Päivi Lohikoski

INFORMATION PROCESSING IN GLOBAL VIRTUAL NPD PROJECTS
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GLOBAL VIRTUAL NPD PROJECTS

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Abstract

In knowledge-based economy an increasing amount of work is conducted in projects in dispersed virtual organisational settings. Information is the raw material of virtual knowledge-based project work and therefore an understanding of information processing in virtual NPD (New Product Development) projects is essential. Information processing is particularly crucial for virtual NPD projects, which are typically implemented in demanding, turbulent and complex institutional settings, where they are subject to various challenges caused by cultural, organisational and human factors and where large amounts of information is processed.

This multi-disciplinary study combines theories of information processing and trust and knowledge-based view of organisations. Particularly impersonal and interpersonal trust and barriers to information processing are investigated to study organisational capabilities and virtual communication competencies, which can enable information processing in virtual NPD projects. The case organisation was selected for the study because it has a lengthy history of multinational and multisite virtual way of work. Survey questionnaires and semi-structured interviews were employed to gather research data. Focus group interviews and document review were conducted to evaluate the results. Altogether, 11 leaders and 12 expert teams were interviewed at sites in the USA, Finland, China and Poland as well as 7 members from the operative management in USA and Finland.

The results of this study enhance the understanding of organisational virtual capabilities and personal virtual communication competencies in virtual NPD project context. The findings indicate that trust is significant and it is clear that both impersonal and interpersonal trust in supporting information processing in projects, are needed. This study also confirms that each phase in virtual project lifecycle has different needs for information processing. Through recognizing virtual communication capabilities in company level and competencies at the personal level, it would be easier to manage information processing in virtual NPD projects. At the personal level, virtual communication competencies are seen to consist of cultural knowledge and sensitivity, company language skills, listening skills, accountability and credibility, mastery in using ICT and e-mail etiquette. The significance of virtual communication capabilities and competencies as part of knowledge management strategies will grow in the future. This dissertation addresses this challenge by providing new practical and theoretical perspectives to enable planning, measuring, training and rewarding from virtual communication competences, and them to be tested in similar constructions in ICT industry or in other organizations to enhance information processing in virtual projects.

Keywords: communication, information processing, knowledge management, trust, virtual communication capability, virtual communication competence, virtual projects, virtual teams
Lohikoski, Päivi, Viestintä virtuaalisissa globaaleissa tuotekehitysprojekteissa.
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**Tiivistelmä**


Tämä monitieteinen tutkimus yhdistelee informaation prosessoinnin teoriaa, tietojohtamista ja luotamustutkimusta globaalitunotekehitysprojektien viestinnän tarkastelussa. Erityisesti keskitytään luottamukseen ja viestinnän vaihtoehtoisiin tapoihin, jotka onnistuneen viestinnän kannalta tärkeimmät organisatoriset ja yksilölliset kykyykyydet voitaisiin tuoda esiin.


Tulokset osoittavat, että organisaatio- ja yksilöä konsepti luottamuksen tarvitaan ja luottamuksen eri lajeilla on erilainen vaikutus viestintään. Tutkimus nostaa myös esille projektin eri vaiheiden erilaiset viestintätarpeet, jotka huomioimalla voidaan kasvattaa virtuaalisten projektien kykykkyyttä. Yksilöitä konsepti tarvittavat virtuaaliset viestintäoidot ovat ammatillinen ja riittävä projektissa käytettävät kielitaito, kulttuurien tuntemus ja herkkyys, kuuntelemisen taito, vastuullisuus, vahvat ICT:n käyttö- ja mediataidot sekä e-mail etiketti.

Tutkimus on merkittävä, koska virtuaalinen projektiperustainen globaali työ on tulee lisääntyä ja lisäksi eätön tarve tulee kasvamaan. Näin ollen virtuaalisten viestintätoimien merkitys osana tietojohtamisen strategiaa tulee kasvamaan tulevaisuudessa.

**Asiasanat:** luottamus, tietojohtaminen, työyhteisöviestintä, viestintä, virtuaaliset tuotekehitysprojektit, virtuaaliset viestintäkykykkyydet, virtuaaliset viestintäaidot, virtuaalitimiit
“The single biggest problem in communication is the illusion that it has taken place.” George Bernard Shaw
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In Oulu, March 2016

Päivi Lohikoski
List of abbreviations and definitions

*Virtual team (VT)*

By definition, virtual teams are an organisationally, geographically or otherwise dispersed collection of individuals who use different forms of ICT to accomplish a specific goal. They are an evolutionary form of network organisations rapidly forming, reorganizing and dissolving. All teams in modern organisations are virtual to some extent, but virtual teams rely mainly on ICT when communicating.

*Information and communication technology (ICT)*

Information and communications technology is often used as an extended synonym for information technology (IT), but ICT is a more specific term that stresses the role of unified communications and the integration of telecommunications, computers and necessary software, middleware, storage and audio-visual systems, which enable users to access, store, transmit and manipulate information.

*Virtual organisation*

A virtual organisation is a form of organisation that involves detached and disseminated entities, such as employees and entire enterprises, which require information technology to support their work and communication.

*Knowledge management*

Human resources management and information management combined, managing all processes concerned with the identification, acquisition, creation, storage, distribution, and effective use of information and knowledge. This thesis refers to “know-what” “know-how” and “know-why” aspects of knowledge management practices.
Trust

Trust is manifested in behavioural patterns: the honesty and predictability of behaviour and the willingness of a party to be vulnerable to the actions of another party. It is also related to the willingness to rely on an exchange partner to fulfil his/her obligations. Trust allows risk taking and increases the willingness to rely on another person. Trust is a fundamental issue in securing efficient communication among virtual teams.

Information

‘Informatio’ in Latin refers to the act of giving form to something. The constructionist viewpoint treats knowledge as an outcome of information that is interpreted and internalized, and thus has changed the person’s knowledge structure.

Tacit knowledge

Cognitive (mental models) and technical (know-how) elements; personal and difficult to externalize in explicit form. It is the sum of experiences and competences that enable people to do their work. Tacit knowledge is manifested in organisational practices and routines and is shared when working together.

Explicit knowledge

Formal, systematic, carefully defined, e.g. memos of meetings, organisational plans, mathematical formulas; easy to store and share in information systems.

Cultural knowledge

Relates to knowledge structures and practices in organisations, and to those attitudes and feelings through which the members of an organisation understand, explain and assess the surrounding environment. Cultural knowledge contains tacit knowledge and is shared through information processing and communication.
Communication

Communication refers to team members’ patterns of exchanging information in order to generate actions or change, or to enhance finding shared understandings.

Communication competence

Communication competence refers to a person’s ability to use written, verbal, oral and cultural understandings and language skills to ensure efficient communication between parties in different environments and contexts. The goal is to accomplish something in a manner that fits the situation in a clear, appropriate and effective manner.

Communication process

The communication process involves interactions between team members to exchange information over geographical distances, different cultures and diverse backgrounds.

Virtual communication competence (VCC)

Virtual communication competence refers to a person’s ability to use written, oral and verbal skills, cultural understandings and language skills to ensure efficient communication between parties. The goal is to accomplish something in a manner that fits the situation in a clear, appropriate and effective manner while using ICT for communication.

Information processing (IP)

Information processing is the most used theoretical view to assess information sharing in organisations, and it has also been used often in the project context. It builds on bounded rationality, suggesting that due to the cognitive limitations of individuals, organisations develop idiosyncratic bases of information and knowledge, creating information processing needs. Information processing tools for communication are divided into impersonal, personal and group modes.
Impersonal mode

Impersonal mode refers to communication that is facilitated with the use of pre-established plans, schedules, formalized rules, policies and procedures, as well as standardized information and communication systems. Examples of communication tools with impersonal mode include project plans, job and role descriptions for the project, standard project procedures and project newsletters. Various web-based tools for managing project planning and communication of the plan as well as social media, such as Facebook, are also communication tools in impersonal media.

Personal mode and group mode

Personal mode and group mode refer to coordination by mutual adjustment and coordination by feedback. In the personal mode, organisational members serve as mechanisms for communication, either face-to-face, through instant messaging or via chat. In the group mode, on the other hand, the mechanism for mutual adjustment is in bringing together a group of people, and communication is facilitated through, for example, scheduled and unscheduled meetings and team work.
List of original publications

This dissertation is based on the following publications:


This dissertation consists of five separate articles, each of which contributes to the dissertation’s overall findings. The first article is an overview of virtual organisation literature and a case study of the virtual competences of management in virtual NPD. The second and fourth articles concentrate on barriers and information contingencies that affect communication at the personal and the organisational level. The third article is on communication practices from the perspective of the lifecycle of a virtual project. The fifth article is based on trust’s impact on communication among virtual team members. Articles two through five final four articles are based on a case study of virtual NPD teams operating globally in China, Poland, Germany, Great Britain, India, Finland and the USA. All five articles have a significant role in meeting the purpose of this study. The first author was responsible for all the research work, gathering and analysing the research data and writing the actual articles. The role of the other authors was to review the manuscripts and comment and give suggestions for improving the text.
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1 Introduction

1.1 Background and research environment

Global competition has intensified, and it has become crucial to quickly leverage existing in-house competencies and resources into new products and services. According to EU statistics, in 2006, in large enterprises 55% of the employees worked remotely at some point in their work week; in medium sized enterprises, the figure was 30%, and in small enterprises it was 13%. However, in the forest industry, ICT industries and medical sector the virtual way of working is an integral part of work for all employees. Therefore, understanding the virtual way of working is crucial. In knowledge-based economy, knowledge is the primary source of wealth and well-being (Drucker 1992), and in such economies knowledge-based expert work has a crucial role. Information is the raw material of knowledge-based work and knowledge processes. Because knowledge and information are partly intangible, a deeper understanding of their nature as resources is essential in order to manage such resources effectively.

The importance of better understanding the functionalities of virtual knowledge-based organisations is increasing as more than 1.3 billion people are forecasted to work in virtual organisations within a few years (Johns & Gratton 2013). In particular, engineering industries depend on the efficiency of their knowledge management practices (Sharma 2015) in such an environment. Knowledge management enables firms to create, store, disseminate and use knowledge efficiently, internally and externally throughout the organisation, to stay ahead of the competition (Nonaka & Teece 2001, Huang et al. 1999, Liebowitz & Beckman 1998). Companies require innovations, value, quality and service, and there is no room for inefficiency (Davenport & Prusak 2005). Thus, product development is usually very complex in nature, and tremendous amounts of information must be transferred within the product development team (Ulrich & Eppinger 2000). Transferring, combining and developing knowledge require communication. Possessing information and knowledge itself is not enough, organisational capabilities and personal competencies are needed as well in order to identify, capture and share information and knowledge, in order to achieve results high in quality (Brandon and Hollingshead 1999, Propp 1999.) The connection between information processing in virtual teams and their knowledge management culture is crucial. Collaborative virtual teams can enable integration
and the alignment of human resources to better tap into the external business environment (Nemiro et al. 2008.)

In global companies, often the only way to seek the competitive advantage in expert work is to establish virtual product development project teams. Virtual teams (VTs) are teams that use communication technology to work across locational, temporal and relational boundaries to accomplish shared tasks (Martins et al. 2004) which are often complex, requiring expert knowledge (Kirkman & Mathieu 2005, Peters & Manz 2007). Thus, virtual teams integrated via electronic means can offer effective solutions when product lifecycles are shortened and there are price and fulfilment-time related pressures, along with demands for higher quality, service and customer responsiveness and individualized productisation (Lee-Kelley 2002).

Virtual expert teams collaborating globally using information and communication technology (ICT) tools are fairly easy to build, and they offer fast solutions in integrating expert teams across geographical distances and different time zones to work on a certain project or to work together in the long term (Holtzman & Anderberg 2011, de Jong et al. 2008, Cooper 2001). Global virtual project teams are utilized in companies for various reasons: they allow flexible working hours, create improved business processes, bring diversity to the teams, save money and time and even reduce pollution (Johnson et al. 2001).

According to multiple studies, it is challenging to lead experts in virtual organisations (Lipnack & Stamps 2000, Daim et al. 2012, Zigurs 2003, Kankanhalli et al. 2007, Faraj et al. 2011). 82% of the virtual teams fail to reach their objectives (Govindarajan & Gupta 2001). Typically, information processing may be hindered by several organisational boundaries, making it vulnerable to misunderstandings. It is also typical that finding a shared understanding, a common language and personal contacts across different sites may be challenging in geographically dispersed companies (Turkulainen et al. 2012). Virtual teams must cope with, e.g., cultural differences (Johns & Gratton 2013, Maude 2011), diverse backgrounds and geographical distances (Townsend et al. 1998), which can lead to misunderstandings, inadequate information flow and misinterpretations in different habits of exchanging information, among other things (Lohikoski & Haapasalo 2013). Delays caused by conflicts can endanger on-time deliveries of projects (Zigurs 2003, Kankanhalli et al. 2007, Jarvenpaa et al. 2004). Managing global virtual teams requires efficient communication practices (Denton 2012, Johnson et al. 2001). Lack of communication and inadequate communication are some of the most significant risks for a project.
(Reed & Knight 2010, Johnson et al. 2001). All these factors make it clear that the increasingly prevalent virtual team information processing needs further investigation.

The information processing view, which is used in this study and was previously studied by Galbraith (1974), Tushman (1979), Daft and Lengel (1986) and Van de Ven et al. (1976), is the most utilized theoretical framework when investigating information sharing and communication practices in organisations (Turkulainen et al. 2013). Information in organisations is typically processed through integration mechanisms consisting of documents, reports, databases, company strategies, meeting practices and media offered for communication (Daft & Lengel 1986). New collaboration technology offers additional electronic platforms for communication in virtual teams, and they allow people to work together using electronic tools such as e-mail, chat and video conferencing (Te’eni et al. 2007, Brown et al. 2007, Lipnack & Stamps 2000). The role of communication is crucial, and it has an effect on overall employee performance and job satisfaction (Pettit et al. 1997). Recent research by Faraj et al. (2011), Dennis et al. (2013), Zigurs (2003) and Mitchell and Zigurs (2009) also shows that although virtual teams need to define and achieve goals, tasks and missions similar to those of more traditional teams, the ways these goals are achieved successfully differ from the methods used in traditional teams. Trust plays a significant role in the effective functioning of virtual teams (Jarvenpaa et al. 2004, Zigurs 2003), and ultimately, trust makes a difference (Huotari & Iivonen 2004).

Knowing what is important, but to know how to operate in each environment is learned by doing and through social interactions at work, which are a crucial part of knowledge work. Knowing how is connected to the ability to interact with colleagues (Ryle 1949). This study provides working knowledge on the competencies needed at both the individual and the organisational level to enhance information processing in global new product development (NPD) projects. Foundations lie on knowledge management, knowledge-based view, which “combines human resources management and information management. It is defined as the management of all processes concerned with the identification, acquisition, creation, storage, distribution, and use of information and knowledge” (Huotari & Iivonen 2005).
1.2 Research objectives and research questions

The amount of prior studies contributing to the understanding of the virtual teams is extensive (Johns & Gratton 2013, Jarvenpaa et al. 2004, Kirkman & Mathieu 2005, Martins et al. 2004). However, ICT is developing fast, companies are making fusions; as new generations from different parts of the world are entering global companies, the usage of integration mechanisms, and therefore information processing methods, in industry and in society in general is changing rapidly. Global NPD projects operate in demanding and complex environments and are therefore subject to the impact of various internal and external challenges. Typically, work tasks include geographical dispersion, electronic dependency, national diversity and task uncertainty (Hoegl et al. 2012). New research and studies are needed in this area to develop existing theories (Lee-Kelley & Sankey 2008) and to enhance information processing in global virtual projects in practice. Contingencies in effective communication and collaboration in dispersed teams require further study. These issues are also relevant in other industries in other contexts (Hoegl et al. 2012). Consequently, we have little understanding of the diverse strategies for effectively organizing communications and implementing communication practices in global NPD projects (Hoegl et al. 2012). Thus Ramsing (2009) has argued that despite the acknowledged need to focus on communication in projects, there is no indication in research that any collaboration exists between the field of corporate communications and the field of project management. This research aims to fill this gap between different disciplines as well.

Regardless of the recognized importance of managing communications efficiently in virtual teams, the scarce body of literature on virtual teams has rarely combined various kinds of research methods at different levels of organisations, including operational management and R&D team members and their leaders in case studies. There is plenty of research, yet it is dispersed and not sufficient. The existing literature is missing an in-depth empirical analysis and multi-disciplinary approach to determining how organisations with a long history of virtual ways of working organize their communications, what the role of trust is in communication and what barriers there are to their information processing. This thesis explains common barriers to information processing, presents the impact of trust on information processing and suggests the most crucial communication competencies needed to work successfully in virtual teams.
The main aim of this thesis is to provide new multi-disciplinary theoretical and empirical insight into virtual project information processing by investigating practitioners in a company with a long history of virtual ways of working. In particular, increasing the understanding of the role of trust in information processing is important. Table 1 presents the research questions, which are explained in the following chapters.

### Table 1. Research questions.

<table>
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<th>Research Question</th>
<th>Description</th>
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<tr>
<td>RQ1</td>
<td>What are the information processing methods in virtual NPD projects?</td>
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<tr>
<td>RQ2</td>
<td>What are the barriers to information processing in virtual NPD teams?</td>
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<tr>
<td>RQ3</td>
<td>What kinds of capabilities and competencies are needed in virtual NPD projects for effective info processing?</td>
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#### 1.2.1 What are the information processing methods in virtual NPD projects?

Working knowledge of information processing in virtual teams (Dennis et al. 2013, Hertel et al. 2005) is enhanced by studying how program and project management and line managers at a large international ICT company organize their communication practices in projects. Publication III investigates project communications and empirically identifies and describes different types of competencies, both at the individual and the organisational level, which are needed to efficiently communicate in global international projects during a project’s lifecycle. This study further develops the research by Wang and Haggerty (2009) and highlights the communication competencies needed in virtual work settings. Publication I contribute to the study by investigating how operational management in a large international company organizes and implements their communication practices.

#### 1.2.2 What are the barriers to information processing in virtual NPD teams?

The barriers to information processing in virtual NPD teams were examined in publications I, II and IV. The barriers were observed using a multi-disciplinary approach from the literature on information processing (Van de Ven et al. 1976,
Daft & Lengel 1986) and information contingency theories (Daft & Lengel 1986), as well as the literature on communication studies (Brashers 2001, Morreale et al. 2001, Rice & Love 1987, Stephens et al. 2013) and the latest research on knowledge transfer barriers (Riege 2005, Holste & Fields 2010). Common barriers to information processing in virtual teams were identified.

1.2.3 What communication competencies are needed in virtual NPD projects?

Publications I, II and III identified the factors which enhance communication practices in global projects. The main contribution of these publications is that they provide answers to the practical problem in determining the kinds of competencies needed to effectively work in virtual NPD projects both at the individual and the organisational level. Article I highlighted the typical barriers to virtual knowledge transfer at the personal and organisational levels. Article II shed light on typical barriers in global cross-cultural teams’ information processing and provided a wide spectrum of necessary competencies at the organisational and personal levels to overcome such barriers. Article III concentrated on virtual project communication practices during a project’s lifecycle and provided a closer look at the communication competencies at the personal and organisational levels.

