utilised as was witnessed during the meeting observations. On the construction side, the collision control meeting displayed a structured application of IT systems. The virtual representation was shown to illustrate the collisions, which assisted greatly with the discussion and the reduction of confusion. However, there is a vast untapped potential in the adaptation of concurrent design to facilitate the collision resolution during the collision control meeting. With a facility that provides the opportunity to solve lesser issues during the meeting both time and cost may be saved. Several of the issues encountered would have been quickly solved if a suitable IT environment had been provided.

On the offshore side, the concurrent design meeting gave a hint of the potential benefit, which could be acquired through the establishment of work groups to faciliatate the creation of trust, suggested in literature, such as knowledge management (Newell et al., 2009), communicational (Hitt, Black & Porter, 2011) and organisational learning (Argote, 2012). However, to obtain the benefit the rate of attendance has to be high and the employees require appropriate education regarding the work process. This links back to the boundary objects (Adenfelt & Lagerström, 2006; Gal, Lyytinen & Yoo, 2008), collaboration (Rogers, 2009) and communication (Hitt, Black & Porter, 2011), where the utilisation has to promote a positive behaviour and increased accessibility.

The utilisation of the IT systems are adequate, however may potentially be improved through a cross-disciplinary in-house review. The author relates this to the boundary objects (Gal, Lyytinen & Yoo, 2008) and organisation learning (Argote, 2012) had a positive effect when set in a heterogenic environment.

5.4 CLOSURE

Currently, modern IT systems are a strong on-going theme in various project teams (Anantatmula, 2010). There are different areas that are being explored, however the primary benefit can be condensed into time and cost efficiency resulting in increased profits. The reduction in time consumption is linked to different areas, such as reduction of required rework due to less modification and work being performed double. The cost improvement is achieved as closer collaboration enables more

suitable material selection and work processes. However, it has to be acknowledged that different industries may not have the same priorities. This can be seen as offshore projects tend to have additional time allocated for the planning phase, as issues at the later stages may be devastating. However, project management theory (Maylor, 2010) suggests that a more extensive planning phase may lower the projects total expenditure, due to avoidance of unforeseen challenges and reduction of necessary modifications at later stages.

Improved collaboration through more efficient cross-disciplinary communication (Argote, 2012), has shown to reduce necessary modifications needed in the later stages. In addition, several tasks can be eliminated through a stronger application integration, which includes automatic generations of components lists and other tasks. However, it has to be considered that there are some features not being utilised due to the complexity of the interface. Tools that enable the usage of features do not necessary result in appropriate usage, as individuals tend to fall back into known work procedures if difficulties arise. There can be said to be an inherent distrust towards change, which can be connected to the status quo trap discussed by Hammond, Keeney and Raiffa (1998; 2006). This links to the lacking participation during the concurrent design meeting, as employees are inexperienced in the work process, which makes them not commit to the method. In addition, the building of trust is hindered by the dispersed nature of teams which rely heavily on IT (Adenfelt & Lagerström, 2006).

6 CONCLUSIONS

The chapter will start with a revisit to the research question and objectives and link those to the data analysis and discussion. Afterwards, the chapter will present recommendations. Finally, limitations and the study's contribution to research is elaborated and further research areas is suggested.

6.1 RESEARCH QUESTION AND OBJECTIVES

The research aim was to establish the impact IT systems held on the collaboration and knowledge exchange within projects. The research question stated in the introduction addressing this notion was the following:

How can project time efficiency be improved through a better interaction, integration and utilisation of modern IT systems?

As was seen during the previous analysis and discussion the question has several facets. These facets are linked to the space in which the exchange of knowledge takes place. Therefore, the research question was broken down into the three pillars of interaction, integration and utilisation. Afterwards, the objectives incorporating these pillars were recognised as the following:

- Establish the status quo interaction pattern found in projects and theory.
- Dismantle the status quo work process to pinpoint the integration of IT tools and compare it to recent academia.
- Compare the integration of IT in different industries.
- Elaborate on synergy effects enabled by cross-industries collaboration.
- Explore the utilisation of the IT tools and factors enabling or hindering the process.

The objectives were met as the interactional pattern was established and compared to literature, which suggested the presence of a boundary spanner. The work process was dismantled through interviews and documentation review to establish the integration and utilisation of technology in the processes and routines. Two different industries were explored to ensure the research validity. Potential synergy effects enabled by cross-industry collaboration were highlighted. Finally, the utilisation of

technology and its influence on the business was established through the recap of the data analysis.

6.2 ANSWER TO THE RESEARCH QUESTION

To structure the answer the three pillars of the questions are reviewed separately. The notion of improved 'project time efficiency' relates to the reduction of work being performed double and errors due to inadequate communication between individuals, application and organisation.

The research found that the interaction among both the projects observed hosted a clear boundary spanning role in the project leader. In addition, the IT systems provided a complement in order to reduce confusion and enhanced the project organisation.

The integration was found to be lacking but sufficient, as a stronger integration could push the interoperability between applications as a point of interest and thereby improve time efficiency. It was suggested that once the level of integration was established, little effort was made to improve. A strong IT coordination and Champion would allow better and more consistent development within the host organisation. In addition, if utilised correctly it would ensure that the investments were placed on the areas in most dire need.

As the industry is quickly advancing, the pace of integration is high. However, the new application being introduced may not receive sufficient resources allocated in order to sprout. Therefore, the quick pace potentially has a negative aspect on the work efficiency.

6.3 RECOMMENDATIONS FOR COLLABORATION AND KNOWLEDGE EXCHANGE

Within the business environment explored it was found that the IT system was heading in a variety of directions due to a lacking overhead organisation. Although, there is disciplinary coordination, it lacks the cross-industry overview, which could be of great benefit. The observations in the construction project, illustrated the integration of BIM as a management tool. However, it was found that several of the

issues encountered could have been solved if appropriate IT facility was provided and thereby the time efficiency would be improved. It was suggested that it was due to the methodology still was developed within the organisation. The observations in the offshore project displayed a clear and concurrent work process, however revealed issues. The work process needs to be educated in order to be embraced. The attendance during the concurrent meeting was low, which reduces the benefits. It was suggested that as the employees get more comfortable to the work process, the attendance would increase. However, this was not explored as opportunity did not arise.

6.4   LIMITATIONS OF STUDY

The study had several limitations mainly tied to the time restriction. Additional time would enable the observations to be expanded in order to ensure the validity of the perspectives explored in the ad hoc interviews. However, the research did find notions that points towards areas of improvement. Furthermore, the conclusions and recommendations are based on a strong theoretical framework established from literature review which reflects a generic viewpoint and should therefore be applicable outside the case study organisation.

The conclusions were not tested due to time constrains. Therefore, the conclusions are limited to the theoretical aspect of how collaboration and knowledge exchange can be improved in the case study organisation.

6.5   IMPACT ON AND SUGGESTION FOR FUTURE RESEARCH

The research leaves a few loose ends, which could be embraced by further research, such as:

- The establishment of a pilot project that utilise an enhanced BIM methodology incorporating concurrent design, in order to explore the potential cross-industry synergy.
- Explore the correlation between efficiency in concurrent design and employee experience.

Further research should consider advancing the practical aspect of the research to evaluate the benefit that cross-industry synergy may hold.

As the research only was conducted in one company it would be suitable to further explore the topic in other industries and settings to ensure its general applicability. This could be achieved by extending the research to large corporations or other consultant firms, operating within a variety of industries.

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