Knowledge sharing in virtual teams

van der Aa, R.W.J.

Award date:
2009

Eindhoven, September 2009

Knowledge Sharing in Virtual Teams

by
R.W.J. van der Aa

Student identity number 0572476

in partial fulfilment of the requirements for the degree of

Master of Science
in Innovation Management

Supervisors:
dr. J.Schepers, TU/e, OSM
dr. A. de Jong, TU/e, OSM
C. de Jong, Capgemini Nederland B.V.
A. Stan, Capgemini Nederland B.V.

TUE. Department Technology Management.
Series Master Theses Innovation Management

Subject headings: vituals teams, knowledge sharing

Abstract

The aim of the study is to develop an understanding of virtual team characteristics that contribute to team knowledge sharing and the consequences of team knowledge sharing. Based on a review of the literature and an online survey the effect of virtual team characteristics on knowledge sharing and team effectiveness will be explained. The following virtual team characteristics were used in this research: 'communication technology use', 'team imbalance' and 'team member isolation'. Knowledge sharing is measured as "quality of knowledge sharing" and 'willingness to share'. The hypotheses are tested with the results of an online survey executed at Capgemini Nederland. Based on the findings several recommendations for improvements in team knowledge sharing and team effectiveness will be discussed.

Preface

This master thesis is the result of my graduation project which I have conducted at Capgemini Nederland. The graduation project is the concluding part of the master program Innovation Management which I have followed at Eindhoven University of Technology (TU/e). Capgemini provided me with the opportunity to investigate the effect of virtual team characteristics on team knowledge sharing. I would like to use this preface to thank all people who have helped me conducting this master thesis project

First of all, I would like to thank my supervisors dr. J. Schepers and dr. A de Jong of the TU/e for providing me with feedback during the project. Also, I would like to thank C. de Jonge and A. Stan of Capgemini Nederland, for both giving me the opportunity to conduct my thesis at Capgemini and providing me with well appreciated feedback. Furthermore I have to thank all colleagues of Capgemini Nederland for participating in the online survey. Last but certainly not least, I would like to thank my family and friends for their support.

Roy van der Aa
September 2009

Management summary

The current competitive environment has forced many organizations to increase levels of flexibility and adaptability in their operations. A growing number of such organizations has explored the virtual environment as one means of achieving increased responsiveness (Hertel et al. 2005). Modern computer and telecommunication networks reduce the cost of coordination, allowing firms to achieve benefits compared to traditional ways of working. The growing number of virtual teams is being ascribed to the combination of technological and organizational developments along with a range of business benefits related with using of virtual teams. This definition combines the core of traditional dimensions together with the extent of virtualness.

"Virtual teams consist of (I) two or more persons who (II) collaborate interactively to achieve common goals, while (III) at least one of the teams members works at a different location, organization, or at a different time so that (IV) communication and coordination is predominantly based on electronic communication media."

There are four drivers why organizations start with virtual teams (Bal and Teo, 2000). First, organizational trends such as globalization, increasing competition and organizational change. Second, business requirements cross organizational product development, changes in existing products and services, offshore development and manufacturing. Third, technology development advances in electronic communication technology. And finally expertise, firms adopt virtual forms in order to gain benefits of acquiring goods and services from specialized producers, who are able to make these inputs more efficiently. Virtual teams can be composed of the best individuals for the task regardless of their physical of organizational location.

The complexity of virtual teams also has several drawbacks and challenges. In geographically dispersed virtual teams communication is almost always electronic. These differences bring other requirements with respect to knowledge sharing compared to collocated teams that communicate face-to-face. Team members with different expert knowledge are often isolated and dispersed from each other by distance which makes it difficult to them to share expert knowledge. Virtual teams depend heavily on effective knowledge management and it is critical for organizational success (Sarker et al. 2005). Many organizations that are attempting to initiate knowledge management are unsure of the best approach to adopt (Moffett et al. 2002). In this study we investigate how the characteristics of virtual team contribute to knowledge sharing and how team knowledge sharing and effectiveness of the team could be improved. The central research question is this study is:

What are the antecedents to and consequences of virtual team knowledge sharing?

The variables that will be used in this research translated into a research model. Communication technology and team composition are the independent variables for knowledge sharing. Knowledge sharing is defined as processes that will influence team effectiveness. Based on this research model and current literature of virtual teams and knowledge sharing, the following hypotheses were formulated:

H1a: Greater use of available information communication technologies will positively influence knowledge sharing within virtual teams.

H1b: The use of richer communication technology will positively influence knowledge sharing within the team.

H2a: Virtual teams with an imbalanced composition will be worse in knowledge sharing than either balanced virtual teams.

H2b: Virtual teams with a single isolate will be worse in knowledge sharing than teams that are collocated but better in knowledge sharing compared to balanced and imbalanced virtual teams.

H3: Knowledge sharing has a positive effect on team effectiveness.

The survey method was used to test the relationships in the hypothesized model. Data were collected from individual members of teams employed by Capgemini Nederland. The survey has been conducted at the Capgemini sector Travel, Telecom and Utilities. This practice is part of the Technology group of Capgemini Nederland B.V. Most work in this sector is project-based and the Telecom, Travel and Utilities (TTU) sector contains in total 709 employees. In total 102 employees responded on the online survey resulting a response rate of 14,3%.The answer to this research question is based results of the survey and on previous literature.

Team design consists of two items, team imbalance index and team isolation index. Both items are not supported for the quality of knowledge sharing. Thus team design has no significant effect on the accurateness, understanding and completeness of knowledge sharing. Nevertheless, the survey results indicate a negative effect of imbalance with the willingness to share knowledge. This indicates that when there is a high difference in the numbers of team members across different locations, team members are less open to share ideas and show less willingness to help other team members. Thus team design affects the willingness to share knowledge. With a more balanced team, members are more likely to share there knowledge with other team members.

The relation between frequency of communication technology use and knowledge sharing was not supported by the results of the survey. The frequency team members communicate with the available technology will not be related to the quality of the knowledge sharing or the willingness to share knowledge with other members. Nevertheless, the experienced importance of several communication technologies may affect the willingness to share knowledge. Teams that indicate that conference calls are an important technology for communication are more willing to share knowledge compared to teams that indicate instant messenger as important communication technology. Conference calls are a rich communication tool by which multiple people can interact with voice over distance. Instant messenger is a less rich communication tool where team members only communicate with short text messages. The use of only text messengers makes it more difficult to share knowledge and make team members less willing to share knowledge. Furthermore, instant messenger has no possibility to communicate with voice what will slow down the knowledge sharing process.

Both items of knowledge sharing, quality and willingness to share were supported for team performance. Thus if team members are willing to share knowledge in a way it is easy to understand, accurate and complete the team is more likely to meet goals with a higher level of quality. Knowledge sharing probably increases the quality by combining ideas and knowledge of different team members which results in better solutions. The item willingness to share has only a significant positive effect on team member satisfaction.

The results of the data analysis were translated to improve knowledge sharing and team effectiveness of virtual teams. The recommendations that are provided address the team design, communication technology and knowledge sharing.

1) Create balanced teams. The first recommendation is concerning the team design. When a team is more balanced over different locations the chance of excluding individual members from the teams is smaller. This results in teams where members are more willing to share knowledge with other members.

2) Importance of communication technology. Virtual teams mainly communicate with help of electronic communication technology. This research indicates that a higher frequency of communication technology use does not result in significant improvements in the quality of knowledge sharing or motivation to share knowledge. Besides that, in most cases are new communication technologies such as video conferencing not used to its full potential.

3) Stimulate knowledge sharing in virtual teams. This study results demonstrate that knowledge sharing is strongly and positively associated with team effectiveness. To improve team performance like meeting goals and increase team member's satisfaction organizations may stimulate knowledge sharing in teams. Besides, if team members are not motivated to share knowledge it is not likely that they are motivated to use communication technologies that facilitate knowledge sharing.

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Chapter 1: Introduction

The growing number of virtual teams is being ascribed to the combination of technological and organizational developments along with a range of business benefits related with using of virtual teams. A study by the Gartner group found that more than 60% of professional employees work in virtual teams. Also the *Wall Street Journal* reports that more than half of the companies with over 5000 employees use virtual teams (Martins et al., 2004).

The current competitive environment has forced many organizations to increase levels of flexibility and adaptability in their operations. A growing number of such organizations have explored virtual teams as one means of achieving increased responsiveness. Virtual teams differ in two ways from traditional teams, (I) at least one of the team members works at a different location, organization, or at a different time so that (II) communication and coordination is predominantly based on electronic communication media (Hertal et al. 2005). Modern computer and telecommunication networks reduce the cost of coordination, allowing firms to achieve benefits compared to traditional ways of working.

There are four drivers why organizations start with virtual teams (Bal and Teo, 2000). First, organizational trends such as globalization, increasing competition and organizational change (flexibility to react on mergers, acquisitions, downsizing and outsourcing). Second, business requirements cross organizational product development, changes in existing products and services, offshore development and manufacturing. Third, technology development advances in electronic communication technology. And finally expertise, firms adopt virtual forms in order to gain benefits of acquiring goods and services from specialized producers, who are able to make these inputs more efficiently. Virtual teams can be composed of the best individuals for the task regardless of their physical of organizational location.

The examples described above show how a virtual organization breaks the size, time and space constraints, broadens the strategic horizon and offers great benefits for the organizations. The previous drivers for creating virtual teams are from a business perspective. The main advantage of creating virtual teams for employees is to get more freedom and flexibility to plan and execute work at the best possible location. This means a much more efficient way of working, because less time is spent on commuting or on being stuck in traffic. In return it creates the opportunity to achieve a better work-life balance. Furthermore, organizations with virtual teams are able to contribute to cost savings, because clients don't have to invest in extra facilities to accommodate hires anymore. And finally, creating virtual teams enables the organization to act in a corporate sustainable way, by reducing the negative effects of travelling, energy consumption, traffic congestion and tiresome commuting.