1.2.4 How does trust impact information processing in virtual teams?

The concept of trust itself has been researched extensively (McAllister 1995, Dirks & Ferrin 2001, Erdem & Ozen 2003), but with regard to managerial and interpersonal relationships, much more empirical attention is needed (Atkinson & Butcher 2003). Lack of trust is one common factor behind failures in virtual teams (Govindarajan & Gupta 2001). The scope for publication V was to investigate how trust impacts communication in virtual NPD projects. Finally, I was able to answer to the main research question (“How is information processed in virtual NPD projects?”), and I was able to define the necessary communication competencies and capabilities needed to perform information processing successfully.
1.3 Research approach and context

Knowledge constantly changes, and what counts as knowledge also changes all the time. Two types of knowledge were identified in ancient Greece, theoretical knowledge (theoria) and practical wisdom (phronesis), both of which were a route to gaining better understanding of the world. Within the past hundred years, knowledge has become the product of organized research. Ever since the 1990s, new technology has been changing the production of knowledge, both in research and in practice. What we consider knowledge is shaped by our culture and by our society, and it is clear that currently, knowledge is often generated in action in real work situations (Barnett 2000). To Aristotle, practical knowledge was related to practical intellect and craft (Moss 2011), which typically develops over time. Knowledge is relevant only if it can be put to work; thus, work is a context in which knowledge can be created, transferred and utilized. What is significant is the fact that work offers a means of testing the claims of knowledge as a form of validation (Barnett 2000). In this study, the research framework and justification for the research were created together with the practitioners, which was done along with validating the research results in focus group interviews. These were conducted in two phases of this research.

In this research, the need to study communication in virtual NPD arises from the managerial challenges in practice, which were identified in first article’s empirical section, together with the operational management of the case company. The justification for the research also stems from the researcher’s personal prior work experience at the case company as a communication and documentation coordinator of R&D programs. In addition, the researcher has designed and managed e-learning projects and taught in e-learning settings, where differences in virtual communication competencies among individuals were clear. Some individuals thrived in virtual work settings, while others mainly struggled, which seemed to be the case both in industry and in academia. The researcher wanted to know the reasons behind these issues and to find out how to support more efficient communication in virtual settings. There is a wide array of research within virtual teams, but the field in industry develops rapidly due to technological advances, globalization and new employees, who are being recruited by global companies. While there is an extensive amount of knowledge on managing virtual teams, according to practitioners, there still are major challenges in managing virtual teams. Therefore, the need for this research mostly arises from the practical dilemmas among managers and experts.
The pragmatic demands of the business are the primary concern of managers (Ketokivi & Choi 2014), and hence also the relevance for the study as the primary criterion. The first article’s data was based on interviews and a questionnaire which were conducted among operational management of the company. The controversial research results (Lohikoski & Haapasalo 2013) of the first publication confirmed the need for this study. As a whole, the study was designed and conducted in close cooperation with the case company regarding the practical dilemmas in managing communication. The research was based on practical problems which were observed through the theoretical lens of information processing and trust. The theoretical foundations lie on knowledge-based view of an organisation. Through a case study approach, our aim was to create new practical knowledge, which has been suggested by Ketokivi and Choi (2014) as being the main contribution of case studies. In practice, we chose the case study approach because in addition to creating new practical knowledge, it can identify key factors, competencies and sources related to dynamic and organisational capabilities in a specific context. Thus, it can explain relationships in a broader sense by providing a structure for complex situations (Ridder et al. 2009). Global NPD offered an excellent foundation for this study. Case studies are also well suited for circumstances where the research area needs more evidence and where the theoretical understanding of the topic should be enhanced. Moreover, it is needed when the research has been inadequate and contradictory (Eisenhardt 1989); in particular, contradictions concerning tacit knowledge transfer, new communication competencies and multi-cultural virtual communication create an additional need for this study. Yin (2009) emphasized the relevance of case studies for research in theory building and for determining the “how” part, which is essential for qualitative research (Lee, Mitchell & Sablenski 1999). The strength of the case study approach is the possibility of creating novel and empirically valid theory through collecting multiple sources of evidence by combining different types of data and data collection methods (Eisenhardt 1989). In this case, the company has extensive experience in virtual working modes and therefore provides a rich and valid case for this research. The interplay between theory and practice is characteristic for a case study as a whole. The formulation of theoretical insight arises from the interaction between empirical context and theory (Ketokivi & Choi 2014), which was a fundamental element for this case study and descriptive of this study as a whole. The aim of this research was to act as an extension to earlier research rather than as its validation, which Ketokivi and Choi (2014) have described is the purpose of
case studies. We conducted a case study combining qualitative and quantitative data, consisting of literature-based semi-structured interviews and electronically obtained survey data, as well as focus group interviews and document reviews among informants. This research approach examined the concepts in their own contexts. (Ketokivi & Choi 2014), striving to study the participants’ perspectives in their natural settings (Lee et al. 1999) in qualitative parts, and in quantitative aspects, the focus was on studying the amounts and intensity (Ketokivi & Choi 2014) of the phenomena. Finally, by evaluating the results together with the members of the case company in document reviews and in focus group interviews, new knowledge of the research topic was created. Transparency, openness and usage of peer-reviewed journals, scrutiny of expert panels (Barnett 2000) at the PMI 2014 Conference Doctoral Colloquium, research seminar at the IEM, TIIM and SCAIEM, the research has evolved together with information processing procedures in practice, thus created working knowledge of communication competences in virtual NPD.

1.4 Research process and publications

The motivation and starting point of the research reported in this thesis is the need to understand communication related phenomena in the context of virtual NPD projects. The thesis studies the phenomena from the standpoints of information processing theory. Furthermore, the associated contextual factors that have an impact on project communications are impersonal and interpersonal trust, which have been examined throughout the research process. In order to discover the key issues related to the studied phenomena and to develop working knowledge of managing information processing in virtual NPD projects, data collection rounds were conducted, and five research papers were written.

The results of the thesis are based on five separate publications that were developed based on studies conducted during 2013 and 2014. An understanding of information processing in virtual projects with regard to the importance of trust in virtual NPD communication and of the contextual factors that explain them emerged through the process of writing each of the papers. In addition, the relevance and contributions of the findings for practitioners were consolidated and validated in the overall research process. The focus of the conclusion section of the thesis is on explaining the implications of the findings for research on virtual teams and research on project communications in general in industrial
engineering and management, but the results are also relevant to information and communication studies.

1.5 The case organisation and data collection and analysis

The case organisation is a leading global enabler of telecommunications services operating in 150 countries and the most successful large European firm. With a focus on innovation and sustainability, the company provides a comprehensive portfolio of mobile, fixed and converged network technologies, as well as consultancy and systems integration, deployment, maintenance and managed services.

The case organisation was selected for the study because it has a multinational and multisite virtual way of working as an everyday routine and a lengthy history in utilising virtual teams in new products development. A semi-structured interview method was considered to be a suitable method for studying the communication and managing of experts in global projects because it was also possible to investigate issues that are more intangible in nature. It is also significant that the informants had relatively significant experience in virtual projects, which provides perspective and adds value when analysing and drawing generalizations from the qualitative interview data.

The research results of this dissertation are based on five separate articles, and two separate research data collection rounds at different levels of the case organisation. Each article and all research data contribute to the dissertation’s overall findings. The related articles and the positions of the case organisation’s informants are presented in Figure 1. and Figure 2. explain case organisation’s size, complexity, locations and phases of product development during the study.
Fig. 1. Case organisation and related articles.

Fig. 2. Case organisation size, product development phase, level of complexity and locations.

The first article’s data were collected from the case organisation’s operational management. The informants worked as, for example, Head of Product Management, Head of Electromechanical Engineering and Head of Sales. Data collection for the first article consisted of semi-structured interviews and an electronic survey. The literature review for the first article was an overview of the research on virtual organisations. The study regarding virtual competences was
conducted on the management of virtual NPD. The educational background of five of the informants was a bachelor of science in engineering, and two of the informants had a master’s in engineering. The informants had 14 to 28 years of work experience, of which 10 to 20 was in virtual organisations. After the interview, the informants were asked to rate the challenges in virtual knowledge transfer on a scale of 1–5 (1 = no challenge, 2 = minor challenge, 3 = average challenge, 4 = significant challenge, 5 = major challenge). Challenges were added and calculated, and summaries were made for each topic. After analysing the results, they were reviewed together with the informants and a target group for the next phase of the research that was planned at the same time.

The second and fourth articles concentrated on barriers and information contingencies that affect communication at personal and organisational levels, and they were based partly on the same data. The second article, which was for the PMI Conference 2014 proceedings, is based only on data from teams and leaders in the United States and in Finland, from a total of 12 interviews and a survey, while the data for the fourth article is the same as in third and fifth articles and also includes data from China and Poland. The informants were program managers, line managers, project managers and expert engineers in various positions. The study in the second article was based on Daft and Lengel’s (1986) theory of uncertainty and equivocality (with additions from our recent research) and then further classified as personal and organisational virtual communication capability themes, which were divided into categories based on organisational and personal virtual communication competence and information processing. These were also used in processing the research data.

The third, fourth and fifth articles were based on interview data collected globally in the United States, Finland, Poland and China among program managers, line managers, project managers and expert engineers in various positions. The survey data, with a 69% response rate, included 94 virtual project members globally. The third article concentrated on communication practices from the perspective of the lifecycle of a virtual project. The fifth article was based on the impact of trust on communication in virtual teams. All five articles have a significant role in meeting the scope of this study. The research data is described in Table 2.
Table 2. Research data.

<table>
<thead>
<tr>
<th>Article</th>
<th>Research data</th>
<th>Validation and verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>7 semi-structured interviews and a questionnaire: global operative management</td>
<td>Results were sent as a document to all informants; 2 meetings were organized to discuss about the results in May and Jun 2013.</td>
</tr>
<tr>
<td>II</td>
<td>12 semi-structured interviews and an electronic survey: program management and R&amp;D programs (USA, Finland)</td>
<td>Altogether, 10 focus group interviews were organized at the case company to review the results.</td>
</tr>
<tr>
<td>III</td>
<td>23 semi-structured interviews and an electronic survey: global program management and R&amp;D programs</td>
<td>Guidelines (“Communication Plan”) for virtual project communications were created.</td>
</tr>
<tr>
<td>IV</td>
<td>--II--</td>
<td>Results were discussed at the document review meetings in Jun 2014 and Oct to Nov 2014.</td>
</tr>
<tr>
<td>V</td>
<td>--II--</td>
<td></td>
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</tbody>
</table>

The themes for the interviews are based on communication practices in virtual organisations, the division of which was also used in processing the research data; however, the theoretical lens for observing the results was different for all articles.

Altogether, 11 leaders and 12 expert teams were interviewed at sites in the USA, Finland, China and Poland in order to obtain reliable data on the studied phenomena. The teams in Finland were interviewed face-to-face and also via teleconferencing. The teams in the USA, China and Poland were interviewed in a web-conference meeting room, and each interview was recorded. A total of 23 semi-structured interviews were conducted. Gathering the research data for the case took a total of 10 months.

The questions regarding trust focused on examples of team building practices, cooperation with members from other sites, the perception of trust on fairness and competence concerning the company, management, colleagues and supervisors. Conflicts and conflict resolution practices were also discussed. Finally, a focus group approach (Marshall and Rossman 1995, Krueger 1988) was used to further test and validate the findings of the interviews and the surveys. A total of ten focus group meetings were organized to share and discuss the results. The results were also shared with all informants at all sites, and their comments were collected. The results were also reviewed and discussed by five members of the operational management board. The review meeting attendees were asked to
propose changes and corrections when needed during the course of the meetings and afterwards via e-mail.

This research data was collected in five phases. First, a literature-based formulation of research questions was made, the agenda for the interviews was designed and survey questionnaire was designed and created. A literature review was conducted to evaluate the research gaps, resulting in the formulation of the research questions as stated in the end of the introduction section. Preliminary research themes (Marshall & Rossman 1995) were also modified and developed at this phase. Research data were gathered through semi-structured interviews. In order to ensure the high reliability of the data collection, we implemented the following procedures: First, we developed a general research protocol to ensure systematic data collection and then sent out an interview outline before each interview (Yin 2009). This type of qualitative method is very effective when a deeper understanding of actual processes and situations is needed (Maxwell 2012, Ketokivi & Choi 2014).

The next phase consisted of test interviews with five engineers in the case company to test the form, order and validity of the questions. The engineers were invited to participate via e-mail, and the test interviews were scheduled on their availability and willingness to participate. The first author conducted the interviews and discussed the form and the order of the questions together with the engineers face-to-face in order to gather feedback. After the meetings, the questions were updated through discussions with the other authors.

Each interview was conducted by the researcher herself and was recorded in order to enhance data quality and reliability. The recordings were also transcribed into text within a few days of the interview. The first author transcribed the recorded data into text documents for ease of analysis, removing as much redundant material as possible. The analytic procedures were as follows: 1) organizing the data, 2) generating categories themes and patterns and 3) testing and re-evaluating the themes.

In particular, the informational adequacy, credibility, usefulness and centrality (Marshall & Rossman 1995) of the data were evaluated. Transcripts were read several times after the interviews in order to become familiar with the data (Marshall & Rossman 1995). Additional notes were made about the central themes and topics. The Internet-based survey program and the questionnaire were built on the interview themes, and a four-point Likert scale was used. Data were processed using Microsoft Excel. Then, researcher analysed the aforementioned primary and archival data to facilitate triangulation (Voss et al. 2002, Yin 2009),
which means showing agreement among different types of data (Lee, Mitchell & Sablynski 1999).

Conducting the research ethically was a serious concern. Research ethics in this case mean respecting privacy and confidentiality and being transparent when using the research data. Ethical practices are based on respect, inclusiveness, trust and an approach to an organisation that seeks to build rather than demolish relationships between people. In order for research to be beneficial to the community, the tension between respecting confidentiality and publication of data should be carefully managed and considered (Rowley 2004). Confidentiality was considered when writing research articles and when communicating the results to the case company. The researcher was responsible for securing the actual permission and interests of all those involved in the study.
2 Information processing in virtual NPD projects

2.1 Information and knowledge

Knowledge is the primary source of wealth and well-being in knowledge-based economy and knowledge-based work has a fundamental role in such economies (Drucker 1992). Knowledge management is a multidisciplinary field, which is applied e.g. in information studies, organisational research, economics, engineering and education. Through managing knowledge, organisations can reach their goals by utilizing the knowledge each individual has (Dalkir 2011). Knowledge and information are ambiguous terms and they have been defined in many ways in scientific discussions (McInerney 2002; Davenport & Prusak 2000; Nonaka & Takeuchi 1995; Koenig 2002) and there has been also criticism in defining knowledge management. Based on Wilson’s (2010) view, activities of knowledge management are management of practices at work and information management, which enable knowledge work. Huotari and Iivonen (2004) have defined knowledge management as combination of human resources management and information management, where information is the raw material for knowledge-based work. Van der Spek & Spijkervet (1997) defined information as data with a meaning.

Cook and Brown (1999) emphasised the need to bridge knowledge as a possession and knowing in general, into organisational knowledge. They stressed the importance of producing services and products and generating new knowledge in new ways. Because knowledge and information are partly intangible, a deep understanding of their nature as resources is essential. These ideas are based on the knowledge-based view of a firm (e.g. Grant 1996; Barney 1991). Individuals possess knowledge, but typically can’t act as productive employees until they have gathered enough organisational knowledge about norms, colleagues, routines and culture (Spender 1996). It is challenging to manage knowledge, because people always do not know what they know: people typically know something only when they need to employ the knowledge to accomplish something. People seem to have very little control over 'what they know' (Wilson 2002.)

Knowledge can be viewed as an outcome of information, which is interpreted and internalized according to the constructionist viewpoint. Therefore information
can change the person’s knowledge structure (Ingwersen 1992.) Whenever people wish to express what they know, they can only do so by uttering the messages orally, in written form, graphically, in gestures or through body language. Such messages constitute information, which a knowing mind can understand, interpret and incorporate into his/her own knowledge structures. In summary: the concept of knowledge management and definitions of knowledge and information are extensive and they contain research from organisation theory, communications, corporate communications, knowledge transfer, information transfer and processing, and organisational learning. Therefore this study does not try to contribute in defining the concepts of knowledge management and in defining information or knowledge. In particular, increasing the understanding of the role and antecedents of trust in reducing uncertainty and equivocality in project communications in virtual NPD context, which is a knowledge-based organisation, is important. This is conducted through using information processing view as a lens in examining global virtual NPD projects’ communications.

2.2 Information processing

The information processing view has been previously presented by Galbraith (1973), Tushman (1979), Daft and Lengel (1986) and Van de Ven et al. (1976), and it is currently the most used theoretical framework when investigating information processing in organisations (Turkulainen et al. 2013). Organisations’ information processing needs can be categorized in two dimensions, uncertainty and equivocality, and all information is basically processed to reduce uncertainty and equivocality (Daft & Lengel 1986). Uncertainty exists in situations and circumstances with the absence of answers or a lack of knowledge about future events or the consequences of certain actions (Daft & Lengel 1986). Uncertainty is also connected to ambiguity, complexity and unpredictability and situations when information is unavailable or insufficient (Babrow, Hines & Kasch 2000); typically uncertainty and equivocality exist together (Sicotte & Langley 2000). According to media richness theory (Daft & Lengel 1986), the richness in communication is based on a medium’s ability to carry nonverbal cues, provide immediate feedback and support natural language use along with personality traits. The goal of communication is to reduce uncertainty and equivocality related to the current tasks and to reduce the absence of information. Galbraith (1974) has suggested that the greater the task uncertainty, the greater the amount
of information needed to be transferred in order for one to achieve the desired goals.

In R&D projects, there typically are large amounts of uncertainty and equivocality, depending on the size and complexity of the organisation itself and depending on task variety and task analysability (Tushman & Nadler 1978, Daft & Lengel 1986). In the literature, several issues have been identified that can increase equivocality and uncertainty in communication among individuals in organisations, which are explained in the following chapters. The media richness hypothesis argues that a face-to-face medium is the richest and most effective medium for reducing equivocality in information intensive environments. Where written documents are low in richness in providing feedback. It is also inefficient in conveying personality traits and natural language. (Kock 1998). Basically, the amount of information in a global company is enormous and can cause an overload of information (Keysar 2007, Morreale et al. 2001, Davenport & Prusak 2005). Davenport and Prusak (2005) defined information as messages that are meant to shape the message receiver’s opinion or insights and to generally make a difference. Information is exchanged between individuals, and in addition, information systems have a link to stakeholders aside from the complex network of home organisation (Te’eni et al. 2007). According to Kock (2005), decreases in the naturalness of the communication medium can lead to increases in ambiguity in communication. Same time also cognitive effort increases and it is typical that the excitement for human interaction decreases.

### 2.2.1 Integration mechanisms

Organisations manage information with various managerial tools, of which integration is one of the most common study subjects. Integration in organisations is based on integration mechanisms, which have foundations in organisation design and theory (Lawrence & Lorch 1967, Galbraith 1974). Daft and Lengel (1986) describe organisational tools for communication as integrating mechanisms, including various types of tools, strategies, documentation and meetings related to, for example, decision making, planning and follow up in projects. With regard to communication, two lines of research are common: the transmission of information and the formation of meaning. Traditionally, communication has been seen as a linear process in which a sender sends a message to a receiver, who then gives feedback (Fairhurst & Putnam 2009). Thus, communication has an impact on relationships and processes, and it affects tasks
and norms (Té eni et al. 2007). This thesis has been built on the classifications of Van de Ven et al. (1976), which divided communication methods and media into impersonal, personal and group modes.