The complexity of virtual teams also has several drawbacks and challenges. In geographically dispersed virtual teams communication is almost always electronic. These differences bring other requirements with respect to knowledge sharing compared to collocated teams that communicate face-to-face. Team members with different expert knowledge are often isolated and dispersed from each other by distance which makes it difficult to them to share expert knowledge. Virtual teams depend heavily on effective knowledge management and it is critical for organizational success (Sarker et al. 2005). Many organizations that are attempting to initiate knowledge management are unsure of the best approach to adopt (Moffett et al. 2002). In this study we investigate how the characteristics of virtual team contribute to knowledge sharing and how team knowledge sharing could be improved. Also the effect of knowledge sharing on team effectiveness will be studied. To access these variables Hackman's model of team effectiveness (1983) is used. Hackman's model distinguished the areas organizational context and group design. This model is selected because it is a sophisticated and exhaustive model in terms of variables that might impact group effectiveness. Hackman's model is often used in previous team

research and perhaps the most thorough theoretical model explaining team performance (Yeatts and Hyten, 1997).

To improve knowledge sharing in virtual teams, the following research question will be answered in this study:

Research question:
What are the antecedents to and consequences of virtual team knowledge sharing?

To answer this research question, four sub questions where formulated to finally provide an answer to the main research question.

Sub question 1: What are virtual teams? There are multiple definitions of a virtual team in the literature. Section 3.1 provides an overview of these definitions and the common characteristics of the different definitions where compared. This section ends with the definition used in this study.

Sub question 2: What is knowledge sharing? Another important variable in the research question is knowledge sharing. Based on the literature review a definition of knowledge sharing will be provided.

Sub question 3: What are the antecedents of knowledge sharing in virtual teams? As mentioned earlier, the distinguishing characteristics of virtual team compared to traditional teams are team design and communication technology use. Team design relates to the dispersion of team members over different locations and for communication are virtual team more dependent of electronic communication technology. The focus of this study is on knowledge sharing in virtual teams, therefore the two distinguishing characteristics of virtual team are used in the research model: team design and communication technology use.

Sub question 4: What are the consequences of knowledge sharing in virtual teams? For the last sub question the effect of knowledge sharing on team effectiveness will be investigated. Team effectiveness covers the performance of the team and the satisfaction of the team members.

The next chapter will continue with a detailed explanation of the methodology used in this research. The research model and hypothesis are described in chapter four. To test the hypothesis an online survey is used. The process of data collection and the analysis of the survey results are explained in chapter five. Finally the conclusion will be presented in chapter six together with limitations of this research and options for further research.

Chapter 2: Methodology

The research approach that is used to answer the research question can be divided in into two parts. The first part consists of a literature review to investigate knowledge processes in virtual teams and factors that affect the performance of these processes. This literature review resulted in a research model. In the second part the research model is tested through a survey. The first section illustrates the overall framework that is used as a guideline through this research. The other two sections discuss the literature review and survey research.

2.1 Overall framework

The roadmap in figure 1 indicates the two different phases in this research and the linkages between input and output of each phase. The roadmap also shows the three areas in the literature that are investigated to underpin the research model. The research model will be quantitative tested with survey research. The results of the survey will be used to answer the research question: How contribute the characteristics of virtual teams to team knowledge sharing? The two phases will be discussed in detail in the following sections.

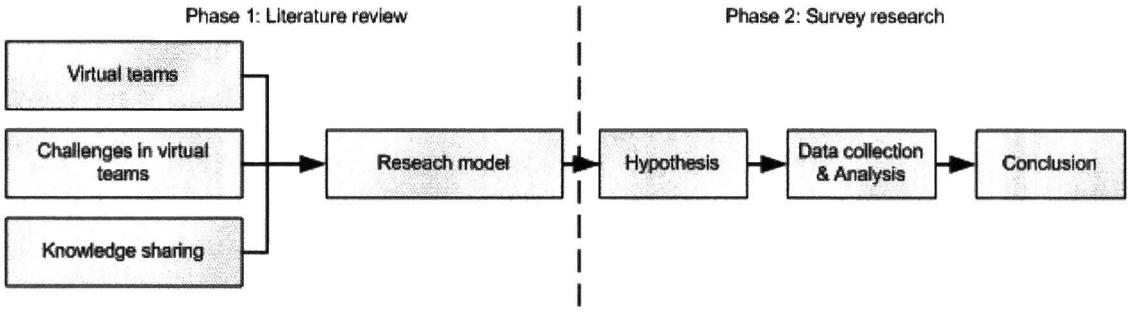

Figure 1 Research roadmap

2.2 Literature review

The literature study consist of three parts, at the end the results of these parts where combined in the virtual team research model. The review begins with a definition of virtual teams and specific characteristics of this kind of teams. The second part describes the challenges of knowledge management in virtual teams. The last part continues with a general view on knowledge management and defines three important knowledge management processes in virtual teams. To access this part of the literature the team effectiveness model of Hackman (1983) is used. Hackman described the areas "organizational context" and "team design that influence team processes and team effectiveness. These three areas are also present in the virtual team research model.

The search for literature was an important aspect to perform this literature review. Search engines like Google Scholar and the database ABI-Inform were used to search for relevant literature. All the found papers were scanned for relevant references.

2.3 Survey research

An online survey will be used to test the hypothesis stated in chapter 4. The questions in the survey are based on the virtual team research model. The survey consist of five blocks, two blocks measuring the independent variables, two blocks the dependent variables and one block measures some general information about team characteristics and respondents. The methodology that is used to perform the survey will be explained in more detail in chapter 5.

2.4 Summary

The research question will be investigated in two different phases. First, studying the literature about virtual teams and knowledge sharing. This review will result in a research model which will be tested in the second phase with survey research.

Chapter 3: Literature review

3.1 What are virtual teams

There are plenty of virtual team definitions in the literature. An examination of the definitions used in the current literature indicates that there is an overlap in the core of the definitions, with some small differences in additional specifications. Examples of such definitions are:

"Virtual teams are teams whose members use technology to varying degrees of working across locational, temporal, and relational boundaries to accomplish an interdependent task." (Martins et al,. 2004)

"Unlike their conventional counterparts, virtual teams can be dispersed across organizational, space, and/or time boundaries and are often cross- functional in nature, where team members come from a variety of organizational departments of business units. Consequently, these teams have a low frequency of face-to-face contact and are able to collaborate through the use of emerging computer and communication technologies." (Lurey and Raisinghani, 2001)

"Global virtual teams are temporary, culturally diverse, geographically dispersed, electronically communicating work groups."(Jarvenpaa and Leidner, 1998)

The basis of most definitions is that communication and coordination is predominantly based on electronic media while crossing several boundaries. The most mentioned boundaries are the geography dispersion, different time zone and organizational differences. Compared to traditional collocated teams, members of virtual teams are not constrained to one location and can be located through the world (Montoya-Weis et al., 2001). Several researchers have focused on this characteristic and studied global virtual teams (Jarvenpaa and Leidner 1998, Jarvenpaa et al. 2004, Montoya-Weis et al. 2001, Paul et al. 2004).

Dispersion of virtual team members can occur due to the different locations of members and the difference in time zone and due to the use of a-synchronous communication technologies such as email. This dispersion limits members to communicate in real time. Finally, virtual teams are often composed from different organizations and work beyond boundaries through outsourcing or through joint ventures among organizations.

The above mentioned characteristics are generally recognized as characteristics of virtual teams, several additional characteristics were noted but have not been generally adopted. Researchers found that virtual teams are more flexible such that membership can be changes when the tasks change (Kirkman et al. 2004). As well, research indicates that virtual teams have a shorter lifecycle compared to traditional collocated teams (Jarvenpaa and Leidner, 1998).

Table 1 Overview virtual team characteristics

Characteristic	Research
Group of two or more people	(Hertel et al. 2005), (Martins et al. 2004), (Lurey and Raisinghani 2001),(Jarvenpaa and Leidner 1998)
Driven by common purpose	(Hertel et al. 2005), (Martins et al. 2004), (Lurey and Raisinghani 2001),(Jarvenpaa and Leidner 1998)
Dispersed over different locations*	(Hertel et al. 2005), (Martins et al. 2004), (Lurey and Raisinghani 2001), (Jarvenpaa and Leidner 1998)
Enabled by electronic communication technologies*	(Hertel et at. 2005), (Martins et al. 2004), (Jarvenpaa and Leidner 1998)

*) specific virtual team characteristics

Table 1 gives an overview of the virtual team's characteristics from the current literature. The first four are common criteria and used in most definitions (Bal and Teo 2000). Recent definitions incorporate the traditional dimensions of virtual teams and emphasize the extent of virtualness. Taking this into account we adopted the definition of (Hertel et al. 2005). This definition combines the core of traditional dimensions together with the extent of virtualness.

"Virtual teams consist of (I) two or more persons who (II) collaborate interactively to achieve common goals, while (III) at least one of the teams members works at a different location, organization, or at a different time so that (IV) communication and coordination is predominantly based on electronic communication media."

The first two characteristics of this definition (I and II) are also valid for traditional teams, however the third and fourth characteristic are specific for virtual teams.

3.2 Virtualness

Previous definitions of virtual teams often contrast virtual and traditional face-to-face teams. As a result this definitions focused on technology based communication and physical dispersion (Martins et al. 2004). The degree of technology mediation is not addressed in this traditional definition. Some researchers defined virtual teams as teams that purely communicate electronically and others define virtual teams as teams where most of the communications is via electronic media. Teams that not use any communication technology are rare nowadays (Griffith and Neale 2001). Nevertheless, researchers make a distinction between pure virtual, hybrid and face-to-face teams (Fiol and O'Connor 2005, Griffith and Sawyer 2003).

It is not clear what extent of electronic communication is sufficient to be classified as virtual. To overcome this shortcoming some researchers recently focus on the extent of virtualness (Kirkman et al. 2004). The extent of virtualness may depend of the percentage of time on the team task not spent face to face (Griffith and Neale 2001, Griffith and Sawyer 2003), extent that processes

occur outside the traditional organizational boundaries (Kraut et al. 1998), physical distance among members (Griffith and Sawyer 2003), level of technology support, nature of the task and the skills of the teams members (Martins et al. 2004). Griffith and Neale (2001) noted that "the form a team takes [on the continuum between purely face-to-face and purely virtual teams] is an interplay between the structures and capabilities provided by the technology, the demands of the task, and the structures that emerge."