Programming and feedback are the two general ways of coordinating organisations (March & Simon 1958). Coordinating organisations through programming is impersonal (March & Simon 1958), and it is utilized through communication using pre-established plans, schedules, forecasts, formalized rules, policies and procedures (Van de Ven et al. 1976), as well as standardized information and communication systems (Daft & Lengel 1986, Galbraith 1973, Lawrence & Lorch 1967). Coordination mechanisms can be written policies, standard procedures, job descriptions and guidelines for work (Galbraith 1973). The amount of information and knowledge in an international company is vast and scattered among offices and plants. However, knowledge is valuable only if it is accessible (Davenport & Prusak 2005). Mechanisms supporting interaction and enhancing information exchange among teams and individuals are needed in organisations (Hoegl, Weinkauf & Gemuenden 2004). Information moves around organisations through networks such as wires, delivery vans, satellite dishes, post offices and electronic mail (Davenport & Prusak 2005). The main characteristic of these activities is that minimal verbal communication is needed (Galbraith 1973, March & Simon 1958). Other examples of communication tools with the impersonal mode include project plans, job and role descriptions for the project, standard project procedures and project newsletters.

Personal and group modes both relate to Thompson’s (1967) coordination through feedback as a mutual adjustment. In the personal mode, employees serve as mechanisms for communication (Child 1972, Hage et al. 1971, Pugh et al. 1968). In the group mode, the mechanisms for mutual adjustment are coordinated through scheduled meetings or informal and unscheduled staff meetings (Van de Ven 1976, Adler 1995). Personal mode involves establishing specific assigned liaison and boundary spanning roles to various stakeholders (Lehtonen & Martinsuo 2009). It is crucial to recognize the distinction between scheduled and unscheduled meetings, because they both serve different purposes in communication (Van de Ven 1976). In the personal mode, however, an individual’s role is communicating either horizontally or vertically in organisations (Thompson 1967). Personal communication, either face-to-face, through instant messaging or chat, has been suggested as one of the most useful tools in breaking down individual and organisational barriers (e.g., Brown et al. 2007). Virtual communication quality is connected to the nature of the tasks at
hand and to the member’s ability and willingness to use such tools; in addition, the availability of proper ICT is crucial (Kirkman & Mathieu 2005). Strong task interdependency increases the need to maintain situation awareness, balance workloads and monitor each other in real time using more personal modes of communication (Van de Ven et al. 1976).

In virtual projects, electronic systems, such as teleconferencing, video conferencing, online meeting system, and collaborative groupware, play a significant role in integrating teams and individuals (Lumsden & Lumsden 2004), and they offer opportunities for working together. Basic tools such as e-mail or chat are also often used (Te’eni et al. 2007). Basically, new communication technologies offer organisational participants a wide array of interaction possibilities that differ significantly from traditional work methods. Therefore, management support systems for feedback, follow up and decision making can significantly differ from those in traditional work settings (Miller 2006).

Within the past two decades, the use of social media and modern ICT for information processing has significantly changed communication patterns among individuals and organisations (Hudson & Hudson 2013, Te’eni et al. 2007). Various web-based tools for managing project planning and communication of the plan, along with social media, such as Facebook, Twitter and WhatsApp, are also common communication tools (Hudson & Hudson 2013, Waters 2009). In virtual projects, the amount, usability and quality of ICT tools and accessibility of databases and information systems are crucial (Miller 2006, Zigurs 2003). Typical technologies used are electronic mail, instant messaging, audio and video conferencing and computer conferencing, which also allows for maintaining transcripts of the proceedings and polling participants. Management information systems, group decision support systems, networked computing and wireless communication also offer the possibility of information sharing (Miller 2006). Technology is developing rapidly, including increased bandwidth, wireless networks, built-in videos, integrated hand-held devices, seamless communication among devices and automatic translation, which cause dramatic changes to organisational communication through ease of use and issues of accessibility (Zigurs 2003).

2.2.2 Uncertainty

People are faced with uncertainty when making decisions, interacting with others and planning events (Brashers 2001). Uncertainty has been connected to a
condition in which managers have limited knowledge of alternatives and limited options available (Buchanan & Huczynsky 2004). It is connected to the inadequateness of information when making decisions and predicting external changes. Uncertainty can increase the risk of failure for organisational responses, and it makes it difficult to compute costs that are associated with alternatives. Uncertainty means the absence of information, and therefore uncertainty can be reduced when the right questions are asked and relevant data are accessible (Daft 2010). Uncertainty can also be about one’s own beliefs and abilities, about the quality and durability of relationships or about the context, e.g., social norms, rules and procedures. In addition, supervisors’ behaviour or leadership style can increase uncertainty in organisations. However, across contexts, it is typical for people to seek to either avoid or increase communication in order to manipulate uncertainty to suit their needs (Brashers 2001).

It has been widely agreed in theory that uncertainty must be managed in order for organisations to be effective (Daft 2010). However, for decades, reducing uncertainty by uncertainty management has been the only response in coping with uncertainty. There are also times when uncertainty allows people to remain hopeful and optimistic, and tasks can be completed regardless of uncertainty. Coping successfully with uncertainty is often the matter of developed ideas and methods in managing uncertainty. The options for coping with uncertainty are adapting to chronic uncertainty, seeking or avoiding information and receiving social support for uncertainty management (Brashers 2001). Uncertainty is avoided within a group to the degree to which members support beliefs, that promise certainty (Buchanan & Huczynsky 2004). However, uncertainty management can be complex and challenging because relevant information might not be available or information can be contradictory (Brashers et al. 2000). Uncertainty is a state of personal feeling about one’s perceptions and a self-assessment about one’s knowledge. A person might have all the necessary information available and the necessary competence to complete a task, yet still feel uncertain. That is, if person believes that he/she is certain about something, then he/she is certain (Brashers 2001).

2.2.3 Equivocality

Equivocality originates from ambiguity and confusion and leads to the exchanging of existing views to define problems and solve conflicts through shared understanding. Ambiguity is by definition missing information (Camerer
and uncertainty about probability, which is caused by a lack of relevant information (Frisch & Baron 1988). Ambiguity is typically not noticed when people communicate. For the speaker or for the writer, the message is usually clear. However, the writer or speaker usually is not aware that all topics can have more than one meaning (Keysar 2007). Message ambiguity refers to either a message with multiple possible meanings or a situation in which the meaning is unknown. Our daily life is filled with more or less ambiguous conversations, group decisions or public presentations (Spitzberg 1994).

Interpersonal communication is often characterized by ambiguity in organisational settings. Strategic ambiguity can also be used to facilitate relational development and efficient task sharing. In those cases, employees purposefully “fill in” what they believe to be appropriate for the context and meaning, and the interpretations are typically made based on previous knowledge and understanding. This can lead to greater ambiguity. However, ambiguity can promote unified diversity and preserve existing positions and facilitate organisational change. (Eisenberg 1984). Context is typically used in reducing ambiguity when interpreting a message and in relying on writers or speakers’ cooperativeness (Grice 1975). Relying on a partner’s goodwill and cooperativeness is essential in reducing ambiguity in communication, but our own perspectives, knowledge and beliefs interfere with the communication process, causing misunderstandings (Keysar 2007). Individuals from different cultural backgrounds usually possess different information processing schemas, causing them to interpret information in different ways (Kock 2005).

In electronic communication through e-mails, people typically are not aware of the lack of intonation. People often overestimate interaction cues and their cues for interaction (Keysar & Henley 2002). Egocentric speech and egocentric understanding are common reasons behind misunderstandings, and it is common for most of the egocentric communication to go unnoticed, making adjustments and improving communication difficult (Keysar 2007). Lengel and Daft (1988) emphasize the importance of selecting media based on a task’s ambiguousness: In ambiguous tasks, rich media should be used, and in unambiguous tasks, lean media is the most efficient choice.

There are multiple factors which impact equivocality and uncertainty in information processing in virtual projects. In long distance phone calls and teleconferences, technical problems such as crackling or fading of the sound are common. Technical problems, internet connectivity issues, server breakdowns and incorrect e-mail addresses can lead to missing information (Cramton 2001,

2.2.4 Synchronous and asynchronous communication

Synchronicity versus asynchronicity of communication is a vital issue when organizing communication within VTs, and it has been studied quite widely among researchers (Jarvenpaa & Leidner 1999, Zigurs 2003, Faraj et al. 2011, Goel, Sharda & Taniar 2003, Pinelle, Dyck & Gutwin 2003). Jong et al. (2007), Faraj et al. (2011), Li (2010) and Vanhala and Ahteela (2011) suggested that the degree of synchronization of communication needs to be planned carefully. The right communication method for each purpose is not always an option, even in issues that require it (Miller 2006, Brown et al. 2007). For example, face-to-face meetings are often difficult to arrange due to time differences (Lee-Kelley & Sankey 2008) and financial restrictions, and therefore alternatives need to be identified to replace the richness of face-to-face communication (Hoeffling 2008, Lipnack & Stamps 2000). The use of asynchronous communication methods can overcome differences in daytime working hours, meaning there is a gap between asking questions and receiving answers, which might be an inefficient way to handle urgent cases (Lee-Kelley & Sankey 2008). However, asynchronicity leaves the opportunity to consider how to communicate and how to respond to the message. It is also possible to look for more information on the topic or consult someone else before responding (Kirkman & Mathieu 2005). Transmitting emotional content or content with high in ambiguity can be challenging because typical asynchronous communication uses e-mail in which vocal cues are usually unavailable for the interaction (Rice & Case 1983), making asynchronous communication often higher in the level of virtuality (Kirkman & Mathieu 2005).

The synchronicity and asynchronicity of information is the most common factor affected by geographical and temporal distribution (Brown et al. 2007, Kock 2005, Miller 2006, Zakaria et al. 2004, Jarvenpaa 1998, Maude 2011, West & Turner 2009). It is crucial to acknowledge that using asynchronous communication methods can inhibit the communication of social and emotional content (Rice & Love 1987, Te’eni et al. 2007). Lower media richness and synchronicity decrease the amount of informal and non-task communication (Martins et al. 2004). However, there is evidence that in some circumstances, virtual work can be conducted efficiently (Lohikoski & Haapasalo 2013). Reed
and Knight (2010) discovered that certain software (SW) teams had learnt to use wikis, blogs, instant messaging and web conferencing in such a way that oral communication was unnecessary; Lee-Kelley and Sankey (2008) identified similar behaviour in their research. However, the lack of opportunities for casual exchanges of knowledge still created risks for projects. Thus, it is crucial to acknowledge that richness of information, speed, synchronicity and completeness of messages need to be recognised and planned (Morreale 2001).

Face-to-face communication has the highest level of synchronization and advances in tacit knowledge transfer. Hence, human- and ICT-related delays ought to be planned for and taken into consideration when managing virtual NPD projects (de Jong et al. 2007, Faraj et al. 2011). It is suggested that a crucial issue in communication is choosing the proper tools and methods for communication. Previous studies have claimed that distributed teams cannot transmit rich information through e-mail; however, recent studies have shown that asynchronous e-mail communication can be rich if trust is in place and if there are strong ties among team members (Harwick et al. 2013).

### 2.3 Trust

There are many definitions of trust in the literature of different fields of science, but this section explains generally the nature of trust. Sections 2.3.1 and 2.3.2 synthesize the most commonly studied types of trust in knowledge management research (McAllister 1995, Huotari & Iivonen 2004, Vanhala & Ahteela 2011). The bottom line is that it is important to recognize how trust can be built and maintained within VTs (Jarvenpaa & Leidner 1999, Zigurs 2003). This study is focused on observing the impact of different types of trust on communication.

Trust is based on team member’s evaluations of other team members’ past or present actions, and it is connected to member’s interpretations of the future actions of another team member (Dirks & Ferrin 2001). Sztompka (1999) has stated that where knowledge ends, trust begins, which means that sufficient amount of relevant information is needed to avoid uncertainty. Uncertainty, whether expectations will be fulfilled accelerates the need for trust. Trust evolves over time, and the development of trust is based on series of interactions and experiences (Mayer et al. 1995). Trust grows in interactions, where shared understanding develops and where egocentric behaviour is reduced and real dialogue is enabled (Hardy et al 1998). Development of trust in teams and in networks is based on communication competences, responsible behaviour,
listening skills, flexibility, inclusiveness in decision making and positive and open attitudes (Bradley & Vozikis 2004.) Therefore the communication perspective in trust research is relevant. Trust has been widely studied in organisational studies (Mayer et al. 1995, Jarvenpaa & Leidner 1999, Jarvenpaa et al. 2004, Dirks & Ferrin 2001, Dennis et al. 2013, Holste & Fields 2010), and it is agreed in theory that trust is necessary for sharing knowledge between individuals (e.g. Anantatmula & Kanungo 2010, Bergiel et al. 2013, Malhotra et al. 2007, Dennis et al. 2013, Holste & Fields 2010, Mitchell & Zigurs, 2009) and that trust plays a crucial role in the effective communication of virtual teams (Jarvenpaa & Leidner 1999, Jarvenpaa et al. 2004) and even positively impacts innovations (Ellonen et al. 2008). A great amount of research has been conducted on the impact on trust, but it is still challenging to explain the differences between different kinds of trust and the significance of their roles in different organisations, between individuals and teams. Due to a lack of specificity in discussions on trust, there is confusion in all levels of analysis. However, it is possible to define trust itself, the factors that cause trust and the outcomes of trust (Mayer et al. 1995).

Trust is manifested in behavioural patterns; honesty and the predictability of behaviours form a strong basis of trust. It is about communicating the expectations and fulfilling them. In order to have trust, it is important that everyone fulfills his/her obligations and behaves in a consistent and predictable manner (Johnson et al. 2001). Mayer et al. (1995) described trust as the willingness of a party to be vulnerable to the actions of another party, while Te’eni et al. (2007) described it as the “willingness to rely on an exchange partner that he/she will fulfil obligations”. Trust enables the reliance on another person and feeling relatively secure despite the chance of negative consequences. This definition can be applied to relationships with others who are perceived to act and react according to their own will. Trust enhances cooperative behaviours, positive attitudes and work performance (Dirks & Ferrin 2001), and it consists of, among other things, interpersonal relationships, the competence to get the job done and the direction and clarity of roles and responsibilities (Joseph & Winston 2005). Persons need to take risks at work, and to be vulnerable and to take risks, trust is necessary (Huotari & Iivonen 2004). Trust is also connected to uncertainty because it allows risk taking (Meyerson et al. 1996).
2.3.1 Interpersonal trust

The principal forms of interpersonal trust in knowledge management studies are cognitive- and affective-based trust, which have been studied extensively in various fields of science (McAllister 1995). Affective trust is related to commitment and care, and it is an emotion-based trust (Scott 1999, Rempel, Holmes & Zanna 1985, Holste & Fields 2010). According to McAllister (1995), affective trust can only be built through time and in relationships that have extensive amounts of communication, empathy and social interaction. Affective trust is an emotional way of considering others trustworthy. Sonnenwald (2004) has argued that when affective and cognitive types of trust are in place, team members are willing to share knowledge and ideas together. They can even consider colleagues as friends. In such circumstances risks on trusting others were considered low.

Table 3. Interpersonal trust types.

<table>
<thead>
<tr>
<th>Trust Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affective</td>
<td>Emotion-based trust: commitment, goodwill, care, respect</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Know-how: personal development, trust in competence and skills</td>
</tr>
<tr>
<td>Normative</td>
<td>Similar values and norms: situation normality, rules, trust between colleagues</td>
</tr>
<tr>
<td>Swift</td>
<td>Relevant in virtual projects: structural assurance, task-based competence, clear work roles, rules</td>
</tr>
</tbody>
</table>

Affective trust is needed when personal motives are involved and tacit knowledge transfer is essential (Atkinson & Butcher 2003) and when cooperation and collaboration is needed (Greenberg 1999). Affective trust is often a history-based process that is rarely realized in temporary global projects.

Other relevant interpersonal trust types in this study are task-based competence (cognitive trust) and normative trust, which is connected to similar norms and values (Huotari and Iivonen, 2004) also swift trust is crucial. In virtual projects, swift trust is needed particularly at the beginning (Zigurs 2003), and it is connected to, for example, clear work roles and task sharing (Jarvenpaa et al. 2004). Cognitive trust refers to the trust in an employee’s ability to fulfill his/her expected work tasks and roles in the work community. However, affective trust is also sometimes needed when personal motives are involved and tacit knowledge transfer is essential (Atkinson & Butcher 2003). A climate of trust among team
members reduces uncertainty, and team members feel secure in investing social relations and actions within the team. Trust enables efficient work towards team goals (Brahm & Kunze 2012). Attributional processes and cognitive and normative competence-based trust are largely rational and cognitive, while the development of motive-based trust is mostly subjective and affective. Huotari and Iivonen (2004) found that trust or mistrust is exposed by organisational values that are the basis for social norms, which have an effect not only on cognitive-based trust but also on knowledge-sharing patterns and knowledge creation through organisational culture.

Faith in a team member’s competence and expertise is particularly necessary in order to build trust in virtual teams (Hunsaker & Hunsaker 2008). Jarvenpaa and Leidner (1999) emphasized the importance of communicating expectations clearly and concentrating on efficient task sharing. Thus, considering the interdependencies of tasks among group members is important. If dependency is at the right level, expectations and vulnerability will also be manageable. The concept of swift trust concept was by Meyerson et al. (1996) and further developed by Jarvenpaa (1998) and has emphasized the significance of the beginning of a project and initial impressions of team members. It can be challenging to establish trust in later phases of projects (Lipnack & Stamps 2000, Robey et al. 2000). Trust in the reputation and competence of team members is significant in the creation of swift trust. Each person’s contribution and reputation counts (Hyllengren et al. 2011). Swift trust is most efficiently created at the beginning of projects through face-to-face interaction (Zigurs 2003, Lipnack & Stamps 2000, Hunsaker & Hunsaker 2008), and it is the first impression that counts (Johnson et al. 2001). However, among managers and team members with prior work experience in virtual projects, face-to-face interaction is not necessarily needed (Lohikoski & Haapasalo 2013, Harwick et al. 2013). That said, swift trust is fragile and may be difficult to maintain in the long term (Zigurs 2003). It can be acquired quickly, but it can also easily turn into distrust if expectations are not fulfilled (Meyerson et al. 1996).

It is also true that too much trust among employees can be a challenge. When unconditional trust exists, this can enable “groupthink”. This includes too much solidarity and uncritical behaviour, which can have negative impacts on projects (Erdem & Ozen 2003, Morreale et al. 2001). In an organisational context, on the other hand, trust and interpersonal closeness are not prerequisites to effective managerial relationships. Trust among colleagues, not management, increases the transactional memory of the organisation, which enhances team performance and
even employee job satisfaction (Atkinson & Butcher 2003, Robertson et al. 2013), and it fundamentally has a positive impact on organisational success (Lipnack & Stamps 2000).