3.3 Challenges in virtual teams

Virtual teams depend heavily on effective knowledge management and it is critical for organizational success (Grant, 1996). The coordination of knowledge in virtual teams is challenging because the knowledge is distributed across team members (Kanawattanachai and Yoo, 2007). Knowledge coordination in virtual teams is problematic due to temporal and spatial separation among members and the use of computers as the primary means of communication (Kanawattanachai and Yoo, 2007). Figure 2 sketched the distributed knowledge in virtual teams compared to collocated teams. In the collocated team the knowledge is centralized and team members communicate face-to-face. Virtual teams communicate mainly through electronic media and the knowledge is decentralized.

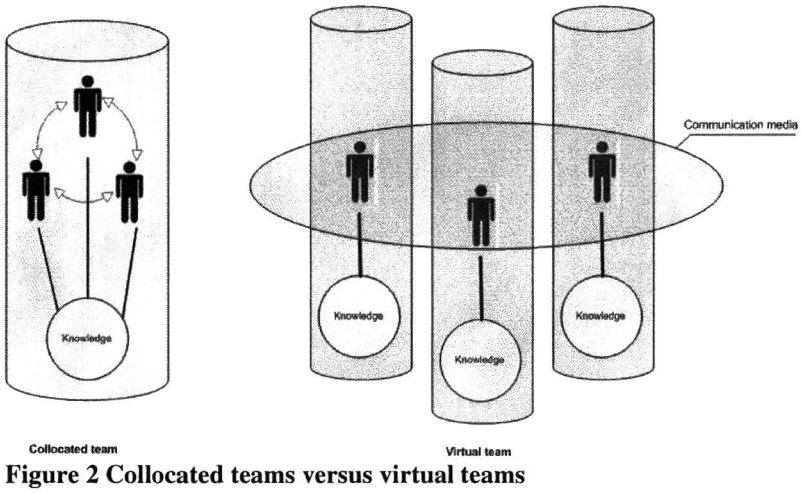

Figure 2 Collocated teams versus virtual teams

The danger is to place information technology at the centre of knowledge sharing implementation, to push information and knowledge towards employees rather than creating the demand-pull for knowledge by employees with a demand for knowledge. On the other hand, in virtual teams knowledge sharing cannot be implemented without technology.

The complexity of virtual teams also has several drawbacks and challenges. In geographically dispersed virtual teams communication is almost always electronic. These differences bring other requirements with respect to knowledge sharing. Team members with different expert knowledge are often isolated and dispersed from each other by distance which makes it difficult to them to share expert knowledge. Virtual teams depend heavily on effective knowledge management and it is critical for organizational success (Sarker et al. 2005).

3.4 Knowledge & knowledge sharing

A crucial factor for gaining and sustaining competitive advantages in the current economic environment is knowledge (Goh, 2002). This section will focus on knowledge processes in virtual teams and starts with a general introduction about knowledge. Next the challenges of knowledge management in virtual teams were discussed and the knowledge processes that need to be executed for effectively use of distributed knowledge. These knowledge processes will be integrated in the virtual team research model.

What is knowledge?
Knowledge is the collection of information, such that its intent is to be useful. Knowledge is a deterministic process. When someone "memorizes" information, then they have amassed knowledge. This knowledge has useful meaning to them, but it does not provide integration. Nonaka and Konno (1998) make a distinction between two types of knowledge, explicit knowledge and tacit knowledge. Explicit knowledge can be expressed in numbers or words and shared in the form of data or documents. This kind of explicit knowledge can be transferred between individuals in a formal way. On the other hand there is tacit knowledge. This type of knowledge is not easy expressible and visible and therefore hard to formalize and transferred or shared between individuals. Tacit knowledge is highly personal and rooted in an individual's action and experience. There are two different dimensions of tactic knowledge; the technical dimension and the cognitive dimension. This technical dimension refers to personal skills also known as know-how. Cognitive dimension of tactic knowledge consist of values, beliefs and ideas which shapes the way we perceive the world.

Knowledge processes in (virtual) teams.
One of the key features of work teams is their capacity to combine the unique knowledge held by individual workers to perform tasks. To effectively make use of their distributed knowledge, teams have to perform three basic knowledge processes: 1) Knowledge acquisition, 2) knowledge integration and 3) knowledge creation (Bhappu et al. 1997). Dixon (2000) found that these activities need to be balanced for successful knowledge management.
Knowledge acquisition is the process whereby team members recognize relevant new knowledge in their environment and are able to acquire this knowledge to perform their team task. The ability to effectively obtain new knowledge is dependent on the absorptive capacity of the team, which is prior related knowledge held by the team members (Cohen & Levinthal, 1990). This prior related knowledge moderates the ability to recognize the value of new relevant knowledge and to apply this knowledge.
Knowledge integration is the process whereby team members combine the distributed knowledge of their team to form a tangible output (Lawrence & Lorsch, 1967). The process of knowledge integration is the most important activity to process knowledge in organizations according to Grant (1996). The ways in which team members combine distributed knowledge depend on the nature of the knowledge. Teams that routinely need to process large amounts of explicit knowledge may implement standardized procedures to perform effectively knowledge integration. However, teams that are required to integrated large amounts of tacit knowledge on non-routine base need to use more personal knowledge integration mechanisms that involve the use of face-to-face communication (Bhuppa et.al, 1997).
Organization use teams in order to create new knowledge (Nonaka & Taekuchi, 1995). Knowledge creation takes place in five different stages. In the first stage team members share their tacit knowledge with each other. Interacting team members generate new ideas from the interplay of their different tacit knowledge. In the second stage these ideas are transformed to explicit concepts. These explicit concepts are tested for validity in the third stage. The knowledge

has been converted to an end product and must be accepted throughout the organization in the fourth and fifth stage respectively.

Knowledge sharing
Knowledge sharing is an activity through which knowledge (i.e. information, skills, or expertise) is exchanged among people, or members of a virtual team, a community or an organization. Before the role of team design and communication technology with relation to sharing knowledge can be considered, some ideas needs to be developed of what sharing knowledge encloses. In this research the distinction is made between two important aspects; the quality of knowledge sharing and the willingness to share knowledge.
The quality of knowledge sharing measures in which extent the shared knowledge is relevant, easy to understand, accurate, complete, reliable and timely. The quality of knowledge sharing is important because if the shared knowledge does not has a high quality it is likely not useful. For example, team members share knowledge that is not understandable for other team members or team members share knowledge that is not inline with the demand for knowledge of the other team members. The other aspect is willingness to share knowledge. If team member are not motivated to share knowledge it is not likely that other team members make use of other team member's knowledge.

3.5 Summary

As indicate above, the dependence of electronic communication technology and the dispersed composition are the distinguishing characteristics of virtual teams. Based on the literature review the first two sub questions can be answered.

Sub question I: What are virtual teams?
This definition combines the core of traditional dimensions together with the extent of virtualness. "Virtual teams consist of (I) two or more persons who (II) collaborate interactively to achieve common goals, while (III) at least one of the teams members works at a different location, organization, or at a different time so that (IV) communication and coordination is predominantly based on electronic communication media."

Sub question II: What is knowledge sharing?
Knowledge sharing is an activity through which knowledge (i.e. information, skills, or expertise) is exchanged among people, or members of a (virtual) team, a community or an organization. Knowledge sharing is will be measured with to variables: the quality of knowledge sharing and the willingness to share knowledge. The next chapter continues with the description of the research model with these variables. The sub research questions are used as foundation for the research model.

Chapter 4: Research model

To access the variables that influence knowledge sharing in virtual teams the team effectiveness model of Hackman (1987) is used as starting point. Figure 3 shows a simplified version of Hackman's model of team effectiveness. In the model of Hackman are organizational context and team design the independent variables that moderates the relationships with critical processes for team effectiveness.

- Organizational context encloses processes and technologies that support and reinforces competent task work via reward systems, educational systems and information systems.
- Issue that is related to team design encloses the design that prompts and facilitates competent work on the task via: structure of the task, composition of the group and group norms about performance processes.

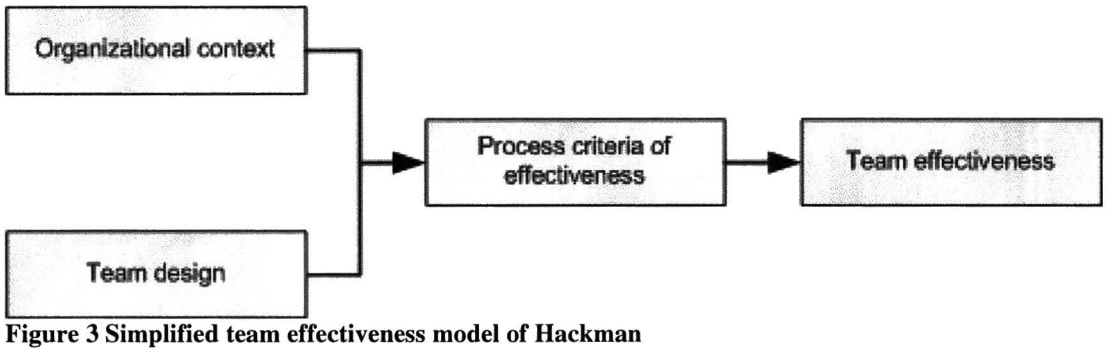

Figure 3 Simplified team effectiveness model of Hackman

In this research, knowledge sharing in virtual teams is the independent variables limited to the characteristics of virtual teams. According to the definition of virtual teams as described in section 3.1, two main characteristics can be defined: I) virtual project teams are geographical dispersed and II) communication and coordination in virtual project teams is predominantly based on electronic communication technology. In the figure below are the variables that will be used in this research translated into a research model. Communication technology and team composition are the independent variables for knowledge sharing. Knowledge sharing is defined as processes that will influence team effectiveness.