### 2.3.2 Impersonal trust

Antecedents for impersonal organisational trust are clear roles, systems and structures along with faith in one another’s competence in fulfilling tasks successfully (Atkinson & Butcher 2003). Accountability, which refers to a person’s willingness to accept responsibility, is a sort of glue that holds the social structure together (Burke et al. 2007). Antecedents of organisational trust has previously been divided into the categories that are presented in Table 4.

#### Table 4. Description of the antecedents of organisational impersonal trust.


Kasper-Fuehrera and Ashkanasy (2001) stressed the importance of a common business understanding, high ethics and proper methods of communication in virtual organisations. Without a shared understanding of the goals and vision, the fundamental antecedents of trust deteriorate. Thus, a strong situational structure is needed, which involves communication about goals, expectations and processes. These factors enhance the development of trust in virtual settings (Jarvenpaa et al. 2004). Malhotra et al. (2007) and Hunsaker and Hunsaker (2008) suggested that by defining processes and roles and clearly communicating expectations, one can establish both predictability and openness, which enhances trust. Vanhala and Ahteela (2011) stated that the employees’ ability to trust their job design and the learning and development possibilities in their organisation is important as well.

Ellonen et al. (2008) have emphasised management’s role in establishing the institutional dimension of impersonal trust. The bottom line is that managers are there to encourage employees to work towards a shared goal (Atkinson & Butcher 2003). Joseph and Winston (2005) suggested that nature of leadership has a strong correlation with the development and maintenance of organisational trust by
fostering competence and integrity and empowering employees. Verburg et al. (2013) have stated that a project manager’s experience and reputation are crucial in motivating employees and in having faith in a virtual project’s success. The influence of trust and leadership practices on the performance of global projects was also emphasised by Anantatmula & Thomas (2010). Therefore, the roles of team leaders, middle management and top management differ from the trust creation perspective. Egolf and Chester (2001) added that mutual respect and trust, active communication and consensus on goals rather than consensus on single decisions are crucial. Organisational trust is significant because after a successful project, a team retains the trust among its team members, creating a new form of organisational wealth (Lipnack & Stamps 2000). Fundamentally Human Resources Management (HRM) practices play a significant role in building impersonal organisational trust (Vanhala & Ahteela 2011). This is particularly important in virtual NPD teams, where communication is characterised by complexity, uncertainty and risk.

2.4 Virtual new product development

In new product development, organisations are often departmentalised in separate divisions operating independently in order to develop, manufacture and sell products (Brown & Eisenhardt 1995, Cooper & Kleinschmidt 1995, Takeuchi & Nonaka 1986). The formation of virtual teams is driven mainly through five factors: horizontal organisation structures, the need for inter-organisational cooperation, changes to workers’ need for organisational participation, increased service business opportunities, knowledge work and globalisation of corporate activities. The shift from competitive business environments to strategic cooperation between firms requires diversification, which makes vertical integration and direct management impossible. Thus, the success of a group of firms or organisations or individuals is dependent on the effective communication and knowledge sharing among members of the group (Townsend et al. 1998).

All divisions often operate independently, the heads of which report to top management. Later on, this organisation model has developed into matrix organisations, where authority is shared between division managers and between managers of specific products (Greenberg 1999). Work is typically conducted in project teams, which offers an efficient and well-institutionalised structure for new product development projects (Brown & Eisenhardt 1995, Cooper & Kleinschmidt 1995) acting in dynamic and intensely competitive markets in high-
technical industries (George et al. 2001). Utilizing expert resources more efficiently is possible globally through ICT, which allows companies to extend their work activities into virtual work settings (Lee-Kelley & Sankey 2008, Hertel et al. 2005, Rad & Levin 2003, Zigurs 2003, Drouin et al. 2010). Virtual team members work using ICT in varying degrees across locational, temporal and relational boundaries in a complex environment (Lipnack & Stamps 2000, Townsend et al. 1998, Martins et al. 2004), conducting work tasks high in complexity and significance (Kirkman & Mathieu 2005), typically with speed being important (Zigurs 2003).

Using distributed teams is a great advantage for companies, increasing the speed and flexibility necessary to respond to market needs, enabling closer relations with customers and reducing travel expenses (Hertel et al. 2005). However, 50% of distributed teams fail to reach their strategic or operational objectives (Zakaria et al. 2004) and teamwork quality is likely to suffer (Hoegl & Gemuenden 2001), both of which increase the need to manage such teams’ communication effectively. Virtual work is about people and how they interact using ICT in the 21st century (Neary & Hingst 2014).

The dimensions in defining the level of team virtuality can be geographic, temporal, cultural and organisational (Zigurs 2003), which poses several challenges to interaction. Linguistic or cultural ambiguity can cause misunderstandings (Fairholm 2009, Keysar 2007, Sonnenberg 1990, Wall & Callister 1995, Jarvenpaa 1998). It is also common that knowledge and information are the source of power (Huijser 2006, Kankanhalli et al. 2007, Morreale et al. 2001, Wall & Callister 1995). Information as an issue of trade and direct power use has been previously identified, particularly by Daft and Lengel (1986), Fairholm (2009) and Sonnenberg (1990). Social status–related attitudes towards other cultures, unconscious motives and psychological noise related to prejudices or feelings towards a person, culture or a message impact communication (Miller 2006, Maude 2011, Wall & Callister 1995, West & Turner 2009). It is common for participants in temporary virtual teams to possess diverse skills and have a limited history of working together; however, collaboration with others is usually needed to produce satisfactory outcomes (Meyerson et al. 1996).

Typically, virtual NPD teams can be formed for a certain project or they can continue to work together in the long term (Te’eni et al. 2007). It is also typical for co-located teams to mainly communicate virtually, e.g., to execute team processes through e-mailing and teleconferencing and utilizing group support decision systems, and it is important to consider the informational value and
synchronicity of such tools. (Kirkman & Mathieu 2005). Martins et al. (2004) have conducted an extensive literature review on virtual teams and pointed to a few fundamental elements which moderate virtual team performance. Virtual teams are impacted by organisational culture in addition to leadership styles, coaching and management support, which have an impact on planning, goal setting, communication and interpersonal issues. Effective communication is typically needed to secure continuous functioning and information flow about current issues, future changes, decision making and new goals. Connaughton and Shuffler (2014) emphasized frequent informal communication for building trust and enhancing knowledge sharing. In theory, the significance of face-to-face communication in virtual teams has been emphasized by Zigurs (2003) to reduce task conflicts (Hinds & Mortensen 2005) and to build trust (Wang & Haggerty, 2009, Jarvenpaa et al. 1998). The level of virtuality in coordinating communication practices is important (Bell & Kozlowski 2002, Griffith et al. 2003), but the informational value of the information processing in projects should also be considered (Daft & Lengel 1986, Venkatesh & Johnson 2002).

Coordinating communication among activities between NPD team members is important (Ulrich & Eppinger 2000, Lohikoski & Haapasalo 2013, Johnson et al. 2001). The role of technology as an enabler of communication is important in having efficient coordination and relationships with good quality in these dispersed work settings (Verburg et al. 2013). Organisational communication systems are established to support information flow between employees and to support the whole organisational entity. The literature on traditional teams and team communication guidelines do not provide adequate information regarding managing communication in virtual projects (Piccolli, Powell & Ives 2004). More research on virtual project communications is needed.

2.5 **Project communications**

Scientific discussions about project communications are part of a complex and multidisciplinary field between corporate communications and project management and it has concentrated mainly on the operative side of projects, though it also includes internal and external communications within projects. Internally project communication can be divided into interpersonal and written communication and scheduled and non-scheduled communication (Ramsing 2009). The people side of project management and its importance have been increasingly acknowledged in scientific discussions (Lechler 1998, Cooke-Davies
Communication is a focal part of project management and the foundation of successful work among stakeholders (Crane & Livesay 2003, Welch & Jackson 2007; Turkulainen et al. 2015). Efficient communication processes are crucial; they are needed to prevent misunderstandings and conflict escalations (Morreale et al. 2001) and to, for example, generate action or change or create a common understanding of organizational objectives (Faraj et al. 2011, Malhotra et al. 2007, March & Simon 1958, Snowden & Boone 2007).

A project is typically dynamic by its nature (Takeuchi & Nonaka 1986) moving through different phases during its lifecycle and it is typically divided into separate project phases, whose characteristics and purpose are significantly different (Morris 1982, Turner 1999). A project is a dynamic and iterative process which often evolves through trial and error, increasing the need for adaptability (Takeuchi & Nonaka 1986). The focus in projects is often on meeting times, budgets and performance goals. There is some consensus among researchers that some face-to-face communication is needed during the course of a project, but it is not clear when this should take place (Lee-Kelley & Sankey 2008). Research results on this topic are also controversial regarding tacit knowledge transfer (Harwick et al. 2013). There is evidence that some managers with a lot of experience in virtual teams believe that all managerial tasks can be handled virtually (Lohikoski & Haapasalo 2013).

Most of a project’s problems are typically associated with poor communication, and communication is often focused on presenting facts, details, statuses and requirements (Ramsing 2009). Over-communication has also been stated as being a common problem among virtual employees. Large numbers of e-mail messages and lengthy conference calls are considered difficult to manage (Lee-Kelley & Sankey 2008. Communication is too often driven by personalities and preferences rather than know-how or principles (Pritchard 2004, Rice & Love 1987). Communication is important for project success because it is people who perform the process and it is quality of their interactions that counts (Cooke-Davies 2002). It is commonly agreed that projects need general guidelines for communication; in particular, when and what information is shared and how team members are expected to communicate should be planned and communicated clearly to team members (Brown et al. 2007, Hertel et al. 2005). In virtual projects, few active team members are needed to share tasks, enhance frequent communication or give the work more structure (Kayworth & Leidner 2001/2002). In addition, determining which tools are used for team interaction is high of an importance. The complexity of projects demands clear decision
making, creativity, constant evaluation and special skills. It is also common that there are limitations in time and budget, but projects enable renewal, flexibility and change in organisations (Artto et al. 2011). The main issue in virtual work is results, not the time spent working in the office (Neary & Hingst 2014). The communication practices of virtual projects are explained next.

In the planning phase, clear rules of behaviour are typically established and the team purpose is clarified (Katzenbach & Smith 2005). Goal setting is particularly important in virtual teams in this phase as it enhances the sense of cohesion, commitment and collaboration (Huang et al. 2002). A project’s vision, mission, priority, rules and success criteria are established and communicated. Members need to believe that the team has an urgent and useful purpose (Hunsaker & Hunsaker 2008, Martins et al. 2004). In addition, a reward system needs to be set up, the level of virtuality should be defined and proper ICT tools are selected (Mukherjee et al. 2012, Hertel et al. 2005, Drouin et al. 2010). The planning phase involves scheduling and determining resource requirements, such as staffing, and typically the project plan is created when developing the business concept during the development phase (Ulrich & Eppinger 2000). The most efficient way to plan, exchange ideas and reach consensus on a variety of issues in the planning phase in virtual teams is to use rich, computer-mediated communication (Kayworth & Leidner 2000).

In the project initiation or kick off phase, the expectations, success criteria, goals and vision are clearly communicated (Martins et al. 2004). This is the also the phase for establishing and managing team boundaries, developing shared mental models, awareness and enhancing motivation. Managing communication processes and orienting to the task is crucial (Hunsaker & Hunsaker 2008, Martins et al. 2004). NPD demands enriched member interactions and greater group cohesiveness, therefore promoting a sense of shared identity, cohesiveness and technology use is important (Mukherjee et al. 2012, Drouin et al. 2010, Hertel et al. 2005). Swift trust emerges in the early phase of the project (Zigurs 2003).

In the execution phase or working phase, expected and unexpected tasks are coordinated in order to achieve the desired goals. The project as a whole is a dynamic entity which develops and evolves throughout the whole process (Ulrich & Eppinger 2000). In the working phase, it is crucial to enhance motivation and pay attention to promoting communication (Mukherjee et al. 2012). Communicating goals, explaining objectives and listening to employee outputs are significant (Anantatmula 2008). Steps are taken in initiation, managing team
boundaries and establishing working conventions and norms. Ground rules are defined (Hunsaker & Hunsaker 2008).

Formal communication must be supported by informal communication that allows the development of collective values amongst team members. Ad hoc informal communication—either face-to-face or through instant messaging or chat—in a virtual office has been suggested as one of the most useful mechanisms in breaking down individual and organisational barriers (e.g., Brown et al. 2007). Basically, communication impacts tasks and norms, and the distance between the message sender and the receiver (Te‘eni et al. 2007). Thus there should also be a focus on management support systems, communication about expectations and objectives and sufficient time for formal and informal discussions. Follow-up procedures also have significance (Brown et al. 2007). Miller (2006) emphasized technical and content reviews as essential factors in organizational information processing. Hertel et al. (2005) emphasised the importance of providing clear success criteria and facilitating feedback processes across the distance.

The closing or post project phase finalizes the project. Typically, a project’s phases and results are documented and a meeting is held for feedback discussions. In addition, a “lessons learned” document is created and stored in a database or in other media. Lessons learned are somewhat equal to best practices, but they refer to more local form of insight; essentially, they are knowledge of the practices which work (Patton 2001). It is typical that re-integration of teams often takes place again and therefore careful disbanding and lesson-learned practices are important (Mukherjee et al. 2012). Cooke-Davies (2002) also emphasized the meaning and significance of learning from experience and continuous improvement in projects, stating that the people side of the project should be acknowledged as a key success factor. Patton (2001) suggested that high-quality lessons learned are usually extrapolated from multiple sources based on high-quality evaluations that are triangulated, adapted and applied to new situations. It should be considered, within projects at least, that what is meant by the lessons learned and what kind of evidence is used to support such lessons. It is also crucial to consider the contextual boundaries around the lesson and to whom it should apply and what kind of evidence is needed to support the conclusions. It is also significant to consider how these lessons connect to other lessons from other projects.
2.6 Communication competence

Communication competence refers to a person’s ability to use written, verbal, oral and cultural understandings and language skills to ensure efficient communication between parties in different environments and contexts (Spitzberg & Cupach, 1984, Morreale et al. 2001). It was also suggested that understanding, ability and doing define communication competence, whereas Payne (2005) recognized motivation, knowledge and skills as a basis for communication competence. Acknowledging cultural factors, improving analysis skills and widening the repertoire of situational communication skills provide efficient strategies for communication competence (Steers et al. 2013). It is agreed that individual communication skills count in virtual work (Zigurs 2003, Blackburn, Furst & Rosen 2003). Media and tools for communication are not competent or incompetent, but communication is competent in a given context and its outcome determines the success of communication process (Morreale et al. 2001). Communication process is not just about sending and receiving information. It consists of several different phases. Just listening process itself includes 3 phases; receiving information, understanding and creating meaning for the message and providing some feedback to the sender (Lohikoski et al. 2015). Listening has been referred to also ethical communication practices. Ethical communication consists of inclusiveness, participation and reciprocity, which enable a real dialogue between people (Rakow, 1994).

The goal for communication is to accomplish something in a manner that fits the situation in a clear, appropriate and effective manner. Conditions in which virtual communication can be done have been under extensive research for the past decades (Jarvenpaa & Leidner 1999, Kirkman & Mathieu 2005, Faraj et al. 2011, Lipnack & Stamps 2000, Hertel et al. 2005). Within virtual teams, clear communication and collaboration, openness and trust are important. Organisational support in terms of proper ICT tools, information systems and rewards for virtual work are needed (Verburg et al. 2013). There are findings in knowledge management that can be divided into organisation level capabilities in managing information and knowledge efficiently (Huang et al. 1999) and personal level competencies (Wang & Haggerty, 2009), which enable successful virtual work. Clearly, virtuality itself is a complex and contingent issue with a wide variety of factors (Kirkman & Mathieu 2005). Both organisational and personal level communication competencies are discussed below.
2.6.1 Individual level competencies

In the world where everything is connected and changing, the ability to learn, adapt and renew has become the most important factor for each individual (Lohikoski 2011). For communication in virtual work projects, Wang and Haggerty (2009) suggest that at the individual level, media skills, virtual social skills and certain self-efficacy skills are needed, in addition to self-management skills (Faraj et al. 2011). Developed ICT skills and general familiarity with lean media are also important (Malhotra et al. 2007, Luther & Bruckman 2011). Thus, it is crucial to recognize that same working practices and communication methods that apply in regular work settings do not apply in virtual work settings. Virtual social skills have been more specifically defined by Bergiel et al. (2013), Holton (2001), Malhotra et al. (2007) and Snowden and Boone (2007), who stated that in addition to language skills, verbal, written, oral and cultural sensitivity and understanding are needed in effective communication. Work experience in virtual projects has previously been identified by Dube and Paré (2002) as a significant factor in enhancing the work performance of virtual team members.

Team members in virtual NPD projects are often multicultural, and therefore cultural and personality issues need to be considered when forming teams, sharing tasks, communicating and giving feedback (Johns & Gratton 2013, Holton 2001, Badinarayanan & Arnett 2008, Gressgård 2011, Faraj et al. 2011). People always filter information through their own culture (Kock 2005, Snyder 2003, Hofstede et al. 2010). Anantatmula and Kanungo (2010) stressed the point that virtual teams and organisations can be successful with employees who are willing to share their knowledge, participate extensively in conversations and have credibility and collectivist values. Social skills were also been emphasized by Dennis et al. (2013). Kirkman and Mathieu (2005) stated that the competencies in the areas of task work, team work and virtuality-related knowledge and skills, abilities and personal characteristics must be suitable to the virtual work environment. Piccolli, Powell and Ives (2004) suggested that virtual teams benefit from team members who are active communicators and who stimulate team interaction, making sure that all are aware of their responsibilities.

Efficient coordination and effectiveness in communication can enhance satisfaction of the work experience. Te’eni et al. (2007) suggested that effective communicators in virtual settings are capable of adapting their behaviour and choosing the right medium and process to best suit the current situation. Individuals have also been classified based on their impact on their networks as
expert networkers with connections and skills in relationship building (Mueller-Prothmann & Finke 2004). Good virtual communication competence is based on professional and company language skills, cultural knowledge and sensitivity, which enable achieving the shared understanding (Lohikoski et al. 2015).

2.6.2 Organisation level capabilities

At the organisational level there are commonly agreed issues which need to be organized to facilitate virtual team communication. Knowledge is a corporate asset, and it is crucial to consider how communication practices are organized (Lohikoski et al. 2015). In expert organisations, it comes down to utilizing knowledge assets efficiently. Through proper knowledge management culture, an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise’s information assets is enabled. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers. (Prusak 1999). Davenport (1994) stated that knowledge management is the process of capturing, distributing, and effectively using knowledge in organisations. In order to manage these assets effectively, the management of all processes concerned with the identification, acquisition, creation, storage, distribution, and use of information and knowledge is needed. (Huotari & Iivonen, 2005.) This view enhances the possibilities in reaching targeted outcomes and achieving value creation for a customer as well (Davenport 1996).

In expert work, certain phases in projects require certain communication practices. Face-to-face meetings and training for virtual work can help to overcome problems in technology at the beginning of a project. In addition, informal communication between team members needs to be facilitated to create interpersonal relations with team members, which is also what Malhotra et al. (2007) and Luther and Bruckman (2011) emphasised. Various studies have highlighted that it is very difficult to co-operate in virtual organisations without knowing colleagues personally at some level, and therefore informal communication is needed. In addition to project knowledge, people share experiences, values, expectations and mental models during project life cycle.

Efficient management of knowledge is based on developing methods, tools, techniques and values, through which organisations can acquire, develop, measure, distribute and provide a return on their expert knowledge (Snowden 2002). Typically, managers in knowledge-based organisations have extensive
knowledge of the organisation and its culture. They also have mastery in using ICT and they are confident and capable of effective leadership by virtue of intellect, personality and understanding in knowledge management. (Earl & Scott 1999.) Management needs to have appropriate competencies for leading virtual teams to ensure the success of projects (Faraj et al. 2011). Hertel et al. (2005) emphasized that team level competences, including conscientiousness, integrity and cooperativity, are required in order to build interpersonal trust. The most significant issues behind success in virtual teams, according to Verburg et al. (2013), are trust, clear communication and technical and corporate support. Particularly, training and clear guidelines at the beginning of the project are important.

It is also clear that effective communication technology and information systems are crucial (Teñí et al. 2007). Access to relevant ICT, the breadth of the communication media and its depth in terms of access to various options within such medium are important. People may recognize the need to improve access to different media, but they may or may not have the competence needed to master the technology (Morreale et al. 2001). New ways of working through ICT is still new to many people (Kock 2004).
3 Research results

3.1 Information processing methods in virtual NPD projects

Information processing methods in virtual NPD projects were investigated in publication III. The components of the study units for the third article were centred on communication needs in different phases of the NPD project. The themes for the interviews and the units for the analysis were observed from the perspectives of synchronous and asynchronous communication. Finally, the results were analysed and enriched with the survey data.

1. Planning: ICT tools in planning, meeting and decision-making procedures; selecting team members; communication infrastructure; rules and norms for communication; selecting ICT tools; considering cultural and professional backgrounds
2. Start: Kick off meeting, team building and decision-making practices, deciding rules and norms for communication
3. Working phase: Access to relevant information, information availability, decision-making procedures, support mechanisms, strengths and problems in virtual communication, virtual meeting practices
4. Lessons learned: Best practices for virtual team’s communication, characteristics of an efficient team member, team spirit, quality of communication, lesson-learned practices and documentation.

Information processing in the case company was characterized by complexity, a variety of ICT tools and various ways in operating. Information processing practices were based on operational managers, project managers and team members’ prior experiences and preferences rather than specific predefined communication processes. Conflicts caused by misunderstandings can cause severe problems for project schedules in the form of delays, especially when trying to solve conflicts across time differences through e-mail. In this manner, the advantages of new ICT, knowledge transfer agents and a global environment are not used to their full potential. The significance of knowledge transfer agents should be appreciated and their performance measured and rewarded, as they play a significant role in transmitting information and building trust between different sites. Based on the results, employees are not systematically trained for working in virtual teams, and therefore equivocality and uncertainty are increased.
Based on the interviews, the most important factors affecting a global team’s performance are face-to-face meetings—at least at the beginning of a project—to reduce information processing barriers. However, the few team members and operational managers with significant work experience (over 15 years) in virtual projects felt that the face-to-face mode is not necessarily needed at all. In their opinion, all the tasks, including hiring, planning and even layoffs, can be handled virtually.

In the informants’ opinion, cultural background and competence in the official company language is a crucial part of information processing, particularly when using personal and group modes for tasks related to giving feedback and following a project’s progress. In particular, based on leaders’ opinions, cultural knowledge is a cornerstone when sharing tasks, giving feedback and interpreting the results of global teams. There are not any fully reliable tools or metrics that can point out possible problems and delays accurately and early enough. Therefore, leaders need to know how to get accurate information from each individual efficiently, and therefore advanced knowledge of and experience in operating with different cultures is needed. After that, cultural differences can be seen as richness and a resource, and hence equivocality brought about by a virtual environment can be reduced.

The most frequently used information processing modes were e-mail and meetings; however, phone calls and a company wiki were also used. Face-to-face communication was very limited, which inflicts additional challenges on projects. Based on the interviews and survey, the company tools were considered efficient and up-to-date, but there were not enough tools enabling virtual face-to-face contact in these sites. Essentially, more web-conferences are needed to replace co-located face-to-face meetings.

After projects are completed, “lessons learned” documents are made and reviewed with the key project members and stakeholders. Documents are stored in company databases for further use. Communication issues also get reviewed, and communication practices for new projects are tailored based on previous projects’ lesson-learned outcomes. Based on the results, the essential communication tasks for the different phases of the project are presented in Table 5.
Table 5. Project phases and objectives for communication.

<table>
<thead>
<tr>
<th>Project phase</th>
<th>Information and knowledge sharing</th>
<th>Knowledge creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Explicit knowledge sharing: vision, mission, project priorities, rules, norms and success criteria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selecting ICT tools</td>
<td>Tacit knowledge sharing: team building, developing swift trust, promoting communication and knowledge management</td>
</tr>
<tr>
<td></td>
<td>Clear rules for behaviour</td>
<td></td>
</tr>
<tr>
<td>Execution</td>
<td>Explicit knowledge sharing: sharing tasks, kick off meeting, promoting communication and knowledge management, sharing information for problem solving and decision making.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tacit knowledge sharing: “Coffee table discussions”, decision making, problem solving, learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Team building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Promoting personal aspect of communication</td>
<td></td>
</tr>
<tr>
<td>Post project</td>
<td>Explicit knowledge sharing: Lessons-learned documentation and practices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rewarding and annotating success</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recognizing achievements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tacit knowledge sharing: Considering team members’ needs, experiences and perceptions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building organisational culture of trust and success through recognizing achievements and annotating success</td>
<td></td>
</tr>
</tbody>
</table>

3.1.1 Synchronous communication

In synchronous communication, the most used communication methods were meetings and teleconferences with the possibility of sharing documents and reports virtually. These had several benefits but also several challenges. After communicating face-to-face at least once, it is easier to interpret a team member’s tone of voice and facial expressions when communicating virtually. Projects have been started within the past without face-to-face kick off meetings, which was considered harmful and difficult among informants from the information sharing perspective.

Secondly, phone calls and web conferences were used, along with the company wiki and chat. Sharing documents, reports and backlogs of questions and answers, in addition to face-to-face meetings, were mentioned as fundamental and efficient information and knowledge sharing practices. Efficiency in virtual meetings at the working phase of the project was considered somewhat of a problem in the USA and Finland based on the interviews. Virtual meetings were seen as inefficient, especially when they were used primarily for sharing explicit knowledge, which was the case particularly in Poland. The use of synchronous communication among leaders and expert teams is as follows:
– Teleconferencing is used at all sites
– Teleconferencing enables discussion while sharing documents
– Phone calls are used among native speakers in the same time zones
– Web conferences are rarely used, and are done mainly by the managers for job interviews
– Face-to-face meetings are used locally

3.1.2 Asynchronous communication

The case company’s use of asynchronous communication was considered useful particularly in testing across different sites. Testing of the product could be conducted 24/7, and test results could be efficiently shared across time zones and sites. It was also considered efficient because documents can be updated simultaneously and information can be shared widely across organisations. It is also a benefit that e-mail offers those with poor company language skills the possibility to communicate; in addition, introverts found it easier to express their opinions in written form rather than at the meetings. It was also clear that cultural differences related to physical presence and various accents have less negative effects in asynchronous communication using impersonal modes of information processing.

When considering issues with more in depth and technical complexity, teams’ preferences of communication methods varied between sites, and also within sites. In particular, e-mail divided opinions. The asynchronous communication mode increases flexibility to the work considering working time and place of an expert and manager, and it decreases the need to have meetings for information sharing. Information sharing in meetings was considered inefficient.

Asynchronous tools were not considered the best possible option for communicating complex technical issues, topics consisting of feelings or topics otherwise high in ambiguity, but they were still used for these purposes. It was also considered important to have things documented so that it was easy to find original sources for information and to share tasks. Leaders considered task sharing easier through asynchronous tools than face-to-face.

3.1.3 Cycle of information processing in virtual NPD projects

Information is processed in virtual NPD projects through integration mechanisms and utilizing integration mechanisms efficiently is crucial for project’s success.
Information processing needs are different in different phases of a project and for enhancing culture of knowledge management, where expert knowledge is fully utilized in projects.

Knowledge is an outcome of information, which is always interpreted, understood and internalized through communication process. Therefore information processing in projects always changes individual’s knowledge base and understanding. Explicit knowledge is typically formal, systematic and well defined. In virtual NPD projects it is e.g. products documentation, test results etc. or memos of meetings, project plans, or mathematical formulas. Explicit knowledge is easy to store and share through ICT and in case company amount of information is enormous.

Tacit knowledge consists of cognitive and know-how, know-what and know-why aspects of work. Tacit knowledge is typically highly personal and difficult to externalize in verbal form. It is the sum of experiences and competences that enable people to do their work. In organisational level tacit knowledge is manifested in organisational culture, in its practices, routines and when employees are working together. Information is assessed and interpreted using tacit knowledge. Through tacit knowledge creation and learning, cultural knowledge evolves and develops.

Cultural knowledge relates to knowledge structures and communication practices in organisations. It also relates to attitudes, beliefs, and feelings through which the members of project understand, explain and assess the surrounding reality. Therefore in interpreting situations and information, a lot of tacit knowledge is shared and utilized through communication. Transferring, combining and developing new knowledge require communication. Information and knowledge are not enough, organisational capabilities and personal communication competencies are needed as well in order to reduce uncertainty and equivocality. Figure 3 explains the cycle of information processing in virtual NPD projects.
3.2 Barriers to information processing in virtual NPD teams

The case studies in articles I and II showed barriers to information processing both at the organisational and the personal level, which have negative impacts on information processing. In addition, publication IV concentrated on barriers to the communication process itself. At the organisational level, the usability of company ICT tools was considered adequate among all the interviewed informants; while there had been connection problems in the past, teleconferences are now seen as working well.

According to the interviews, there are company-level social collaboration platforms and knowledge sharing databases, but most of the informants at all sites stated that it is not clear who is using them or why employees should use them. Social collaboration platforms were mentioned as being used only in China; however, at other sites, there seemed to be a lot of variety about which databases
and platforms are used and for what purpose. There was variety among different sites concerning which tools were used and which were considered effective and for what purpose. A lack of proper web conference rooms was evident, and therefore ad hoc face-to-face meetings with team members at other sites were unutilized. At the organisational level, the following issues decreased the quality of information processing:

- Communication norms and guidelines are lacking
- Absence of conflict resolution strategies
- Virtual meetings without planning, preparation or structure
- Unreasonable number of ICT tools and systems
- Information is scattered in too many locations
- No clear rules regarding versioning and sharing documents
- Communication and commenting on a team’s work is done on impulse
- Absence of virtual feedback and rewarding procedures
- Knowledge transfer agents are not recognized or utilized

However, there were also differences in opinion within sites and within teams regarding, for example, the use of e-mail. Some informants considered e-mail as a useful and easy communication method, even for complex issues, whereas others considered it harmful and a potential cause for misunderstandings and even conflicts. Tone of voice, humour and sarcasm can be interpreted incorrectly very easily in e-mail. Also, all team interviewees and most leader interviewees emphasized how inadequate language skills are hindering information processing in meetings and in e-mails. However, unstructured e-mails, large numbers of emails and excessive length were also listed among the most common problems.

The clarity of shared goals and norms in information processing between HW and SW, and generally the clarity of shared goals between sites, was a problem. Whenever there were delays in schedules, changes to original project plans or technical problems, the clarity of common goals is seen to disappear. Relationship-based problems were the second biggest issue, consisting of challenges relating mainly to inadequate language skills, which cause misunderstandings, conflicts, and decreases in virtual team performance, leading to frustration among team members. Cultural differences and unclear communication without a clear focus also add potential misunderstandings. In addition, based on the interviews, information overload in e-mail messaging and inefficiency in virtual meetings were seen as significant problems.
E-mail messaging related problems are tangled together with relationship-based conflicts, which result from unclear messages that are easily misinterpreted. Cultural background was mentioned by all the informants as significantly influencing both the sending and receiving of information. Factors negatively influencing information processing at the personal level were described as follows:

- Lack of shared e-mail etiquette
- Responding to messages by personal preferences rather than by shared rules.
- Inadequate type and amount of informal team communication
- Unwillingness to adopt new technologies
- Egocentrism in listening and in information sharing
- Relying on feelings and assumptions rather than on facts when interpreting and responding to messages
- Individualistic values

Common barriers were also native speakers’ tendency to dominate conversations in teleconferences due to their better company language skills. It was also considered difficult for someone with inadequate language skills to discuss complex technical issues in a foreign language. Misunderstandings and misinterpretations were common in meetings across sites. Inadequate company language skills also negatively impacted the quality of phone call conversations and web conferences. In synchronous meetings, inefficient knowledge about other cultures has in some cases caused conflicts. Particularly in conflict resolutions and solving work and task related problems, a lack of cultural sensitivity had led to problems.

With regard to phone calls, native speakers found it easy to talk to others with sufficient company language skills, but this was rarely the case in cooperation with other sites. Also, it was unclear in the 24/7 working environment when it was a suitable time to contact a person by phone.

3.2.1 Barriers to communication process

The fourth publication concentrated on different phases in the communication process, which typically includes an initiation phase, transfer phase and response phase. The most common communication barriers related to the initiation phase were egocentrism, miscommunication, information-sharing behaviours and
previous interaction. More specifically, the inability to choose the proper methods for each purpose caused an overuse of e-mails. In the response phase, the greatest barrier to communication was inadequate language skills, which also increased the amount of time used for communication. In addition, equivocality, ambiguity and miscommunication caused by differences in technical knowledge and cultural background were seen as harmful to the communication process. One of the most significant findings was the strong reliance on asynchronous communication even in complex technical issues and conflicts. This was related to time differences as well as to an inability to choose the best tools for each purpose. Unclear communication with no clear focus leads to inefficiency in exchanging e-mails and in time spent in virtual meetings. E-mail-related problems are tangled together with relationship-based conflicts, which result from unclear messages that are easy to misinterpret. In the initiation and response phases, the common barriers to communication were the following:

- Egocentrism
- Mistrust
- Information-sharing behaviour concerning e-mail etiquette, using databases, sharing tasks and resources, taking synchronicity into account, decision-making practices, utilizing company’s internal social media
- Previous interaction
- Knowledge as a source of power
- Miscommunication
- Equivocality and ambiguity
- Inefficient meeting practices
- Time differences
- Technical problems with ICT

An unwillingness or inability to listen may also harm communication, which was also a typical barrier. In the listening phase, egocentrism, inadequate language skills, equivocality and previous interaction were also common inhibitors. It was found that listening phase is often inadequate in virtual settings, because when communicating asynchronously, feedback is often missing, it comes too late or is does not come at all and therefore reaching shared understanding becomes difficult. Cultural issues were highlighted, both in terms of country and corporate culture, which were seen as major influencers. The leaders in the case company saw cultural knowledge as a cornerstone when communicating with global teams.
because there are no reliable tools or metrics to describe potential problems in an accurate and timely manner during the course of the project.

### 3.3 Trust’s impact on information processing

Impersonal trust in the virtual work setting is based on reliable and usable information systems, an efficient knowledge management culture and communication practices which are designed for virtual project work. Shared goals, guidelines and rules for virtual communication increase predictability, which is a fundamental element in establishing impersonal organisational trust, adding situational strength caused by goals, rules and rewards. Situations with few cues, rewards or guidance will increase ambiguity in communication. Impersonal trust increases the likelihood of virtual communication, resulting in favourable outcomes. Projects have different communication needs at different phases which must be taken into account, otherwise efficiency in projects is seen to decrease.

Survey and interview results showed that there were no company-wide proactive training or general guidelines available for virtual project communication. In addition, the human resources department and communication department, who typically are responsible for organizing such training, did not have any role in supporting virtual projects members and their leaders. It was clear that those members who had received training for virtual communication were more satisfied and comfortable with their work than those without training.

Organisational impersonal trust is needed to enhance the clarity of common goals and guidelines, in addition to offering team building, support and guidelines for a global virtual way of working. Aligning organisational goals and objectives is an important ingredient in organisational impersonal trust. Having different KPIs for each site increases competition, which makes knowledge a source of power; therefore, sharing information and knowledge becomes an issue of trade in virtual projects. Rather than having impersonal trust in the organisation as a whole, stronger impersonal and interpersonal trust had developed within each site. The willingness to share critical information and knowledge with other sites decreased due to increased competition. The lack of shared goals among projects and having different KPIs for each site increased protective, egocentric behaviour at the expense of information sharing.

Differences related to ethnic and corporate culture and to professional backgrounds can increase uncertainty in communication and therefore the
development of trust. Fusions within other global companies in recent years have created additional challenges to the development of impersonal trust. As the interviewees explained, corporate culture and ethnic culture are among the greatest challenges in virtual work; they cause different processes and ways of working and dealing with information, which increases uncertainty and the willingness and capability to communicate. Furthermore, team members’ personalities, rapid changes in technologies, projects and prioritizing work globally increase unpredictability.

The bottom line is that a lack of impersonal trust decreased the willingness to personally contact a person at another site and to answer messages. However, using asynchronous communication such as e-mail was preferred in such circumstances.

Interpersonal trust moderates the ability and willingness to communicate at many levels. Without interpersonal trust, tasks that are shared through e-mail can be ignored; in addition, messages are easily misinterpreted. If persons at another site do not have the proper company language skills or technical understanding, team members are less willing to try to communicate, and communication consumes more time. Trust in colleagues’ professional competence was considered high at the case company, although this applied mostly to co-located team members. Trust among project members was considered more challenging to build. In addition there were professional differences among teams. Teams in Poland were developing SW, whereas teams in China, Finland and the United States were developing HW. Diversity in professional knowledge was mentioned to increase challenges due to different professional backgrounds.

It was clear that prior interactions influenced interpersonal trust among team members. There had been unresolved conflicts which harmed interactions between people. This was reported as a common problem among teams in Poland collaborating with teams in China, Finland and the United States. Teams in Poland and China typically had less than five years of work history together and they faced challenges due to their different professional and ethnic backgrounds.

Interpersonal trust in the case company was based on good relationships among colleagues and was strong in all sites. However, team spirit and casual relationships had not developed in virtual projects. A major cause for this was a lack of team building practices. Most of the informants considered their ICT and communication skills adequate for working in virtual projects, but language and relationship problems were mentioned as a major challenge. Transmitting tone of voice or humour via e-mail is difficult. Survey results varied regarding
transmitting complex technical knowledge through ICT. Some considered it is possible, while others considered it is more difficult.

One of the strengths of the case company is that team members strongly rely on their colleagues’ professional competence, as shown in the survey and interview results from all sites. Colleagues were mentioned as a primary source of support, and employees had strong faith in the competence of their colleagues and supervisors, which is a form of cognitive trust. However, this was not the case in all teams. The most relevant work advice came from colleagues from the same site; they only contacted persons from other sites by e-mail or by phone if information was not available at the same site. Interdependency between team members was acknowledged, as most of the survey respondents said they needed each other in order to perform well.

Interpersonal affective trust among colleagues at the same site enhances the development of shared understanding but can also risk the willingness to communicate with other sites. There was high affective trust among co-located team members and a tendency to develop emotional attachments among colleagues. Team members with high affective trust and emotional attachments to their colleagues were also more critical towards the quality of work from other sites and towards management’s decisions than other teams. This type of high emotion-based trust among local colleagues can decrease the willingness to build trust with colleagues at other sites.