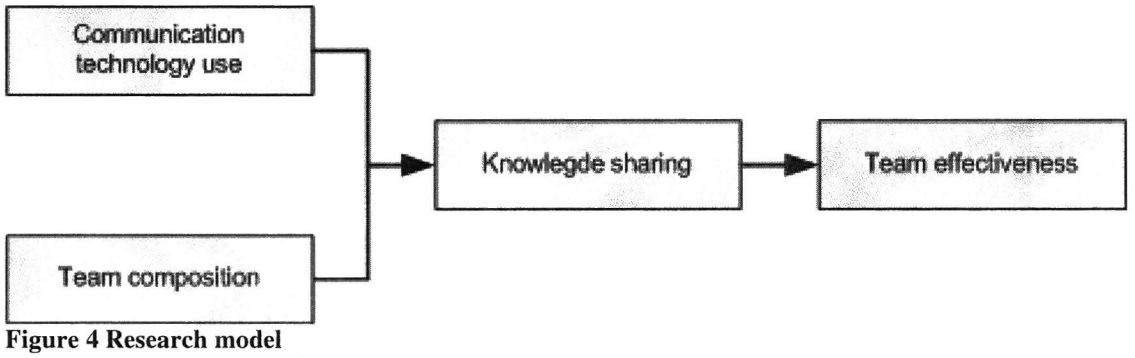

Figure 4 Research model

In the next section are the relationships in the research model explained in more detail. First the relationships between the independent variables will be explained: communication technology, team composition and knowledge sharing. Second is the relationship between knowledge sharing and team effectiveness explained.

4.1 Computer mediated communication & knowledge sharing

For teams to perform effectively, organizations must provide the right context, including the appropriate support. Hackman (1987) formulated three categories of organizational context variables namely reward systems, education system and information systems. Through the dispersed composition of virtual teams are information systems important for communication and exchange of knowledge within the team. For this reason we focus on the role of computer mediated communication technologies in knowledge sharing within project teams.

Previous research on computer mediated communication:
Researchers found that organizational context will moderate the effect of virtualness on team effectiveness. For example, Alavi and Leidner (2001) and Grant (1996) highlighted the importance of information and communication technology and applications for linking information and knowledge.
In the field study of Zack and McKenny (1995) two organizations operating in the same industry and using the same type of computer mediated communication. The results indicate that communication openness and cooperation improved the overall team performance.
Previous research has focused on individual technologies instead of considering the available "tool set" of technologies (DeSanctis and Poole, 1994). In this study the complete "tool set" is considered.

Technology use & knowledge sharing:
Davenpoort and Prusak (1997) state that a key factor for enabling knowledge sharing is the presence of extensive communication between the source and the recipient. In addition, Alavi and Leidner (2001) found that information technology increases knowledge sharing by extending a team members' reach beyond formal communication lines. Examples are computer networks, community of practices, discussion groups, groupware system, intranets and knowledge management information systems that facilitate contact between those knowledge contributing and knowledge seeking.
This study examined how team members' usage of information technology applications affects their knowledge sharing activities within the project team. Kanawattanachai & Yoo (2007) argued that cognitive-based trust and expertise location will mediate the coordination of knowledge within the team. Zand (1972) hypothesized that when team members experience low-trust behavior of other team members they are reserved and unlikely to share knowledge for the fear that others will use the knowledge for its own sake. Additional, he found that team with a high level of trust were more openly to share their ideas, and were better at finding and utilizing other members expertise than teams with low levels of trust.
Past research indicates that regular communication between team members regarding task-related knowledge lead to a higher level cognitive trust (Butler & Cantrell, 1994). In virtual teams are tasks primary carried out through electronic communication technology. Based on these findings it is likely that frequent communication will positively influence the formation of cognitive-based trust and therewith knowledge sharing within the virtual teams. Based on the findings of previous research we suggest the following hypothesis.

H1a: Greater use of available information communication technologies will positively influence knowledge sharing within virtual teams.

Media richness:
Media richness is explained as the ability of a medium to carry information. The criteria for ranking a medium's ability to carry information can be based on the ability of the media to, relay immediate feedback, provide feedback cues such as body language and transmit the feelings or emotions of the communicators. (Daft and Lengel 1984).
In the media richness theory, the richness of a communication technology determines its ability to reduce ambiguity and uncertainty. Ambiguity refers to the existence poor understanding and confusion. Uncertainty refers to lack of knowledge and information. According Daft and Lengel (1984) is the richness of communication technologies based on four dimensions. First, the availability of feedback mechanisms, for example is two way communication possible to check mutual understanding. Second, the availability of multiple cues such as verbal and non-verbal. Third the variety of the language that is supported and fourth the personal focus. Based on this fourth dimension the communication technologies can be classified from rich (e.g. face-to-face communication) to lean (e.g. written documents). Through the geographical dispersion of virtual teams they cannot communicate face-to-face and are more dependent of leaner communication media such as video conferencing, instant messenger, telephone and email.
Current research proposed that existing communication technologies do not provide the same media richness as face-to-face communication (Daft and Lengel 1984). Nevertheless, the type of communication technology used by virtual teams is an important input as media richness has been found to positively impact the amount of communication, team effectiveness and efficiency, (Hinds and Kiesler, 1995; Jarvenpaa, Rao and Huber, 1988).
Use of rich communication technologies also influences the relationship among teams (Chidambaram and Jones, 1993). When team members have a strong relationship their social presence is high. Social presence is the feeling that the other members are involved in information and knowledge sharing. When a communication technology has diminished visual and non-verbal cues like in virtual team it is more probable that less attention is paid to the presence of other participants. This is the reason why virtual teams take longer to make decisions and are less able to make inferences about other team members' knowledge and virtual teams are less able to anticipate on other team members' responses (Cramton, 2002). Based on the findings of relationship building and social presence we propose that the richness of communication technology also influence knowledge sharing within the team. This results in the following hypothesis.

H1b: The use of more rich communication technology will positively influence knowledge sharing within the team.

4.2 Team design & knowledge sharing

The second factor that influences team effectiveness is the degree to which the team design facilitates competent team work. Team design include the composition of the team (Hackman, 1987), in the case for virtual teams the dispersion over different locations.

Previous research on team design:
Team design is not a new topic in research. Nevertheless, only few researchers have explicitly explored composition and its effects on team level. Studies that investigate dispersed teams simulate dispersion by locating team members on different locations but they do not take into account the composition of dispersion. Besides that, experimental studies with student teams use mostly teams with an equal distribution over different locations (e.g. for a four-person team, two people at each location (2-2) or one person on each location (1-1-1-1)). In the review of field

studies by O'Leary and Cummings (2007) only the study of Rice and Aydin (1991) measured the team configuration and only one study mentioned the importance of team composition (Ahuja, Galletta and Carley, 2003).
However, case studies investigated the effect of team composition in relation to the consequences for the team (Polzer et al. 2004, Baba et al. 2004) . Polzer et al. (2004) found that distributed teams with an equal number of team members on each location exhibited less trust and more conflict compared to collocated teams. Teams with isolated team members across each locations exhibited more trust and less conflict then teams with balanced subgroups. Baba et al. (2004) studied the effect of dislocated project teams with 20 members dispersed across seven locations. Half of the team members where located at the headquarter, five member are located in another country and the last five team members where isolated at five different locations. Results indicate that clustering and cross cultural teams may result in subgroups which affected the performance of the team.

A main characteristic of virtual teams is dispersion. The dispersion of the team is the arrangement of team members across different locations independent of the distances among them. Dispersion is not only the number of different locations within a team, but also the team imbalance and isolation of team members. For example, a eight-member team there are multiple compositions. The two extreme compositions are completely collocated (8-0) and completely dispersed (1-1-1-1-1-1-1-1). A third possible team composition is teams which are dispersed and balanced (e.g. 4-4 or 2-2-2-2). The fourth and fifth composition are teams that are imbalance with isolated members (e.g. 6-1-1 or 6-1) and imbalanced teams without isolated members (e.g. 6-2 or 4-2-2). The goal of this research is to find out what the ideal composition for knowledge sharing in virtual teams. To answer this research question we focus on two characteristics of team composition. First, the balance between the different subgroups. Second, the number of isolated team members.

Team balance:
Imbalance index is equal to the standard deviation of members per site divided by the size of the team. A low index indicates relatively balanced membership across sites. (Staples & Webster, 2008). Sme studies indicate that imbalance in virtual teams will have a negative influence on team knowledge sharing. In a study of the relations between equity, equality, power and conflict, Kabanoff (1991) found that in situation where team members perceive inequality often lead to partial psychological withdrawal and decreased involvement. This kind of behavior results in team members putting less effort into the relationships with other team members and, we suppose, reducing their willingness to share knowledge with other team members. Furthermore, research by Kiesler & Cummings (2002) indicates that face-to-face contact increases the ease of communication and in that way the likelihood of sharing knowledge between team members. Teams communicate more frequently and freely to people who are collocated. If the communication lines of the balanced virtual team (3-3 composition) are compared with imbalanced virtual team (4-2 composition), then can be concluded that there is a difference in the number of communication lines. The balanced team has twelve within-location communication lines and eighteen between-location lines, the imbalanced team has ten within and sixteen between-location communication lines. See figure 5 for a graphical representation of the two team compositions.

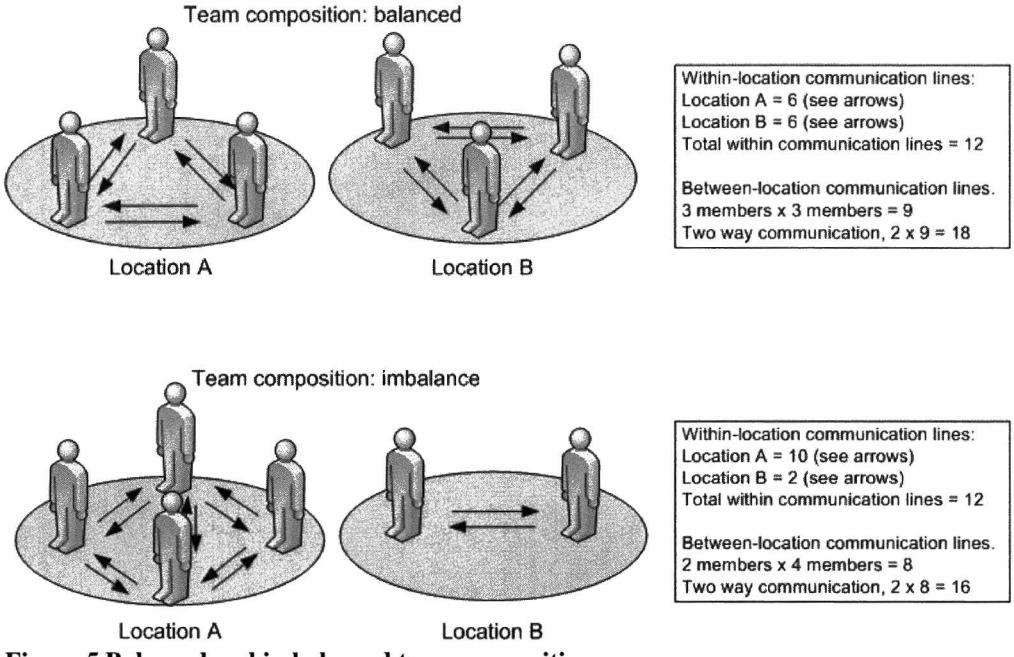

Figure 5 Balanced and imbalanced team composition

Regarding Kabanoff's (1991) argumentation can be expected that in imbalanced teams the possibility is higher that the team members of the minority location will be discounted, resulting in a loss of communication lines. If we again compare the balanced in imbalanced teams, the balanced team would still have twelve within and eighteen cross-team communication lines and the imbalanced team only eight within-location communication lines and no between between-location communication lines when the minority sub team is cut off. Based on the previous research finding of communication lines we expect that imbalance has a negative effect on knowledge sharing. This results in the following research question:

H2a: Virtual teams with an imbalanced composition will negative influence knowledge sharing within the team.

Team member isolation:
A team member is social isolated in case there is less or no communication between the isolated member and the rest of the team. As mentioned earlier, teams with isolated members are a unique case and must be considered separate.
Through the geographical dispersion of virtual teams the team members can communicate mainly through computer mediated technology to accomplish their tasks across vast psychical distance (Jarvenpaa & Leidner 1999, Cramton 2001, Maznevski & Chudoba 2000). The team members work in different environments and have therefore access to a wider variety of task related knowledge. A wider variety of knowledge may open up opportunities for knowledge sharing (Monge et al., 1985). Team dispersed over different locations probably have access to different social networks outside the project team because team members meet different people and communicate with different people (Conrath, 1973). In spite of this, the dispersion across different locations will only improve the relationship between knowledge sharing and team effectiveness when team members access unique task related knowledge through these outside

networks. Dispersed teams are more dependent of electronic communication technology for knowledge sharing.
Prior research suggests that being an isolated team member may be difficult, and the teams risk missing valuable knowledge and expertise by excluding isolated members. In research closely related to virtual teams Cooper & Kurland (2002) suggest that physical isolation from members in the virtual team can reinforce social isolation.
We expect that single physical isolated member has a negative effect on knowledge sharing because this possible results in exclusion of the isolate team member and a loss of communication lines to the isolated team member. With less communication lines it is more difficult to distribute knowledge within the team. This results in the following hypothesis.

H2b: Virtual teams with a single isolate member will negative influence knowledge sharing within the team.

4.3 Knowledge sharing & team effectiveness

The virtual team research model proposes that knowledge sharing will improve team effectiveness. Sharing of knowledge is necessary for good decision making and helps the build team's knowledge base. From research in traditional teams we know that knowledge sharing is essential for team effectiveness (Cohen & Bailey, 1997). Thereby, research in cross functional teams indicates that knowledge sharing is a critical success factor for teamwork (Holland et al., 2000).
Sharing of knowledge is also important for virtual team effectiveness (Staples, 2008). A reason why virtual teams often are composed is to bring together knowledge and diversity of expertise. With the increasing needs for technical knowledge bases and the requirements to integrate different technical and professional knowledge, team members can rarely hold all the necessary knowledge domains to accomplish their team tasks (Sapsad et al., 2002). In order to perform the team tasks members must share knowledge with others, otherwise it is not likely that the team meets its objectives (Staples, 2008). Previous research on traditional and virtual teams indicates a positive relationship between knowledge sharing and team effectiveness (Cummings, 2004). Therefore we propose that:

H3: Knowledge sharing has a positive effect on team effectiveness.

4.4 Summary

In total there are five hypotheses formulated in this research. The first two hypotheses describe the relationship between communication technology and knowledge sharing. The second and third hypothesis describes the relationship between team composition and knowledge sharing. And the last hypothesis describes the relationship between knowledge sharing and team effectiveness. The model below indicates how the hypothesis fit the research model.

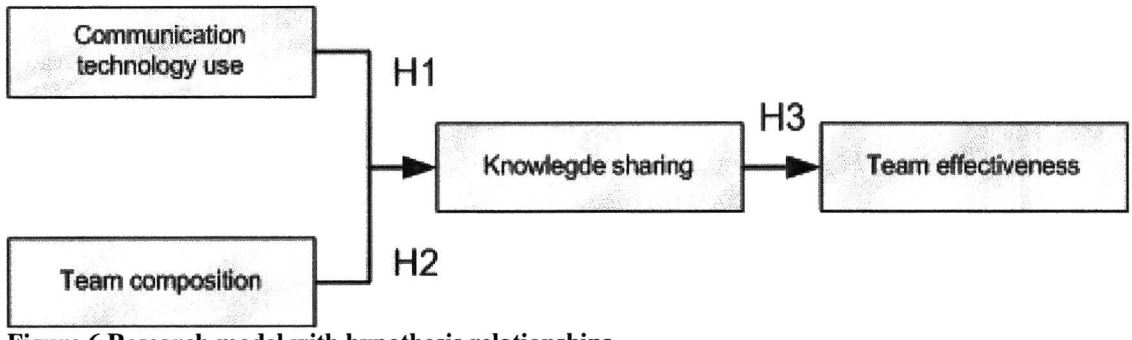

Figure 6 Research model with hypothesis relationships

The following hypotheses were formulated to answer research question: What are the antecedents of knowledge sharing in virtual teams?

H1a: Greater use of available information communication technologies will positively influence knowledge sharing within virtual teams.

H1b: The use of richer communication technology will positively influence knowledge sharing within the team.

H2a: Virtual teams with an imbalanced composition will negative influence knowledge sharing within the team.

H2b: Virtual teams with a single isolate will negative influence knowledge sharing within the team.

The following hypothesis was formulated to answer research question: What are the consequences of knowledge sharing in virtual teams?

H3: Knowledge sharing has a positive effect on team effectiveness.

Chapter 5: Data collection and analysis

5.1 Survey administration

The survey method was used to test the relationships in the hypothesized model. Data was collected from individual members of teams employed by Capgemini Nederland. In case that a respondent was a member of more than one team, the survey instructed each participant to evaluate only one team. The survey was pilot tested with one graduate student and two employees and took about 10 minutes to complete.
The survey has been conducted at the Capgemini sector Travel, Telecom and Utilities. This practice is part of the Technology group of Capgemini Nederland B.V. Most work in this sector is project-based and the Telecom, Travel and Utilities (TTU) sector contains in total 709 employees. The online survey was sent out on 28th May 2009, this resulted in 63 respondents. The email reminder was sent on 8th of June 2009 which resulted in another 39 responses. The survey went offline at 14th of June 2009.
Figure 7 shows the response rate over time. In total 102 employees responded on the online survey resulting a response rate of 14,3% (useful responses / (total sample - not useful responses) x 100%). Missing data reduced the sample size from 102 to 83. The adjusted response rate without missing data is 11,7%. However, it is difficult to make statements on the response rate, because size of the target group is unknown. Employees that never had worked in project teams do not fit the target group, and therefore should not take into account when calculating the response rate.
Of the total 83 respondents 84.3 percent were male and 15.7 percent female. The majority of the respondents (37.2 percent) is between 25 and 35 years old and has between 2 and 5 years work experience in project teams. About half of the respondents have a consultant function, the number of project leaders is lower with 27.7%. As can be seen in table 2, most respondents work in 1 team. This is in line with the total work time spent in the project teams. About 48% of the respondents spent 100% of there work time in the project team. In total 3 sets of two responses are merged because the respondents picked the same team to answer the survey. This resulted in 80 responses for 80 unique teams.

Table 2 Survey demographics

Measure	Items	
Gender	*Male,*	*84.3%*
	Female	*15.7%*
Age	*< 25 years*	*1.2%*
	25-35 years	*37.3%*
	36-45 years	*32.5%*
	45-55 years	*21.7%*
	> 55 years	*7.2%*
Years of experience	*< 2 years*	*3.6%*
	2-5 years	*31.3%*
	6-10 years	*15.7%*
	11-15 years	*19.3%*
	> 15 years	*30.1%*

Measure	Items	
Function	*Project leader*	*27.7%*
	Consultant	*49,40%*
	Other	*22,90%*
Other project teams	0 teams	59%
	1 team	18.1%
	2 teams	16.9%
	3 teams	1.2%
	> 3 teams	4.8%
Time spend	<25%;	3.6%
	25-50%;	9.6%
	51-75%;	16.9%
	76-99%;	21.7%
	100%	48.2%