3.4 Virtual communication capabilities and competencies

3.4.1 Organisational virtual capability

The main issues in organizing information processing in virtual NPD projects are based on communication practices, which are planned and realised based on culture of knowledge management, which supports virtual communication competences. In particular the “how” and “why” parts of virtual communication are critical in addition to the “what” part, which is the content and professional knowledge and important as well. Enhancing knowledge management culture and utilizing expert knowledge is crucial in processing information. Through knowledge management culture an integrated approach to identifying, storing, retrieving, and sharing all of an organisation's expert and cultural knowledge is enabled within project cycle and from one project to another.
Cultural background and virtual way of working always impacts on ways in understanding, explaining and assessing information and therefore virtual communication capability is crucial part of information processing in global projects. Proper information systems and availability of ICT is crucial as well as communication planning, training and processes. Survey results show that there were no company-wide proactive training or guidelines available for information processing at the case company. Additionally, the human resources and communications departments did not have any role in supporting virtual projects communication practices.

It is clear however that in order to create new knowledge in global virtual projects, virtual communication capability is required. Information and knowledge alone are not enough, organisational capabilities are needed in order to achieve the intended results through utilizing expert knowledge. This has been previously verified also by Brandon and Hollingshead (1999) and Propp (1999) in knowledge-based organisations. Global virtual projects are very complex by nature and new organisational capabilities are needed to enhance personal virtual communication competences. The informants did not acknowledge that some tools are more suitable for transmitting complex professional knowledge than others. Therefore, teams might benefit from acknowledging the differences between different types of information, choosing the right tool for each purpose and defining rules for using them. While personal virtual communication competence can enhance virtual project work, organisational support is the most crucial as an enabler for virtual communication competence.

A lack of systematic training and support for working in virtual teams causes and increases the number of unnecessary barriers to information processing. The use of integration mechanisms should be acknowledged, planned for and taught. The structure and efficiency of the virtual meetings for different purposes requires more evidence and knowledge. Internal and external social media within a case company is still often unused and its benefits unutilized, and therefore its role, usage and needs were not serving the objectives of project communication.

### 3.4.2 Personal virtual communication competence

In addition to organisational factors, information processing is impacted by personal characteristics and skills. Cultural background and competence in official company language impact on way on assessing information. These competencies were not systematically measured or trained at the case company,
which caused conflicts among teams. Conflicts can cause severe problems in project schedules, especially when trying to solve them across time differences through asynchronous methods. In this manner, the advantages of new ICT, the diversity of global team members and the flexibility of virtual work were not used to their full potential. Based on the results, cultural knowledge and language skills are cornerstones when sharing tasks, giving feedback and interpreting the results of global teams. There are no fully reliable tools or metrics that could point out possible problems accurately and early enough over cultural barriers. Therefore, accurate methods for efficiently gathering information from each individual are needed, as are advanced integration mechanisms and knowledge and experience in working with different cultures. Listening skills are needed for achieving shared understanding in projects when communicating virtually. Listening process itself has three phases, receiving the message, constructing meaning for the message and giving feedback. Listening skills are needed to reduce equivocality and uncertainty in virtual communications.

When coordinating and communicating with people from different organisational and cultural backgrounds, their cultural characteristics should be carefully considered. First, part of virtual communication competence is to become aware of one’s own characteristics when operating in virtual work settings. Then virtual communication competences based on interviews at the personal level include mastery of using ICT. It also means listening skills in a virtual environment, adequate company language skills, competence in writing succinctly and structured e-mail messages while taking the recipient into account in terms of differences in cultural and professional backgrounds. Virtual communication competence at the personal level enhances communication in projects, and it also enables communication about complex technical issues. If these skills are accounted for, the diversity of global teams and information processing over cultural and time differences can be seen as richness and as a resource, and the equivocality and uncertainty increased by the virtual environment can be reduced and trust over sites can develop. Table 6 describes the main results of the communication competencies in virtual NPD projects.
Table 6. Communication competencies in virtual NPD projects: main results.

<table>
<thead>
<tr>
<th>Organisational virtual communication capability Results</th>
<th>Personal virtual communication competence Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge management culture</td>
<td>Accountability and reliability, fact based communication are highly appreciated skills. Feedback is given ad hoc rather than systematically. More negative feedback than positive Ability and willingness to listen is needed.</td>
</tr>
<tr>
<td>Teams’ goals are not clearly aligned.</td>
<td>Team work skills</td>
</tr>
<tr>
<td>Communication competence training, measuring, feedback and rewarding practices do not exist at all sites. Knowledge transfer agents are not utilized. HR department and communications department are not supporting NPD team work.</td>
<td></td>
</tr>
<tr>
<td>Information processing procedures</td>
<td>E-mail etiquette and media skills</td>
</tr>
<tr>
<td>Project communication support mechanisms are not provided at all sites.</td>
<td>Amount of e-mails is extensive and e-mails lack structure; e-mail etiquette is needed. Written company language skills are not adequate. Ability to choose right tool for each purpose is not sufficient; e-mail usage is a habit. Web conferences are not sufficiently utilized.</td>
</tr>
<tr>
<td>ICT tools and information systems</td>
<td>Company language skills</td>
</tr>
<tr>
<td>Excessive amount of ICT tools increases uncertainty. Not enough web conferences available.</td>
<td>Company language skills are not adequate at all sites. Training and measuring language skills are not systematically organized. Strong company language skills are a source of power among native speakers.</td>
</tr>
<tr>
<td>Strong reliance on e-mail and meetings. Social media and social collaboration tools are not systematically utilized.</td>
<td>Mastery in using ICT</td>
</tr>
<tr>
<td>Testing is conducted efficiently in a 24/7 environment.</td>
<td>Cultural knowledge and sensitivity</td>
</tr>
<tr>
<td></td>
<td>Accountability and reliability</td>
</tr>
<tr>
<td></td>
<td>Country cultures are acknowledged, yet training for shared communication practices is not provided. Roles and responsibilities are sometimes unclearly defined in each project from the very beginning. Different communication needs in each project phase are not acknowledged.</td>
</tr>
</tbody>
</table>
4 Discussion

4.1 Global virtual NPD projects

Organisations have transformed to suit the global marketplace at different levels, and virtual teams are now increasingly utilized in global businesses. Virtual teams offer more possibilities to benefit from experts working across the globe, increasing adaptability, flexibility, agility and speed (Strader et al. 1998), which is the main driver at the case company for establishing virtual teams. All teams in the case organisation are virtual to some extent, which offers flexibility but also leads to additional challenges. A few different types of global businesses have been identified by Stohl (2002) based on the level of integration of different cultures. The case company has characteristics of all these types: International companies identify with several countries with different characteristics and distinct national interests exist within management, clients and organisations in general, which was typical for all sites, excluding the USA, which mentioned corporate cultures more dominantly than country cultures. In global workplaces, therefore, a global system is identified and organisational membership has taken over national allegiances. There were some signs of this development among management, but instead of a global workplace, the case company’s state of globalization mostly corresponded to the characteristics of an international company.

Previously, globalization was about conquering lands and seas, but now it is more about creating shared virtual realities (Aaltonen & Jensen 2013). As Zahra (1999) and Jensen (1999) predicted, globalization has escalated technological advancement and change, bringing cultures together and societies closer to each other. In Zahra’s (1999) vision, globalization was to foster cooperation, goodwill and peace among nations, increasing growth and prosperity and sustaining excellence. Tools and competencies for sharing information globally are present in the case company, but, sharing good practices virtually and globally is not obvious, as O’Leary et al. (1997) as well has found in other contexts.

Information sharing is happening, or not happening for several different reasons. The different KPIs at each site foster competition at the expense of information sharing. Employee layoffs, outsourcing, intensified competition and transferring operations to low cost countries hinder the development of
antecedents of impersonal trust, which significantly decreases the willingness to communicate tacit knowledge.

Despite the barriers to communication in global projects, companies are often reluctant to reveal their best practices for competitive reasons, and they are not willing to reveal failures in organizing global projects. In particular, communicating these issues to the competitors is avoided (O’Leary et al. 1997). This was also the case among the sites and projects in this study. Sites were competing with each other. Competition among global companies is tough both within companies and between companies, and information is not voluntarily shared. Building trust in these circumstances is clearly difficult, and based on the results of this study, impersonal organisational trust is the foundation for other trust types. Both in research and among employees and managers, trust is agreed to be a fundamental factor for cooperation among interdisciplinary and diverse teams, and efficient information processing is crucial for the NPD project.

Secondly, a major issue impacting project communications is also the fact that, historically, many project managers have a background in engineering, with very limited education and training in communication and knowledge management, and therefore the emphasis is on the processes, products and structures rather than on human side (Kerzner 2006). This was the case in this study as well. At the focus group interviews, there was agreement that there is not enough emphasis on the soft people side of projects and team building. In project lessons learned discussions for example, the amount and nature of feedback given on the “how” side of project work, in addition to the content side were considered inadequate. It is easy to forget that information and knowledge in projects is always shared -or not shared- through humans and hence a fundamental understanding of the human aspect is needed.

This study further develops the research on information processing in global virtual projects and provides knowledge on the most significant issues which impact communication in virtual work settings. The results show that organisational virtual capability is an antecedent for impersonal trust and it fundamentally impacts development of personal virtual communication competences, which can enable development of interpersonal trust types in virtual work settings. Finally, the concept of virtual communication capability and virtual communication competence are offered for further investigation and validation in different organisations and different research environments and more in depth. The following discussion provides a new multi-disciplinary perspective for understanding information processing in virtual teams.
4.2 Research contribution

Conceptually, this work follows the work of, e.g., Daft and Lengel (1986) and Jarvenpaa (1998) and Martins et al. (2004) by adding knowledge to the scientific discussion of temporary, culturally diverse and geographically dispersed work groups. Foundations lie on knowledge management, which relates to knowledge structures at work, and to those attitudes and feelings through which the members of a community understand, explain and assess their work environment through communication (Choo 1998). The goal of NPD projects is to create value to all stakeholders through efficient information processing, which results into economic success and knowledge creation and learning on personal and organisational levels. This study theoretically develops the body of research on virtual teams, virtual communication competencies, virtual capabilities, through which organisations can develop antecedents of impersonal and interpersonal trust. In addition it brings new perspectives to new literacies and information environment research in Information Studies.

Knowledge management culture enables utilizing organisational and expert knowledge and value creation through identifying, capturing, and sharing information and expert knowledge through integration mechanisms. Efficient information processing practices enable return on organisation’s expert knowledge and on individual level, personal virtual communication competence enables information to transfer into knowledge. This can change experts existing knowledge structures. However, as Wilson (2002) has argued that history has shown; whatever businesses claim about the significance of knowledge management culture and people being their most important resource, businesses never hesitate to rid themselves of that resource (and the knowledge it possesses) when market conditions decline. Therefore the uncertainty of the environment will always be present and there will be challenges in building impersonal trust in organisations.

Communication in virtual teams was investigated through an information processing lens, which follows the research tradition of Daft and Lengel (1986), Van de Ven (1976) and Galbraith (1974). Information processing is typically organized through both informal and formal communication practices by using integration mechanisms to enhance commitment, plan, share tasks, manage change, generate action, create common understanding, make decisions, enhance the development of trust and simply transmit knowledge and information between
teams and individuals. Therefore, information processing is a crucial aspect of knowledge management.

Traditionally communication has been seen as a linear process where sender sends the message to the receiver, who then gives feedback (Fairhurst & Putnam 2009). This study expands the field of Communication and Information Studies and virtual project management research, through observing different phases in the communication process in virtual work settings, which realizes in various information processing practices through organisation’s integration mechanisms. Information studies the virtual communication competence research contributes to the research on literacies e.g. on new literacies’ research by Coiro et al. (2008).

Instead of discussing the advantages of using virtual teams in projects versus traditional project teams, the discussion would benefit from focusing on organisational virtual capabilities and personal virtual communication competencies instead. It is a matter of how virtual teams should be organized, supported and managed in order to ensure the development of trust in different contexts and situations. Particularly dynamic and complex projects in product development seek to leverage superior knowledge in virtual settings to capture favourable labour costs and combine expert knowledge (Gibson & Gibbs 2006). It is also matter of defining the tasks, which are needed to accomplish and then decide, if virtual team is the best solution. Virtual projects are here to stay, and virtual communication capabilities and competencies are needed to secure efficiency in global projects, enable remote work, utilize expert work globally and enhance experts’ general satisfaction and wellbeing at work.

This research complements virtual project research and field of knowledge management by shedding light on the impact of antecedents of impersonal and interpersonal trust on virtual project communications, particularly the impact of different types of trust on communication is a significant finding (Lohikoski et al. 2016). Barriers to information processing were investigated using a multidisciplinary approach, and the discussion on virtual project teams was enriched with an approach from communication and information studies.

4.2.1 Information processing in virtual NPD projects

Cross-cultural global projects have changed the working environment significantly, and it is crucial to recognize what kind of information processing and integration mechanisms are needed in each phase of a project. Knowledge is a corporate asset, and therefore it is crucial to consider how information processing
practices are organized and what the organisation’s role is in supporting interactions. In R&D projects, information processing needs depend on the size and complexity of the organisation itself and on task variety and task analysability (Tushman & Nadler 1978, Daft & Lengel 1986). Extensive experience in cross-cultural virtual project work itself can be tacit knowledge on, for example, how to give and receive feedback and how to share tasks across different cultures and across organisational boundaries through ICT. This can be referred to as tacit knowledge that can exist in relationships, practices and social networks that emerge over time. This is in line with previous research by Choo (1998).

However, in large global companies, economical objectives and knowledge management culture and the ways of conducting information processing do not always meet in a way which would enhance a project’s success. Knowledge management culture, which sees knowledge as a resource is essential. It is suggested that recognizing, measuring and rewarding virtual communication competence would benefit knowledge-based work. Also communication planning and training in addition to usable information systems and ICT are needed to support identification, capture and sharing information and knowledge. Figure 4 explains the positive cycle of building knowledge management culture for information processing in virtual projects.

Fig. 4. The connection between company knowledge management culture and communication processes and information processing in projects.
Foundations of successful virtual project communications lie on knowledge management culture with vision, mission and strategy for each project. Each project phase has different communication needs, which need to be taken into account when organizing communication practices in virtual work settings. Particularly starting and ending the project define how information and knowledge can be identified, captured and shared within projects. In this study organizing and utilizing communication practices in virtual projects stemmed from prior experiences and habits rather than systematic training, which lends support to Davenport and Prusak (2005).

Information processing should typically be the most intensive at the beginning and end of a project (Ramesh & Dennis 2002) when there is the most equivocality and ambiguity in information. In the case company, the need for information processing was acknowledged at the beginning of a project, when there typically was not enough emphasis on team building and “how?” aspect of communication. This negatively impacted information sharing behaviours due to lack of shared understanding on goals and objectives and virtual team spirit.

The completion of the project did not receive appropriate emphasis at the case company, as the lessons learned were not collected, discussed, shared and distributed efficiently enough. Nor were the tasks analysed in terms of using integration mechanisms properly. Proper lesson-learned practices are suggested to prevent information processing barriers in future. There were also prior negative experiences in virtual projects, which impacted information processing. Such barriers are typically e.g. inadequate and inefficient information sharing behaviours, egocentrism (Lohikoski et al., 2015) and escalations of unresolved conflicts, which can be potential factors in harming interactions between people, which were presented also by Kankanhalli et al. (2007). Limited shared working history combined with improper lesson-learned practices had led to unresolved conflicts in the case company, which continuously harmed interactions in virtual projects. This study confirms the significance of lesson-learned practices in projects. It would be beneficial to evaluate and discuss both the content side “what” and communication aspects “how” and “why” sides of a project’s success.

### 4.2.2 Barriers to information processing in virtual NPD teams

The case company’s most frequently used communication practices during the lifecycle of a project are e-mail and meetings. Telephone calls, teleconferences, and web conferences are also used, in addition to wikis in Poland. There was
variety among the different sites concerning which tools were used and which ones were considered effective and for what purpose. However, there were also differences in opinion within sites and within teams, for example, regarding the use of e-mail. Some informants considered e-mail as a useful and easy communication method, even in complex issues, whereas others considered it harmful and a potential cause for misunderstandings and even conflicts. This finding validates the previous studies (Zigurs 2003, Kirkman & Mathieu 2005) about e-mail’s harmful impacts. In e-mails, people typically overestimate interaction cues (Keysar & Henley 2002), which caused inefficiency in information processing in the case project. Communicating emotions and transmitting content that is high in ambiguity or is humorous can be challenging because vocal cues are not usually present (Rice & Case 1983). This study further shows that emotions can be transmitted, but they are often interpreted the wrong way. For example, in e-mails, emoticons or humour are understood in different ways in different situations by different people.

There are several types of barriers to processing information in virtual teams. People often expect to communicate better when they share more information than when they share less (Keysar 2007), but this sort of communication does not lead to success in virtual teams where information overload is increasing. Extensive ICT usage in information processing can be a risk to projects and can lead to harmful interactions among individuals (Baltes et al. 2002), increasing the amount of conflicts in virtual teams (Hertel et al. 2005). In asynchronous communication, unstructured e-mails, large numbers of e-mails and excessive length in e-mail messages are common information contingencies. Large numbers of e-mails cause an inflation in the urgency of actions needed, and it is not always clear who is responsible for the tasks delegated via e-mail. Unstructured messages and/or those with excessive length can cause the actual message to be lost and even cause conflicts, which has been previously identified by Lohikoski and Haapasalo (2013) and Brown et al. (2007). Pre-planned response times to e-mail messages would avoid conflicts and delays due to decreased uncertainty. Rules for sharing information have also previously been identified by, e.g., Malhotra et al. (2007) and Zigurs (2003). It is significant that for some team members of the case company, communicating emotional content was easier through e-mail than face-to-face. The leaders in the case study also considered e-mail to be a safer and easier way to share tasks.

The inability to choose the right tool for each purpose is a result of a lack of training and planning for virtual work. It was not acknowledged among
informants that some tools are more suitable for transmitting tacit knowledge than others. Tools and methods for information processing were wrong in some cases, depending on the task. Therefore, teams would benefit from acknowledging the differences between different types of information, choosing the right tool for each purpose and defining rules for using them.

Miscommunication caused by language use has been identified by Wall and Callister (1995) and Liebowitz and Wilcox (1997) as one of the most common problems in team communication. This was also recognizable in the case company. Inadequate language skills cause misunderstandings, and communication with those who have inadequate language skills takes more time than communication between native speakers and speakers who are fluent in the company language. Similar barriers to the communication process have also been recognised by Daft and Lengel (1986), Huijser (2006), Rice and Love (1987) and Wall and Callister (1995). To sum up, the different methods of using and interpreting language and ICT tools make communication complex in virtual NPD teams, which supports the findings by Morreale et al. (2001). Also Wilson (2002) stated that knowledge structures between each individual are different. Therefore the knowledge, which is built from the received message, can never be exactly the same as the knowledge base from which the messages were uttered.

4.2.3 Overcoming information processing barriers

Knowledge exists at the organisational and the personal level. Knowledge stems from the previous working experiences of team members, and it is applied to organisational experiences. Knowledge is basically a product of learning. Knowing “what” is not enough (Huang et al. 1999); particularly, in virtual expert organisations knowing “how” and “why” to do things is also significant. Recent research indicates that skills related to organisational virtual communication capabilities and personal virtual communication competence can enhance work flow among virtual teams. Even tacit knowledge transfer is possible in some circumstances in virtual work settings (Harwick et al. 2013, Hertel et al. 2005, Wang & Haggerty 2009, Lee-Kelley & Sankey 2008, Lohikoski & Haapasalo 2013, Lohikoski et al. 2014). This study confirms that knowing “how” is learned by doing things and that engaging in social practices at work is a crucial part of knowledge work. Knowing “how to” reflects the ability to interact with colleagues as well (Ryle 1949). There is a connection between experienced and
perceived efficacy in communication at virtual work and perceived efficiency in information processing in virtual teams (Lohikoski et al. 2015).

It can be expected that by recognizing virtual communication capabilities at the organisational and competencies at the personal levels, it is easier to enhance project success in virtual global companies. In information processing in virtual teams, the “how” part requires planning, measuring, training and rewarding. Particularly knowing the purpose “why” is crucial as well. It is important to recognize, measure, train and reward from developing virtual communication competencies in addition to just measuring the professional content side of the work performance. Virtual communication competence is closely linked to the knowledge management practices of a company as it is an enabler in capturing and sharing expert knowledge. It is agreed among researchers, that training can lead to learning, which result into better performance outcomes in affective, skill-based and cognitive levels (Kraiger et al. 1993).

Knowledge management culture

Aim for knowledge management practices in supporting information processing in projects is to increase knowledge creation and learning, but to enhance collectivist values, accountability and willingness to share information are crucial as well. Organisational culture, leadership styles and management support have an impact on planning, goal setting, communication and interpersonal issues (Martins et al. 2004), which this study addresses further by linking them as antecedents of organisational impersonal and interpersonal trust. Shared KPIs are needed among teams in order to enhance information processing (Lohikoski et al. 2015). Aligning the goals properly is particular crucial antecedent of impersonal trust. During times of a turbulent global business environment, downsizings, merges and employee layoffs, company ethics in managing human resources is crucial. Organisational and management fairness is connected to impersonal trust (Vanhala & Ahteela 2011), which is a basis for managing information processing. It comes down to the question of whether people are willing to share information and knowledge or not.

Organisational virtual communication capabilities include factors which support information processing in informal and formal contexts, both of which are crucial for a virtual project team’s success. An organisation’s support of information processing is particularly needed in project coordination, information processing and building trust among team members. Drouin et al. (2010) has
previously emphasized top management’s support in HR, resourcing and coordination and communication support systems, which this study also validates. A lack of support from the HR and communication departments has lead into a situation in which there were no training or systematic guidelines for communication and utilising expert knowledge in virtual projects in the case company. This directly impacted project efficiency.

**Communication processes and training**

Proper communication practices and adequate ICT tools are needed in each phase of the project lifecycle (Lohikoski *et al.* 2015). Training and support for virtual communication creates clarity for work tasks and enhances information sharing practices and efficiency in communication (Zigurs 2003, Jarvenpaa *et al.* 2004). Several researchers have previously addressed the significance of virtual communication training as well (e.g. Kankanhalli *et al.* 2007, Han and Harms 2010, Lohikoski & Haapasalo 2013).

When coordinating tasks in projects, giving feedback, checking project status and sharing tasks, different organisational and cultural backgrounds need to be carefully considered, which is in line with the previous studies by Bergiel *et al.* (2013), Johns and Gratton (2013), Holton (2001), Faraj *et al.* (2001) and Chen *et al.* (2011). Ambiguity in information processing often leads to inadequate information flow, which is caused, e.g., by misinterpretations of messages, different patterns in sending and checking messages and interpreting silence in different ways, which hinders interpersonal trust. There is a strong need for clear communication about goals and team building virtually (Hertel *et al.* 2005), which was confirmed in this study. Thus, project managers should provide an opportunity for face-to-face communication when possible (Sias *et al.* 2012). Face-to-face communication is especially crucial at the beginning of a project, as also emphasized by Zigurs (2003) and Wang and Haggerty (2009), but it would also be beneficial at the end of the project to secure proper lessons learned practices.

Meetings in the form of a web conference also provide an alternative opportunity for face-to-face interaction and therefore enhance relations between co-workers, but only if they are used systematically and if employees are trained in using them instead of traditional methods of communication, such as e-mail. Informal virtual communication is a crucial part of virtual project communications, which is a finding that contributes to the virtual team literature.
Communication competence is developed through current state analysis, training, feedback and rewarding processes that support virtual team building. Situational strength, which is enhanced through setting clear team and individual level goals and rules and promoting positive feedback and rewards, is likely to positively affect performance and trust. Work situations with little cues, rewards or guidance will increase ambiguity in communication (Dirks & Ferrin 2001), which is a finding supported by this study. The likeliness of media selection depending on the task has been emphasized by Daft and Lengel (1986), but according to the results of this study and communication research, e.g. Keysar (2007), the message sender or speaker usually is not aware of the ambiguity of his message.

**Virtual communication competence**

It is suggested that virtual communication competence is needed to impact positively to projects success. It has been seen to enable information to transfer into knowledge in both individual level, project level and on organisational level. Basically, better knowledge of an expert’s characteristics and virtual communication competencies can lead to efficiency in product development projects. Knowledge of these competencies can also be used to form smarter strategies on learning and knowledge management practices and to make wiser decisions on customers, communication strategies and product and service lifecycles.

Past research has indicated that tacit knowledge related to complex technical issues is difficult to transfer virtually. It has been indicated that physical presence is often needed for knowledge creation and communication, as suggested by, e.g., Nonaka and Takeuchi (1995). Davenport and Prusak (2005) have stated that managers get most of their information from face-to-face and phone conversations. However, recent research by Harwick *et al.* 2013, Hertel *et al.* (2005), Wang and Haggerty (2009) and Lohikoski and Haapasalo (2013) has argued that certain communication skills enhance tacit knowledge transfer, even among virtual global teams.

Personal communication competence is crucial in order to effectively work on virtual global projects. Professional competence and knowledge of the content is, of course, the foundation, but company language skills are the foundation on which to build the interaction. Cultural knowledge and sensitivity, which profoundly enhance communication as well as the ability to listen is crucial.
Listening has three phases, receiving the message, constructing meaning for the message and giving feedback. Therefore to work successfully in virtual project teams, the ability and willingness to listen and understand the message sender is crucial, in order to achieve shared understanding and to form new knowledge. Giving feedback virtually is often inadequate and therefore listening can become difficult.

A vast amount of communication is often conducted via e-mail, even if it would beneficial to choose other tools, such as social collaboration platforms or web conferences, for certain purposes. Thus, e-mail etiquette is needed for employees to determine which topics are suitable for communication via e-mail and which topics are better suited to another method. E-mail etiquette also consists of the ability to write brief and informative e-mail messages with proper company language skills across cultures and time zones. Further, it is important to choose the correct receivers for each message and to avoid discussing complex or emotionally charged issues and topics high in equivocality via e-mail as the possibility of misunderstandings or conflicts is great in such circumstances.

In virtual projects, it is typical that using ICT extensively for information processing can be a risk to projects. It can also lead to toxic interactions among individuals (Baltes et al. 2002), which increases the number of conflicts in virtual teams (Hertel et al. 2005). Spontaneous communication impacts positively on building shared identity between team members and it can even reduce conflicts (Hinds & Mortensen, 2005). Therefore utilizing company social media and chat offers lots of potential for building team spirit virtually. Mastery in using ICT is needed to efficiently utilize the impersonal mode of communication, such as wikis, blogs and company social media. In addition, team working skills consisting of accountability and credibility are globally highly valued characteristics of employees in virtual projects. Typically there are differences between nations and corporate cultures with regard to how companies share information. Figure 5 presents elements of personal communication competences.
Fig. 5. Elements of personal virtual communication competence.

4.3 Impact of trust on information processing in virtual teams

In the case company, the willingness to receive and share critical information and knowledge with other sites decreased due to increased competition. This is something that has previously been identified by Lipnack and Stamps (2000). Fairholm (2009) identified managing competition and fair play as part of organisational capability; according to Vanhala and Ahteela (2011), organisational fairness has an impact on impersonal trust. The lack of shared goals among virtual projects is also in line with Daft’s (2010) perceptions of common challenges in multinational global teams. The significance of trust for communication is a commonly agreed fact among knowledge management researchers. The capability and competence to build antecedents of impersonal and interpersonal trust is a foundation for international virtual project teams, which is one of the main findings of this study. It is suggested that impersonal trust can be built through organisational virtual communication capability, which has a direct impact on personal communication competence and the development of interpersonal trust among employees as well. Structural factors (technology, operational and individual) have previously been identified as an essential element in team

**Impersonal trust**

Impersonal trust has a fundamental role in building knowledge management culture. Antecedents of impersonal trust are moderating employee virtual communication competence, but also their willingness to communicate. First, a supportive knowledge management culture is needed to ensure aligned organisational goals and ethical and fair management practices. Recognising knowledge assets is crucial in order to create value of expert knowledge. Important antecedent of impersonal trust is reliable and usable ICT and information systems, which are needed for virtual information processing. Through knowledge management culture and communication processes, integration mechanisms are utilized, aligned and designed for the characteristics of virtual work. Shared goals, guidelines and rules for virtual communication increase predictability as well (Zigurs 2003). Shared goals and guidelines is a fundamental antecedent in establishing impersonal organisational trust in virtual projects. Importance of goals and guidelines is a finding, which is in line with prior research by Mayer et al. (1995) as well.

Impersonal trust enhances the willingness to communicate, and particularly efficient HRM practices have a crucial role (Vanhala & Ahteela 2011). The importance of human resources in staffing, training and career development purposes in virtual teams has previously been identified by Drouin et al. (2010). This study underlines the fact that antecedents of impersonal trust increase the likelihood of virtual information processing, resulting in favourable outcomes. Team members’ objectives and goals should be aligned, as verified in this study. As suggested and discovered in this study, impersonal trust is the foundation for interpersonal relations. Trust in fairness, within both organisational processes and the supervisor–employee relationship, can impact wellbeing at work and even employee health, as was previously argued by Elovainio et al. (2002).
Interpersonal trust

Interpersonal trust is needed to enhance the willingness to communicate and to receive information and knowledge. Without interpersonal trust, tasks that are shared through e-mail can be ignored; in addition, messages are easily misinterpreted. If persons at another site do not have the proper company language skills or technical understanding, they are less willing to try to communicate. Thus, communication becomes difficult and more time consuming, as Kock (2005) also discovered. In the case company, the communication methods and tools were chosen based on assumptions regarding the receiver’s language skills rather than on the communication need. Cognitive trust in colleagues’ professional competence was considered high, although this applied mostly to co-located team members, which increased willingness to receive and send information and knowledge locally.

Trust among virtual project members was considered challenging to build. In addition, interpersonal trust was considered challenging due to the quality of previous interactions and the team-building practices in global teams, which can be connected to poor lesson-learned practices in prior projects. Lack of interpersonal trust impacted negatively on listening phase, as interpretations of messages and constructing meaning for the message was more prone to misunderstandings and misinterpretations, which could result into time consuming conflicts and manager escalations.

Interpersonal trust in the case company was based on work relationships and was strong in all sites. However, it had not developed in virtual projects due to inadequate communication skills, a lack of support mechanisms and a lack of team-building practices for virtual work. Most informants considered their ICT and communication skills adequate for working in virtual projects, but language and relationship problems were mentioned as major challenges. Transmitting tone of voice or humour via e-mail is difficult; usually, the sender is not aware of this until it causes conflicts. In addition, communicating social and emotional content is challenging, which was previously discovered by Rice and Love (1987) and Te’eni et al. (2007). Survey results were varied regarding transmitting complex technical knowledge through ICT. Some deemed it possible, while others considered it more difficult. In virtual communication, it is typical that goodwill is hard to observe and humour is hard to interpret over different cultures, and expectations about actions and the actions themselves are not visible.
The interviewees mentioned that interpersonal trust reduces relationship-based conflicts, even in asynchronous communication. It was stated that after meeting someone face-to-face even just once, one can tell whether he/she can competently perform work tasks, which is related to impersonal trust and cognitive and swift trust capabilities. Therefore, when communicating only asynchronously, competence-based trust does not develop so easily. Brashers (2001) explained that previous interaction can either increase or decrease uncertainty. In a project successful previous interaction is an ingredient in the development of interpersonal trust. More specifically, previous unsuccessful interactions were identified as a common barrier to communication, as Sonnenberg (1990) also has found.

Previous work history—or the lack of it—among virtual projects also had an effect on impersonal and interpersonal normative and cognitive trust. There was normative and cognitive trust between team members in Finland and team members in the United States due to previous successful shared projects and 15 years of shared work history. Therefore, professional communication between these teams was considered easier than with other sites.

Moderating roles of interpersonal trust have been earlier identified generally by Dirks (1999): high trust levels in general translate into better group processes and low levels of trust lead into high performing individuals rather than high performing teams. One of the most essential findings of this study was that interpersonal cognitive trust in colleagues’ professional competence and language skills is needed for information processing. Trust is needed in order to ask for advice and support, which is line with the findings by Peters and Manz (2007). Thus, cognitive trust is an essential type of interpersonal trust for virtual projects, because it is needed to give advice as well. Cognitive trust also has a substantial influence on the willingness to use tacit knowledge (Holste & Fields 2010), and it is based on the rational process of choosing between costs and benefits of sharing (Lewicki & Bunker 1995), which was true in the case company. Colleagues whose competence level was perceived as unclear by colleagues or who were perceived as incompetent were not involved in decision making and they were easily blocked out of conversations. Cognitive trust is essential in virtual global projects, and communication processes should enhance the development of employees’ faith in their own and in their colleagues’ both professional and communication competences. Therefore emphasising and promoting knowledge management practices in projects, is important.
4.4 Working knowledge for practitioners

This study provides working knowledge in the competencies needed at both the personal and the organisational level to enhance information processing in virtual projects. There is clearly a connection between experienced and perceived efficacy at virtual work and efficiency in information processing in virtual teams. In addition, there is a strong connection between organisational impersonal trust and the development of interpersonal trust in virtual teams. It can be expected that by recognizing virtual communication competencies at the organisational and personal levels, it would be easier to enhance the knowledge management culture in virtual global projects, therefore increasing the success of virtual projects. In addition to knowing the “what” part in virtual team members competencies, the “how” part needs more attention. Further, the “why” parts of knowledge management require clarification through clear goal setting.

It is crucial to recognize, measure, train and reward employees when developing virtual communication competencies. At the personal level, such competencies are cultural knowledge and sensitivity, adequate company language skills, listening skills, mastery in using ICT, e-mail etiquette and reliability and accountability.

At the organisational level, support for developing virtual team communication is needed, and it is the knowledge management culture which counts. It is necessary to recognize, measure, train and give feedback and rewards for proper communication practices and reliable behaviour. In addition, ICT tools and communication processes which take into account the different information processing needs at different phases of projects are crucial. Having different KPIs for each site increases competition between sites, which makes knowledge a source of power; therefore, sharing information and knowledge becomes an issue of trade in virtual projects. Organisational support in practice means setting clear goals which support teamwork, and providing the necessary tools and proper training for virtual work are also needed. In practice, this enhances the development of organisational impersonal trust, which is the foundation for interpersonal trust in virtual teams. Interpersonal trust enables efficient information processing and communication, which is behind a virtual project’s success.

The significance of communication competencies as part of knowledge management strategies will grow in the future. An increasing amount of work is conducted in projects at dispersed organisational settings globally, which places
additional challenges on communications management. This dissertation answers to these challenges by proving the concept of virtual communication competence to enable planning, measuring, training and rewarding to communication competence in global teams. Table 7 describes the practical implications of this study.

Table 7. Personal communication competencies in virtual NPD projects.

<table>
<thead>
<tr>
<th>Personal communication competence</th>
<th>Working knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-mail etiquette and media skills</td>
<td>Follow the etiquette. Limit the length of emails and use structured messages and lists. Mandatory company language and e-mail etiquette training. Organize follow-up and rewarding procedures and practices. Utilise modern web conferences (“virtual windows”) and social intranet solutions more often to replace face-to-face communication to reduce e-mailing and to enable informal coffee table discussions. Utilise chat to enable informal and formal ad hoc communication.</td>
</tr>
<tr>
<td>Company language skills</td>
<td>Mandatory language training. Do not allow other languages in, e.g., meetings, documentation or any type of e-mail. Organise follow-up and rewarding procedures.</td>
</tr>
<tr>
<td>Mastery in using ICT</td>
<td>Peer to peer communication by, e.g., chat tools and phone. Avoid manager escalations in e-mailing. Know which tools are appropriate for each task, topic and project phase and provide training. Utilize social media tools for transmitting ideas, emotions and concepts and to influence decision making and opinions. Be visible and market your own and your project’s competence and success. Use blogs, videos, wikis, digital photos and company internal and external social media for networking and knowledge creation and learning.</td>
</tr>
<tr>
<td>Cultural knowledge and sensitivity</td>
<td>Encouragement of ethical behaviour through management. Ethics in communications means also inclusiveness. Principle: no one will hurt you. Mandatory cultural training.</td>
</tr>
<tr>
<td>Listening skills</td>
<td>Inclusive behaviour, reducing egocentrism, ability and willingness to understand message sender’s point of view in virtual meetings, when reading text and in face-to-face communication and to give feedback and to ask questions in order to create a shared understanding.</td>
</tr>
<tr>
<td>Accountability and reliability</td>
<td>Roles and responsibilities clearly defined in each project from the very beginning. Recognize the different communication needs in each project phase. Fact-based decisions and information processing to avoid confusion, misinterpretations and conflicts.</td>
</tr>
</tbody>
</table>
4.5 Conclusions

Producing services and products and generating new knowledge in global virtual project environment requires new capabilities and competencies. Knowledge is always partly intangible and amount of information is vast, which means a deep understanding of their nature as resources is essential. This finding contributes to the view of knowledge-based firms, which means individuals can’t contribute and work fully productively without proper organisational culture, information systems, ICT and communication processes. Global virtual project environment is a collection of variety of norms, routines, cultures and different ways of interpreting and using information and knowledge, which increases uncertainty and equivocality. Therefore strong organisational capabilities are needed in order to support information’s transformation into knowledge in projects and on individual level and to enable learning and change. In addition virtual communication capabilities are needed to support information’s transfer into knowledge on project level. Proper communication practices are needed in each phase of the project lifecycle, in addition to provide adequate tools for both informal and formal communication. Culture of success is enabled when, information can transfer into knowledge in projects and when lessons learned in projects can be shared into organisation to be used. These are the antecedents of impersonal trust, which is an enabler for interpersonal trust.