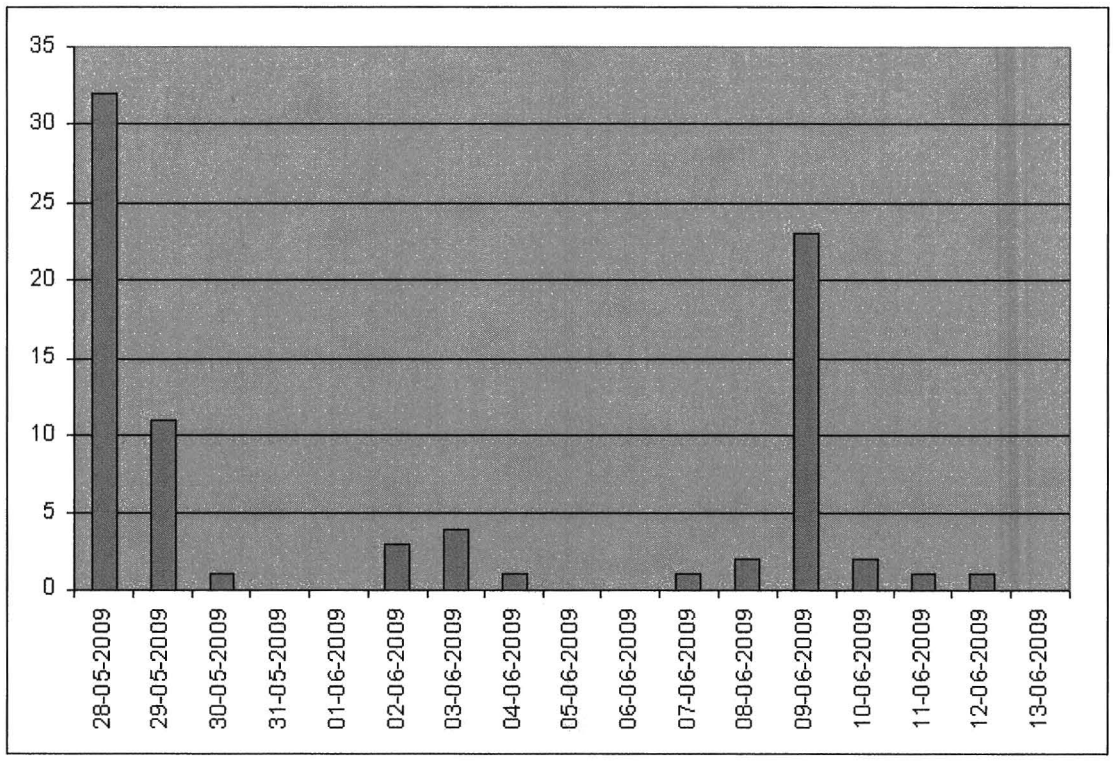

Figure 7 Survey responses over time

Non response bias indicates that respondents respond different to those of who did not (Armstrong and Overton, 1977). Non response bias has been checked by comparing the first 75% of the respondents with the last 25%. (The two tailed student t-test indicated no significance difference for all constructs (p= 0,00). Thus if another respondent would be added, no significance difference in the results is expected. See appendix B for more detailed results.

5.2 Measures

Measurement items were adopted from the literature and measured on a likert scale. The communication technology use variable measured the extent of employees' use of instant messenger, voicemail, video conferencing, fax, telephone, email and conference calls (Lurey and Raisinghani, 2001). Communication technology is measured on a 6-point likert scale; never (1), less than once a month (2), once a month (3), once a week (4), a few times a week (5) and daily (6). Results indicate that e-mail is the most often used communication technology (mean = 5,90 and S.D.= 0,34) followed by Telephone (mean= 5,47 and S.D.= 0,65) Voice mail (mean= 4,25 and S.D.= 1,62) Instant messenger (mean= 3,53 and S.D.= 2,21), conference calls (mean= 3,231 and S.D.= 1,69) and video conferencing (mean= 1,90 and S.D.= 1,40). Fax was the least used (mean = 1,21 and S.D.= 0,72).

Multiple indicators of team design where captured. The total number of team members was measured. To access the degree of dispersion we adopted two measures from O'leary & Cummings (2007). First, the number of people isolated members per location (isolation index, mean= 0,62 and S.D.= 1,50). Isolation index is the percent of team members who worked at locations with one or no other team members. The second measure is imbalance index (mean= 0,13 and S.D.= 0,13). Imbalance index is equal to the standard deviation of members per site

divided by the size of the team. A low index indicates relatively balanced membership across sites. (Staples & Webster, 2008).
Multiple items were used to measure the constructs knowledge sharing and team effectiveness, the items are shown in table 3. The quality of knowledge sharing was measured using the scale of Chui et al. (2006) and the willingness to share knowledge items were adopted from Connelly & Kelloway (2003). Both measures used a 5-point likert scale. The scale for knowledge sharing and team members satisfaction ranges from strongly disagree (1) to strongly disagree (4) or not applicable (5) and the scale for team performance ranges from low (1) to high (4) or not applicable (5).

Table 3 Knowledge sharing survey items

Construct	Item	
Knowledge sharing quality	KS01	The knowledge shared by members in the project team is relevant to teams' task.
	KS02	The knowledge shared by members in the project team is easy to understand.
	KS03	The knowledge shared by members in the project team is accurate.
	KS04	The knowledge shared by members in the project team is complete.
	KS05	The knowledge shared by members in the project team is reliable.
	KS06	The knowledge shared by members in the project team is timely.
Knowledge sharing willingness	KS07	People in this team keep their best ideas to themselves.
	KS08	People in this team are willing to share knowledge/ideas with others.
	KS09	People in this team share their ideas openly.
	KS10	People in this team with expert knowledge are willing to help others in this team.
	KS11	This team is good at using the knowledge/ideas of employees.

The following dimensions of team effectiveness were assessed: team performance and team member satisfaction, the items are shown in table 4. The team performance scale was derived from Janz & Pasarnphanich (2003). The respondents were asked to evaluate the quality of the team's performance, the efficiency of the team's work; and the degree to which projects were completed in a timely fashion. The items were measured on a 5-point likert from extremely low (1) to extremely high (4) or not applicable (5). The team satisfaction scale was derived from Lurey & Raisinghani (2001). This scale measures in what extent team member are satisfied with their team participation on a 5-point likert scale (strongly disagree (1) – strongly disagree (4) or not applicable (5)).

Table 4 Team effectiveness survey items

Construct	Item	
Team performance (efficiency)	TE01	The efficiency of team operations.
	TE02	The amount of work the team produces.
Team performance (effectiveness)	TE03	The quality of work the team produces.
	TE04	The team's ability to meet the goals of the project.
Team performance (timeliness)	TE05	The team's adherence to schedules.
	TE06	The team could have done its work faster with the same level of quality.
	TE07	The team met the goals as quickly as possible.
Team member satisfaction	TE08	I feel my input is valued by the members of the team.
	TE09	I enjoy being a member in this team.
	TE10	In the future, I would be interested in participating in another virtual team.

5.3 Validity and reliability

Construct validity can be divided into convergent and discriminant validity. Convergent validity can be evaluated by inspecting all item loadings on their respective constructs. All items with a loading lower than 0.5 have been removed one by one. To assure discriminant validity, the bivariate correlation matrix was computed (appendix C). In case there is a strong correlation between constructs which not exceed correlations between items within a construct, the items should be removed one by one. In this research there are no items removed to assure discriminant validity. To assess the scale reliability the Cronbach alpha was computed. The cut off value was set on 0.7 (Hair et al. 2006). All results from the analysis are described in section 5.4.

5.4 Data Analysis

The data analysis utilized a two-step approach. The first step involves the analysis of the measurement model, while the second step tests the structural relationships among the constructs. The aim of the two-step approach is to assess the reliability and validity of the measures before their use in the full model.

In this case a component analysis is chosen because the number of factors is known beforehand (Hair et al. 2006). First all the items of knowledge sharing were included in the factor analysis. The items with loadings below 0.5 or items with loadings on multiple factors have been removed one by one. This resulted in deletion of item K01, KS07, KS05 and KS06 respectively. For the team effectiveness items this resulted in deletion of item TE07, TE06 and TE10 respectively. Details of the unrotated factor analysis can be found in appendix C.

The rotation method Varimax gives a clear separation between the factors as indicated in table 5. Table 5 also shows that the Cronbach alpha for the items of team member satisfaction is slightly under 0.7. This indicates that an item should have been dropped. Although since the item which should have been dropped was essential for this construct the choice have been made to set a slightly less reliable scale.

Table 5 Measurement items and descriptive statistics

Items		Mean	SD	Loading	Cronbach's alpha
Knowledge sharing quality (KS_A) (1-5 scale; disagree-agree/not applicable)					0,766
KS02	The knowledge shared by members in the project team is easy to understand.	2,42	0,68	0,785	
KS03	The knowledge shared by members in the project team is accurate.	2,26	0,6	0,851	
KS04	The knowledge shared by members in the project team is complete.	2,56	0,65	0,834	
Knowledge sharing willingness (KS_B) (1-5 scale; disagree-agree)					0,834
KS08	People in this team are willing to share knowledge/ideas with others.	1,77	0,7	0,828	
KS09	People in this team share their ideas openly.	1,91	0,72	0,816	
KS10	People in this team with expert knowledge are willing to help others in this team.	1,67	0,63	0,798	
KS11	This team is good at using the knowledge/ideas of employees.	2,07	0,67	0,769	
Team performance (TE_A) (1-5 scale; disagree-agree/not applicable)					0,747
TE01	The efficiency of team operations.	2,73	0,63	0,749	
TE02	The amount of work the team produces.	2,99	0,54	0,512	
TE03	The quality of work the team produces.	2,97	0,54	0,649	
TE04	The team's ability to meet the goals of the project.	2,88	0,6	0,804	
TE05	The team's adherence to schedules.	2,67	0,67	0,772	
Team member satisfaction (TE_B) (1-5 scale; disagree-agree/not applicable)					0,659
TE08	I feel my input is valued by the members of the team.	1,68	0,49	0,862	
TE09	I enjoy being a member in this team.	1,69	0,49	0,850	

The variables were statistical tested for normality based on skewness and kurtosis values. The statistical value (z) for the skewness value and kurtosis value was calculated with the following formules adopted from Hair et al. (2006):

$$z_{skewness} = \frac{skewness}{\sqrt{\frac{6}{N}}} \qquad z_{kurtosis} = \frac{kurtosis}{\sqrt{\frac{24}{N}}}$$

N is the sample size. The critical value is taken from a *Z* distribution based on the significance level of 0.01, the corresponding critical *Z* value is +/- 2.58. If the calculated *Z* value exceeds the critical value, then the distribution is non-normal. Table 6 displays the values for skewness and kurtosis. The variable isolation index and willingness to share knowledge exceed the critical values and are non-normal distributed. Explanation for the non-normal distributed variable isolation index could be the very few teams in the survey sample with more then one isolated member. Furthermore teams with one isolated member are also rare.
The kurtosis and skewness values for the variable willingness to share knowledge also exceed the critical value for normal distribution. Because this variables is key in the research model was decided to maintain this variable.
Because the inclusion of multiple non-normal distributed variables the choice is made the use linear regression to test the hypothesis. This method is relative insensitive for non-normality in variables (Ramsey, 1969).