Interpersonal trust is needed to enhance the willingness to communicate and to listen to others on personal level, which reduces equivocality and uncertainty. Without interpersonal trust, tasks that are shared through e-mail can be ignored; in addition, messages are easily misinterpreted and messages are not listened. It can significantly hinder information’s transfer into knowledge on personal level and on project level, which can have a negative impact on organisations as whole. Personal communication competence is crucial in order to effectively work on virtual global projects. Company language skills are the foundation on which to build the interaction. Cultural knowledge and sensitivity, which profoundly enhance communication as well as the ability to listen is crucial. Therefore in order to work successfully in virtual project teams, the ability and willingness to listen and understand the message sender is crucial, in order to form new knowledge. There are differences between nations and corporate cultures with regard to how companies share information, particularly there are differences concerning perceptions of trust and values. Accountability and reliability are valued in all countries considering this study, and it is the matter of knowledge
management culture in projects to support such behaviour. Knowledge management should support information processing in projects in order to enhance knowledge creation and learning, but to enhance collectivist values, and to reduce egocentrism. Increasing accountability and willingness to share information are particularly crucial.

4.6 Recommendations for further research

Naturally there are several extensions for further research. Such research could collect data from other empirical contexts and collect large-scale data to test the presented conclusions. It is evident that there is a connection between virtual communication training, impersonal trust, experience and perceived efficacy at virtual work and development of interpersonal trust in virtual teams. It can be expected that through recognizing virtual communication competencies at the organisational and personal levels, it would be easier to enhance the knowledge management culture in virtual global projects, therefore increasing the success of virtual projects. Future research could thus assess the ways virtual competencies develop in various types of organisations and what kinds of competencies are needed in different environments and in different projects. Further research could also assess parts of virtual communication in more depth; for example, mastery in using ICT could be investigated more closely in terms of utilizing company social media for decision making and in enhancing different types of interpersonal trust. The utilization of social media in companies’ internal communications offers a huge potential both for research and for practice. Social media can provide an organisation and its stakeholders an effective tool for relationship building and networking, and it may be a crucial success factor for projects in the future (Hudson & Hudson 2013, Waters 2009); more multi-disciplinary research could systematically assess the use and implications of communication practices in social media.

Another fruitful approach would be to study the relations between company knowledge management culture, the selection of ICT tools and their usability in virtual communication. Also usability and value creation through crowdsourcing, internal and external social media and new collaborative tools for learning and decision making are significant areas for research. This would be especially useful for comparing working practices among different generations. Moreover, the broader area of a company’s efforts to enhance employee retention in Asia and how to integrate different working cultures in virtual settings could be studied.
further. Particularly studying different ways of listening and scanning the environment would be beneficial to enable transfer from information to knowledge in project and organisational level.

In the context of this study, in project communications, utilizing modern ICT efficiently and for the right purposes requires further development. Utilizing proper communication practices in communicating goals and giving feedback also require more work. Aligning company strategy to a particular project’s goals needs more work and more efficient company internal communication.

Naturally, the empirical data presented in this dissertation are based on a specific empirical context. Future research could engage in collecting data from other empirical contexts as well as on a large scale to test the presented conclusions. One aim of this study is to promote multi-disciplinary discussion by telling researchers and practitioners with different purposes in different fields of science about richness in human communication, so they can draw inspiration and ideas to their work.

4.7 Validity and reliability

A multi-method case study, which was utilized in this study, does not lead to a validated new theory with widely generalizable results. However, it provides empirical insights, working knowledge (Barnett 2000) and theoretical ideas for future research. The case organisation has extensive experience in virtual ways of working in a global environment. Informants presented a rich variety of nationalities and positions in the organisational hierarchy, with up-to-date knowledge and experience in virtual NPD projects.

Construct validity (Yin 2009) concerns the relevant research setting for the topics being studied, which can be enhanced by using multiple sources for evidence and letting research partners review the outcomes of the research process and research reports. This was realized in each phase of this research project. Co-authors, case company members and participants at scientific conferences and seminars had a chance to comment on the research process.

The internal validation (Yin 2009) of the research was enhanced by creating a trusting atmosphere in the interviews and by discussing the results with the informants. The informants were encouraged to provide honest communication by assuring them of the confidentiality and high research ethics of the study. The informants were prior colleagues of the researcher, and therefore the questions were answered honestly and openly. Also, the accuracy of the research results was
validated in focus group interviews. Other researchers and case company members were involved in the data analysis phase. Finally, each article was double-blind reviewed and commented on by the members of the scientific community in academic journals.

The case organisation has extensive experience in virtual ways of working in an international environment. The informants had a rich variety of nationalities and positions in the organisational hierarchy, which increases the relevance of this study. It is very rare to have an access to this type of data and it requires trusting relations with the case company members, which was realized in this study.

Reliability is related to the consistency of a researcher’s approach across different researchers and projects (Cresswell 2009). This thesis is based on a case research protocol (Yin 2003) which was developed together with other researchers. Reliability increases when data collection is standardized and the data is recorded and documented properly; hence, multiple researchers were utilized in this study and the semi-structured interview protocol (Riege 2003, Yin 2009) was used. The case study protocol was also discussed with the case study participants at the case company before the interviews. Test interviews were conducted and interview questions were improved based on the comments from the participants. The interview questions and a description of the research group, research aims and foundations were also sent to the informants well in advance of the interviews. Reliability addresses the replicability of the research (Denzin & Lincoln 1994). It refers to the ability of subsequent researchers to arrive at the same results if they conducted the research along the same path again (Denzin & Lincoln 1994). The same data collection method was used at each phase and a consistent set of interview questions was used at each interview. In the analysis phase, the data were coded and sorted into themes in order to ease the analysis and make comparisons. Conducting the same research twice and finding exactly the same results is, however, impossible since the organisation has renewed and changed since 2014 and interviews with human beings are often subjective. It is also impossible, because the case organisation’s members were trained for better virtual communication competence by the researcher and communication guidelines were offered to the organisation members.

### 4.8 Limitations of this research

This research has several limitations: The first is that this research is a case study, which does not allow for wide generalizations. Siggelkow (2007) suggested that
building theory from case studies results in narrow and there are only modest results concerning theory. With a wider spectrum of cases in different companies, more universal knowledge would have been created. The case company has extensive experience in virtual working modes, with great diversity in employees with regard to both corporate and country cultures, and therefore it offers fruitful arena for research, making this research relevant. Every community has its own norms for how to get along, what information can be shared or withheld and what interests must be protected (Schein 1996), and therefore new case studies are always needed. They provide rich and deep knowledge of the studied phenomena and concepts.

The generalizability of the findings is lower in this case study than it is in multiple case studies. It is also lower because the research was conducted only in limited number of countries and only in the ICT industry in NPD teams. Hence, the outcome of this dissertation may not be generalizable to other types of projects or industries. Furthermore, if there had been a chance for, e.g., ethnographic longitudinal research, the virtual communication competence could have been investigated more substantively and in depth.

Other limitations arise from researcher bias. Because I previously worked in the case company and as an e-learning teacher, it is possible that my experiences and opinions about virtual communication competencies have influenced my analysis and practical implications. A researcher’s own biases and instincts tend to impact on research (Berg & Smith 1988), and therefore it is important to question the research and look for alternative explanations. This was realized in discussions with co-authors and case company members, because in research, it is crucial to discuss and look for alternative explanations for situations. Critical thinking is an ability to observe phenomena from different perspectives from different theoretical angles, which is a competence that I learned at the Faculty of Humanities. Another bias arises from interview-based evidence, which is seen to sometimes be false due to retrospective sense making (Eisenhardt & Graebner 2007). This was tackled through focus group interviews during research validation.

The research terminology is challenging due to the researcher’s multi-disciplinary background, which evolved throughout the research process. In information studies, communication studies and industrial engineering management, there are different traditions in terms of communication, which is seen in this dissertation. However, in Finnish language the term “viestintä” in this dissertation’s context in practice means information processing, communication
The term information processing refers to both knowledge transfer (publication I) and communication (publications III and IV). The concept of virtual communication competence also evolved throughout the research process. Diverse terminology and a variety of concepts is a common issue in project and virtual team literature due to its multi-disciplinary field, and thus the reader must be aware of the different traditions in different fields of science. I have had the opportunity to transfer from one research community to another, which also resulted in this diverse use of terminology. The meaning of each concept has been explained in this thesis. In addition, conceptually, trust is a challenging topic to study, but it is possible to define trust itself, the factors that cause trust and the outcomes of trust (Mayer et al. 1995). However, it is clear that doubt can never be entirely removed what comes to a researcher’s personal understanding and final conclusions (Berg & Smith 1988). Hopefully this raises new research questions for further studies.
5 Summary

This dissertation offers empirical insights and working knowledge in the form of practical implications for managing virtual projects and it also provides theoretical ideas for future research. The case organisation has extensive experience in virtual ways of working in an international environment. Informants were from a rich variety of nationalities and positions in the organisational hierarchy, which increases the relevance of this study. It is very rare to have access in this type of data, and it required trusting relations with the case company.

Organisational impersonal trust and interpersonal trust are interrelated in virtual teams. There is also a connection between antecedents of impersonal and interpersonal trust and experienced and perceived efficacy at virtual work and efficiency in information processing in virtual teams. It can be expected that by recognizing virtual communication capabilities and competencies, it would be easier to enhance learning and knowledge creation in virtual projects. It is all based on the knowledge management culture, which can be an enabler for successful global projects. In addition to knowing the “what” part of virtual team members competencies, the “how” part needs more attention. Further, the “why” parts of knowledge management practices need more attention. It is crucial to recognize, measure, train and reward employees to develop virtual communication competencies. At the personal level, such competencies are cultural knowledge and sensitivity, company language skills, listening skills, accountability and credibility, mastery in using ICT and e-mail etiquette. These are also related to virtual social and teamwork skills.

At the organisational level, support for developing virtual team communication is needed, and it is the knowledge management culture which counts. Recognizing knowledge assets, measuring, training and giving feedback and rewards and organizing proper communication practices for each phase of the project is crucial. In addition, ICT tools and communication processes which take into account the different information processing needs in different phases of the projects are crucial. Organisational support in practice means, management support, fairness and ethics and setting clear goals which support teamwork and leadership in virtual projects. It is necessary to provide necessary tools and proper training for virtual work. In practice, these are the antecedents of organisational impersonal trust, which is the foundation for developing interpersonal trust. Interpersonal trust enables efficient information processing and communication,
which is an enabler for information’s transfer into knowledge on personal level, which is fundamentally behind also virtual project’s success.

The main objective of this work was to study information processing in global NPD projects to define the virtual communication competencies which support a virtual project’s success. The significance of communication competencies as part of knowledge management strategies will grow in the future. An increasing amount of work is conducted in projects in dispersed organisational settings globally and locally remotely, which leads to additional needs in communications management. This dissertation answers this challenge by proving concepts of organisational virtual communication capability and personal virtual communication competence to enable planning, measuring, training and rewarding in virtual NPD projects, which is a model to be developed further in different context in different fields of science.
References


## Appendix 1

### Questions for semi-structured interviews in Finland, China, Poland and the USA

<table>
<thead>
<tr>
<th>Interview questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
</tr>
<tr>
<td>1. How do cultural differences affect your virtual team’s performance?</td>
</tr>
<tr>
<td>2. How do different personalities affect your virtual team’s performance and structure?</td>
</tr>
<tr>
<td>3. How do you share information and knowledge with your colleagues?</td>
</tr>
<tr>
<td>4. From whom and where do you seek and get support for your work? How?</td>
</tr>
<tr>
<td>5. What kind of role does the training and guiding of colleagues have in your team?</td>
</tr>
<tr>
<td>6. Is professional terminology used as a tool against others?</td>
</tr>
<tr>
<td><strong>Decision making and influencing</strong></td>
</tr>
<tr>
<td>7. In your virtual team, how are crucial decisions made concerning:</td>
</tr>
<tr>
<td>- Recruiting team members (competence needs and requirements)?</td>
</tr>
<tr>
<td>- Evaluating the results of the team?</td>
</tr>
<tr>
<td>- Evaluating the performances of the team members?</td>
</tr>
<tr>
<td>8. How can you influence:</td>
</tr>
<tr>
<td>- Organizations?</td>
</tr>
<tr>
<td>- Projects?</td>
</tr>
<tr>
<td>- Your personal goals?</td>
</tr>
<tr>
<td><strong>Planning and feedback</strong></td>
</tr>
<tr>
<td>9. How can you affect virtual meeting agendas?</td>
</tr>
<tr>
<td>10. How can you influence decision making?</td>
</tr>
<tr>
<td>11. How does your team solve work-related problems and conflicts?</td>
</tr>
<tr>
<td>12. How do you express differences of opinion in your team?</td>
</tr>
<tr>
<td>13. There is a saying, “Knowledge is power”. How do you see that happening at your work place?</td>
</tr>
<tr>
<td><strong>Integration mechanisms</strong></td>
</tr>
<tr>
<td>14. How are your feedback and rewarding procedures planned?</td>
</tr>
<tr>
<td>15. What are the actions that you get feedback and rewards from?</td>
</tr>
<tr>
<td>16. How and in what situations do you get feedback?</td>
</tr>
<tr>
<td>17. How is feedback collected and handled?</td>
</tr>
<tr>
<td>18. What about your personal needs—how do they count in rewarding procedures?</td>
</tr>
<tr>
<td>19. What kind of feedback do you get from making mistakes?</td>
</tr>
<tr>
<td>20. Have you or others been punished from making mistakes? How?</td>
</tr>
<tr>
<td>21. Virtual team infrastructure consists of, e.g., communication tools, goals, meeting procedures and rewarding procedures.</td>
</tr>
<tr>
<td>22. Has your team created its own practices or adopted some other practices to do the work? Could your team’s communication infrastructure is built? What works well?</td>
</tr>
<tr>
<td>23. What kind of strategies do you use to balance personal and work life in a 24/7 global business? How do you work a week?</td>
</tr>
</tbody>
</table>
24. Describe your team spirit.

25. Does everyone do what is expected?

Information contingencies and virtual communication competencies

26. Are you aware of any coalitions between teams or sites?
27. What kind of communication problems have you seen in your team during the project?
28. What are the strengths of your virtual team communication? Why?

29. What characteristics or competencies do you need to perform well in virtual projects?

30. What are the most important characteristics or competencies of a good virtual leader?
31. How would you describe the best practices in virtual team work that enable success in achieving goals?
## Appendix 2

**Operational management interview questions from publication**

<table>
<thead>
<tr>
<th>Themes for the interviews</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Management</strong></td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td>How does trust affect the process of transferring knowledge in a virtual team?</td>
</tr>
<tr>
<td>Conflict resolution strategies</td>
<td>Describe the conflicts in your working environment? How are they solved?</td>
</tr>
<tr>
<td>Leadership</td>
<td>What kind of leadership is needed for virtual projects to succeed?</td>
</tr>
<tr>
<td>Rewarding and feedback</td>
<td>Tell me about your feedback and rewarding procedures? How are they done in a virtual context?</td>
</tr>
<tr>
<td>Job satisfaction</td>
<td>How does the virtual environment affect employee wellbeing at work in general? How about your job satisfaction?</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>How does the virtual working environment affect the company hierarchy and social interactions?</td>
</tr>
<tr>
<td>Recruitment of talented employees</td>
<td>How does the virtual working environment affect the availability of talented employees for projects?</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td></td>
</tr>
<tr>
<td>Nonverbal communication</td>
<td>How does the virtual environment affect the message being discussed? How do you view the lack of nonverbal communication?</td>
</tr>
<tr>
<td>Communication skills</td>
<td>How would you describe effective communication?</td>
</tr>
<tr>
<td>Task-oriented communication</td>
<td>How does the virtual environment affect the delegation of tasks?</td>
</tr>
<tr>
<td>Knowledge transfer agents</td>
<td>What is the role of “knowledge transfer agents” or “gatekeepers” in your organization? What kind of skills do they have?</td>
</tr>
<tr>
<td>Transfer process</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
</tr>
<tr>
<td>Describe the ICT technologies you use. Do you see them as enhancing good</td>
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<tr>
<td>communication?</td>
<td></td>
</tr>
<tr>
<td>Multiple time zones and geographical dispersion</td>
<td></td>
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<tr>
<td>How do multiple time zones and geographical dispersion affect your work? Do</td>
<td></td>
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<tr>
<td>you see them as a challenge?</td>
<td></td>
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<tr>
<td>Virtual competencies</td>
<td></td>
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<tr>
<td>What kind of competencies are needed if you want to work successfully in a</td>
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<tr>
<td>virtual organization?</td>
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</table>

<table>
<thead>
<tr>
<th>Working process</th>
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</thead>
<tbody>
<tr>
<td>Training</td>
</tr>
<tr>
<td>Did you get trained for virtual work? Do people get trained for it?</td>
</tr>
<tr>
<td>Relationships</td>
</tr>
<tr>
<td>How is team and relationship building between colleagues done? Do they get</td>
</tr>
<tr>
<td>evaluated?</td>
</tr>
<tr>
<td>Passion and diversity</td>
</tr>
<tr>
<td>What do you think about the cultural differences and diversity of people in your</td>
</tr>
<tr>
<td>organization? How does that impact projects?</td>
</tr>
<tr>
<td>Effective NPD</td>
</tr>
<tr>
<td>How does the virtual work environment affect new product development in general?</td>
</tr>
<tr>
<td>Temporary convergence</td>
</tr>
<tr>
<td>How do you cope with uncertainty? How about the lack of responses and feedback?</td>
</tr>
<tr>
<td>Tacit knowledge transfer</td>
</tr>
<tr>
<td>Are there things or issues that can’t be transferred via ICT? When is face-to-</td>
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<tr>
<td>face communication needed?</td>
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</tbody>
</table>
Informants’ background information

<table>
<thead>
<tr>
<th>Name:</th>
<th>Age:</th>
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<tr>
<th>Gender:</th>
<th>Educational background:</th>
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<tr>
<th>Position:</th>
<th>Work experience:</th>
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<table>
<thead>
<tr>
<th>Work experience in years:</th>
<th>Work experience in virtual projects in years:</th>
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</table>

Part 2: Description of the challenges and questions
Define the challenges of knowledge transfer and engineering process requirements described below from your perspective. How do they show in your practice?

<table>
<thead>
<tr>
<th>Challenges/themes</th>
<th>Rate from 1-5: How big of a challenge?</th>
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</thead>
<tbody>
<tr>
<td>Management</td>
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<tr>
<td>Trust</td>
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<tr>
<td>Conflict resolution strategies</td>
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<td>Strong leadership</td>
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<tr>
<td>Rewarding and feedback</td>
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<td>Job satisfaction</td>
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<tr>
<td>Hierarchy</td>
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<td>Communication</td>
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List of original publications


Reprinted with permission from IJMKL (I), PMI Conferences (II), IGI Global (III, V), Inderscience (IV).

Original publications are not included in the electronic version of the dissertation.
550. Irannezhad, Masoud (2015) Spatio-temporal climate variability and snow resource changes in Finland
551. Pekkinen, Leena (2015) Information processing view on collaborative risk management practices in project networks
553. Nelo, Mikko (2015) Inks based on inorganic nanomaterials for printed electronics applications
556. Omran, Mandooh (2015) Microwave defosphorisation of high phosphorus iron ores of the Aswan region, Egypt: developing a novel process for high phosphorus iron ore utilization
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559. Ferdinand, Nuwan Suresh (2016) Low complexity lattice codes for communication networks
560. Xue, Qiang (2016) Analysis of near-optimal relaying schemes for wireless tandem and multicast relay networks
563. Huusko, Jarkko (2016) Communication performance prediction and link adaptation based on a statistical radio channel model
564. Nguyen, Vu Thuy Dan (2016) Transmission strategies for full-duplex multiuser MIMO communications systems
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