Table 6 Descriptive statistics normality test

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Z	Statistic	Z
Isolate index	80	0,65	1,493	3,993	14,58	20,541	37,503
Imbalance index	80	0,1388	0,12861	0,536	1,959	-0,728	-1,329
CT_A	80	3,6438	0,73192	0,006	0,021	-0,544	-0,993
KS_A	80	2,4125	0,52903	0,314	1,146	0,47	0,859
KS_B	80	1,9047	0,61983	1,823	6,656	7,406	13,522
TE_A	80	2,8475	0,42096	-0,114	-0,418	1,067	1,948
TE_B	80	1,6844	0,42236	-0,673	-2,458	-1,034	-1,887

5.5 Testing the model

After computing the constructs the hypothesis could be tested. In this section the elements of the research model; communication technology use, team composition and knowledge sharing will be discussed separately.

To test the hypothesis, linear regression was used. The regression coefficient is the estimated change in the dependent variable for a unit change of the independent variable. The R-square indicates the percentage of the dependent variable explained by the independent variable. Due to the small sample size, relationships between constructs tend to be less significant (Hair et al. 2006). All relations with a significance level below 95% have been assessed as not significant.

Nevertheless the results showed no significant effect between the use of communication technologies and knowledge sharing. Also the use of a richness correction factor resulted in no significant relations. Therefore hypothesis H1a was rejected.
The values of communication technology use with correction factor were calculated by the multiplication of the value of use and the correction factor. The correction factor ranges form 7 for the richest technology (video conferencing) en 1 for the least rich technology (fax)

Next to the frequency of use also the experienced importance of the different communication technologies was measured on a 5 point likert scale from not important (1) to very important (4) or not applicable (5). The importance communication technology has no significant effect on knowledge sharing quality (see table 7). Nevertheless, the results indicate that if conference calls play an important role in the team for communication this has a positive effect on the willingness to share knowledge (see table 8 for more details). Instant messenger on the other hand shows a negative effect on the willingness to share knowledge. Conference calls are a more rich communication tool compared to instant messenger, however this evidence is not strong enough to supports hypothesis H1b: Richer communication will positively influence knowledge sharing within the team. Therefore hypothesis H1b was rejected. Video conferencing is not wide enough adopted to investigate relationships with knowledge sharing.

Table 7 Linear regression output for communication technology importance (I)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Conference calls	0,084	0,07	0,257	1,174	0,251
E-mail	-0,088	0,17	-0,104	-0,52	0,605
Telephone	-0,127	0,21	-0,134	-0,61	0,548
Fax	0,135	0,12	0,223	1,145	0,263
Video conferencing	0,013	0,06	0,045	0,218	0,829
Voice mail	0,009	0,07	0,024	0,12	0,906
Instant messenger	-0,073	0,06	-0,285	-1,16	0,258

Dependent Variable: Knowledge sharing_quality (R square ,190)

Table 8 Linear regression output for communication technology importance (II)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Conference calls	0,094	0,04	0,342	2,576	0,012
E-mail	-0,005	0,1	-0,005	-0,05	0,963
Telephone	-0,114	0,08	-0,164	-1,44	0,154
Fax	0,107	0,07	0,157	1,481	0,143
Video conferencing	-0,03	0,04	-0,102	-0,87	0,388
Voice mail	0,072	0,04	0,203	1,688	0,096
Instant messenger	-0,08	0,03	-0,296	-2,39	0,020

Dependent Variable: Knowledge sharing_willingness (R square ,273)

The results of team imbalance showed a negative effect on the willingness to share knowledge (β= -0,510 and p= 0,013)(see table 9 for more details). Isolation index showed no significant relationship with knowledge sharing (see table 10 for more details). This could be explained by the very small sample of teams (13) with more then one isolated members. This support hypothesis H2a and rejected hypothesis H2b.

Table 9 Linear regression output for team design (I)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Isolation index	-0,017	0,09	-0,047	-0,19	0,851
Imbalance Index	-1,003	0,94	-0,265	-1,07	0,298

Dependent Variable: Knowledge sharing_quality (R square ,063)

Table 10 Linear regression output for team design (II)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Isolation index	0,045	0,07	0,13	0,619	0,544
Imbalance Index	-1,839	0,76	-0,51	-2,43	0,026

Dependent Variable: Knowledge sharing_willingness (R square ,327)

The relationship between knowledge sharing and team performance indicated the most significant relationships in this research (see table 11 for more details). Both, the quality of knowledge sharing (β= 0,313 and p= 0,004) and the willingness to share knowledge (β= 0,329 and p= 0,004) are positive related to team performance. The results of the analysis supported H3: Knowledge sharing has a positive effect on team performance. The R square is 0,290 which indicates that a large part of the variance of team performance can be explained by the quality of knowledge sharing and the willingness to share knowledge.

Table 11 Linear regression output for knowledge sharing (I)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Knowlegde sharing_quality	0,264	0,09	0,313	2,953	0,004
Knowlegde sharing_willingness	0,313	0,1	0,329	3,106	0,003

Dependent Variable: Team effectiveness_performance (R Square ,290)

In contradiction to team performance is team member satisfaction not supported by all the items of knowledge sharing (see table 12 for more details). Only willingness to share showed a significant reaction with team member satisfaction (β= 0,378 and p= 0,002). The quality of knowledge sharing has no significant effect on team member satisfaction.

Table 12 Linear regression output for knowledge sharing (II)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Knowlegde sharing_quality	-0,129	0,11	-0,144	-1,22	0,226
Knowlegde sharing_willingness	0,381	0,12	0,378	3,203	0,002

Dependent Variable: Team effectiveness_satisfaction (R Square ,119)

The results will be further discussed in the next chapter conclusions.

5.6 Summary

This chapter provided an overview of the survey results. The survey was conducted to investigate the effect of virtual team characteristics on knowledge sharing within the team. Five hypothesis derived from the research model were tested.

H1a: Greater use of available information communication technologies will positively influence knowledge sharing within virtual teams.**(rejected)**

H1b: The use of richer communication technology will positively influence knowledge sharing within the team.**(rejected)**

H2a: Virtual teams with an imbalanced composition will negative influence knowledge sharing within the team. **(partly accepted, only with willingness to share knowledge)**

H2b: Virtual teams with a single isolate member will negative influence knowledge sharing within the team. **(rejected)**

H3: Knowledge sharing has a positive effect on team effectiveness. **(accepted, for both knowledge sharing quality and willingness to share)**

The online survey was sent to 709 employees of Capgemini and had a response rate of 11.7%. However this is estimation since not all employees which received the survey have experience in project teams. Those employees should not be taken in into account for calculating the response rate. The survey was tested on non response bias and the results indicate no significant bias.
The survey results have been analyzed using the multiple regression method. This resulted in acceptation of hypothesis 2a (partly) and 3 and rejection of hypothesis 1a, 1b and 2b.

Chapter 6: Conclusion

This research started with showing the trend of increasing virtualness in organizations and the importance of knowledge sharing in teams. Therefore the aim of this research was to investigate in which ways the characteristics of virtual teams contribute to team knowledge sharing. This chapter will combine the literature and the results from the survey to draw conclusions for the research question: *What are the antecedents to and consequences of virtual team knowledge sharing?* The first section will focus on the antecedents of knowledge sharing within virtual teams. The consequences of knowledge sharing in virtual teams will be discussed in section two. The third section will transform these conclusions into recommendations for knowledge sharing virtual teams. The last two sections will conclude with the limitation of this research, and provides possibilities for further research.

6.1 Antecedents of knowledge sharing

This section will answer the sub question: *What are the antecedents of knowledge sharing in virtual teams?* The answer to this sub question is based on the literature and the results of the survey.

The two characteristics team design and communication technology will be discussed one by one. The combination of theory and practice resulted in the fact that the survey results can be explained by the theoretical findings from the literature. From the survey results appeared that imbalance has a positive effect knowledge sharing willingness. The effect of communication technology on knowledge sharing is dependent of the experienced importance and not the frequency of use. The effect of communication technology and team design will be explained separately in the next two sections.

Team design
Team design consists of two items, team imbalance index and team isolation index. Both items are not supported for the quality of knowledge sharing. Thus team design has no significant effect on the accurateness, understanding and completeness of knowledge sharing. Nevertheless, the survey results indicate a negative effect of imbalance with the willingness to share knowledge. This indicates that when there is a high difference in the numbers of team members across different locations, team members are less open to share ideas and show less willingness to help other team members. Thus team design affects the willingness to share knowledge. With a more balanced team, members are more likely to share there knowledge with other team members.

The absence of a significant relation between isolation index and knowledge sharing could be explained by the lack of trust to share knowledge with other team members. Team members who trust each other are more confident to share knowledge with each other. From traditional collocated team is known that trust is very difficult to build and requires frequent face-to-face contact (Kirkman et al., 2002). An extra challenge for virtual teams is to build trust between team members who rarely see each other. When you are working with people you never see you can develop trust but you must respond to that person. The trust has been build through the task based relationship that has evolved. For example, in collocated teams, members trust the other team members after sharing meals, spending time with them or socializing outside work. Trust in virtual teams grows through team member reliability, consistency, and responsiveness when dealing with team members, what is known is as task-based trust.

Translating this finding in a recommendation; building trust in virtual teams requires rapid responses to communication via electronic communication technologies from other team members and a reliable performance. Accordingly, team managers should coach team members to avoid long lags in responding and failure to follow up in commitments (Kirkman et al., 2002).

Communication technology
The relation between frequency of communication technology use and knowledge sharing was not underlined by the survey. The frequency team members communicate with the available technology will not be related to the quality of the knowledge sharing or the willingness to share knowledge with other members.

Nevertheless, the experienced importance of several communication technologies may affect the willingness to share knowledge. Teams that indicate that conference calls are an important technology for communication are more willing to share knowledge compared to teams that indicate instant messenger as important communication technology. Conference calls are a rich communication tool by which multiple people can interact with voice over distance. Instant messenger is a less rich communication tool where team members only communicate with short text messages. The use of only text messengers makes it more difficult to share knowledge and make team members less willing to share knowledge. Furthermore, instant messenger has no possibility to communicate with voice what will slow down the knowledge sharing process.

The weak relations could be explained by the media richness theories (Daft & Lengel, 1986). These theories assume that decision-making effectiveness depends on the match between the coordination needs of the task and the degree to which a particular communication technology support that coordination. The same could be implied for knowledge sharing. Knowledge sharing effectiveness depends on the match between the type of knowledge sharing and the degree to which a particular communication technology support sharing a particular type of knowledge. Probably are there more communication needs for teams then only richness of communication technologies. Next to richness (i.e., the need to transfer very complex knowledge) are speed (i.e., the need to transfer knowledge quickly) and volume (i.e., need for large amount of information) key communication needs for teams (McDonough et al., 1999). In section 6.3 (recommendations) are these needs further explained.

Expected was that video conferencing is the most rich communication technology because it has the possibility to communicate real time with voice and view. However, video conferencing is not widely enough adopted within Capgemini to draw significant conclusions. Video conferencing may have technical limitations for sharing knowledge. The hardware for video conferencing within Capgemini is not widely available. To make use of video conferencing you need to plan the conference room in advance together with the team members on the other location. In the future this problem will maybe diminish because more and more laptops have a build in webcam which can be used for video conferencing.

6.2 Concequences of knowledge sharing

In previous section the influence of team characteristics on the items of knowledge sharing were explained. This section elaborates on the consequences of knowledge sharing on overall team effectiveness and answers the sub question: *What are the consequences of knowledge sharing in virtual teams?* Both items of knowledge sharing, quality and willingness to share were supported

for team performance. Thus if team members are willing to share knowledge in a way it is easy to understand, accurate and complete the team is more likely to meet goals with a higher level of quality. Knowledge sharing probably increases the quality by combining ideas and knowledge of different team members which results in better solutions.
The item willingness to share has only a significant positive effect on team member satisfaction. An explanation could be that team member like the open climate of knowledge sharing and learning from other team members.

6.3 Recommendations

The recommendations that are provided in this section address the team design, communication technology and knowledge sharing.

Create balanced teams
The first recommendation is concerning the team design. When a team is more balanced over different locations the chance of excluding individual members from the teams is smaller. This results in teams where members are more willing to share knowledge with other members.

Importance of communication technology
Virtual teams mainly communicate with help of electronic communication technology. This research indicates that a higher frequency of communication technology use does not result in significant improvements in the quality of knowledge sharing or motivation to share knowledge. Besides that, in most cases are new communication technologies such as video conferencing not used to its full potential.
As mentioned earlier in the conclusion, the chosen communication technology should be suitable to share the particular type of knowledge and needs to fit the specific knowledge sharing needs. Different communication technologies have different capabilities related to speed, richness and volume (McDonough et al., 1999). For example, the use of email allows for quick transfer of knowledge, but only in written form. Next to that, email permits sharing large volumes of knowledge. Thus when members of virtual teams have a need to quick share large volumes of knowledge they have several options including email, phone calls or fax. Though, these communication technologies only knowledge sharing between two team members. Furthermore, only conference calls and phone calls have the possibility for two way communication and provide immediately feedback. The shortcoming of conference calls and phones is that it permits only sharing small volumes comparing to email of fax.
Organizations that want to implement virtual teams should make the right assessment between knowledge sharing needs and type of communication technology. The table below shows the abilities of different communication technologies to deal with speed, richness and volume. With this table is possible to make the assessment between knowledge sharing needs and communication technology (adopted from McDonough et al., 1999). If there is a need to share knowledge quickly, the value for the ability speed needs to be high. If there is a need to share very complex knowledge the value for the ability richness needs to be high. And finally, if there is a need to share a large volume the value for the ability volume needs to be high.

Table 13 Communication technology abilities

	Speed	Richness	Volume
Conference calls	3	3	1
E-mail	5	2	3
Telephone	4	3	2
Fax	4	3	4
Video conferencing	2	4	1
Voice mail	4	2	1
Instant messenger	4	3	2
face to face meetings	2	5	5

Stimulate knowledge sharing in virtual teams

This study results demonstrate that knowledge sharing is strongly and positively associated with team effectiveness. To improve team performance like meeting goals and increase team member's satisfaction organizations may stimulate knowledge sharing in teams. Besides, if team members are not motivated to share knowledge it is not likely that they are motivated to use communication technologies that facilitate knowledge sharing.

Previous research indicated multiple variables that influence the intention to share knowledge (Bock et al., 2005). First, the greater the sense of self-worth through knowledge sharing is, the more favorable the attitude toward knowledge sharing will be. And second, the greater the anticipated reciprocal relationships are, the more favorable the attitude toward knowledge sharing will be. Greater extrinsic rewards are not favorable to the attitude toward knowledge sharing will be (Bock et al., 2005). Extrinsic rewards are rewards external to the job, such as pay, promotion of benefits (Gibson et al., 2003).

6.4 Limitations of this study

This research investigate in which way the characteristics of virtual team can contribute to knowledge sharing within project teams of Capgemini Nederland. This has resulted in the following limitations.

First, the sample size of this research is relatively small and limited to project teams of only one company. This makes it hard to generalize the findings to other types of project teams. As well the number respondents per team are low. Most teams are represented by only one respondent.

Second, the data over the project teams was collected after the projects were finished. Because of this, respondents need to remember there past experiences in the project team which makes it more difficult to provide objective and accurate answers.

6.5 Options for further research

Despite the fact that this research identified how the characteristics of virtual teams contribute to knowledge sharing there are several possibilities for further research.

As mentioned before is the sample of this research limited to one company in the ICT industry. Interesting topic for further research could be the effect of virtual team characteristics on knowledge sharing of for virtual teams in other industries, for example in the financial industry.

Another interesting topic for further research is the influence of task type or type of knowledge on the relation between communication technology use and knowledge sharing. Are there communication technologies that are better to share a particular type of knowledge?

Last interesting topic for further research is the influence of time. In this research the time aspect is not taken into account. It would be interesting investigate of the effect of virtual team characteristics on knowledge sharing stays constant over the whole lifetime of the team. Or is there maybe a learning curve for the use of communication technology? Unfortunately within this research the above mentioned initiative could not be further analyzed.

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Appendix A: Survey questions

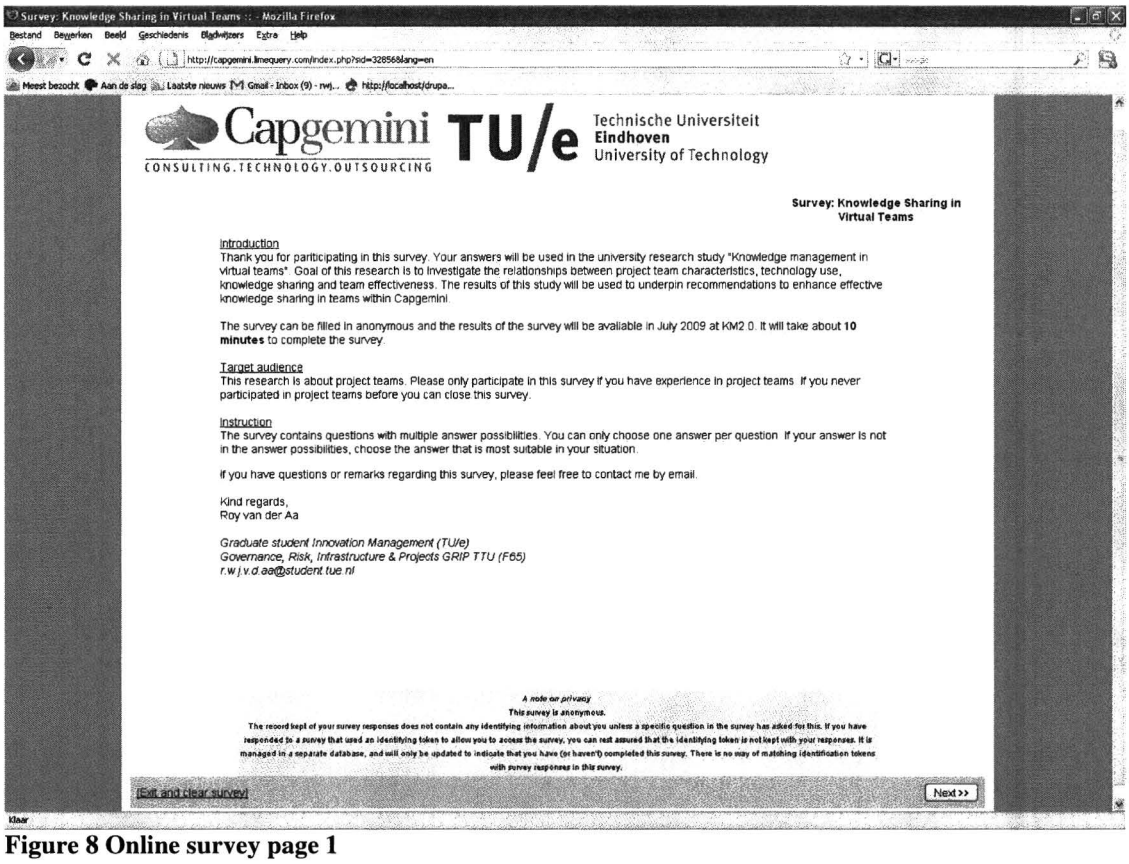

Figure 8 Online survey page 1

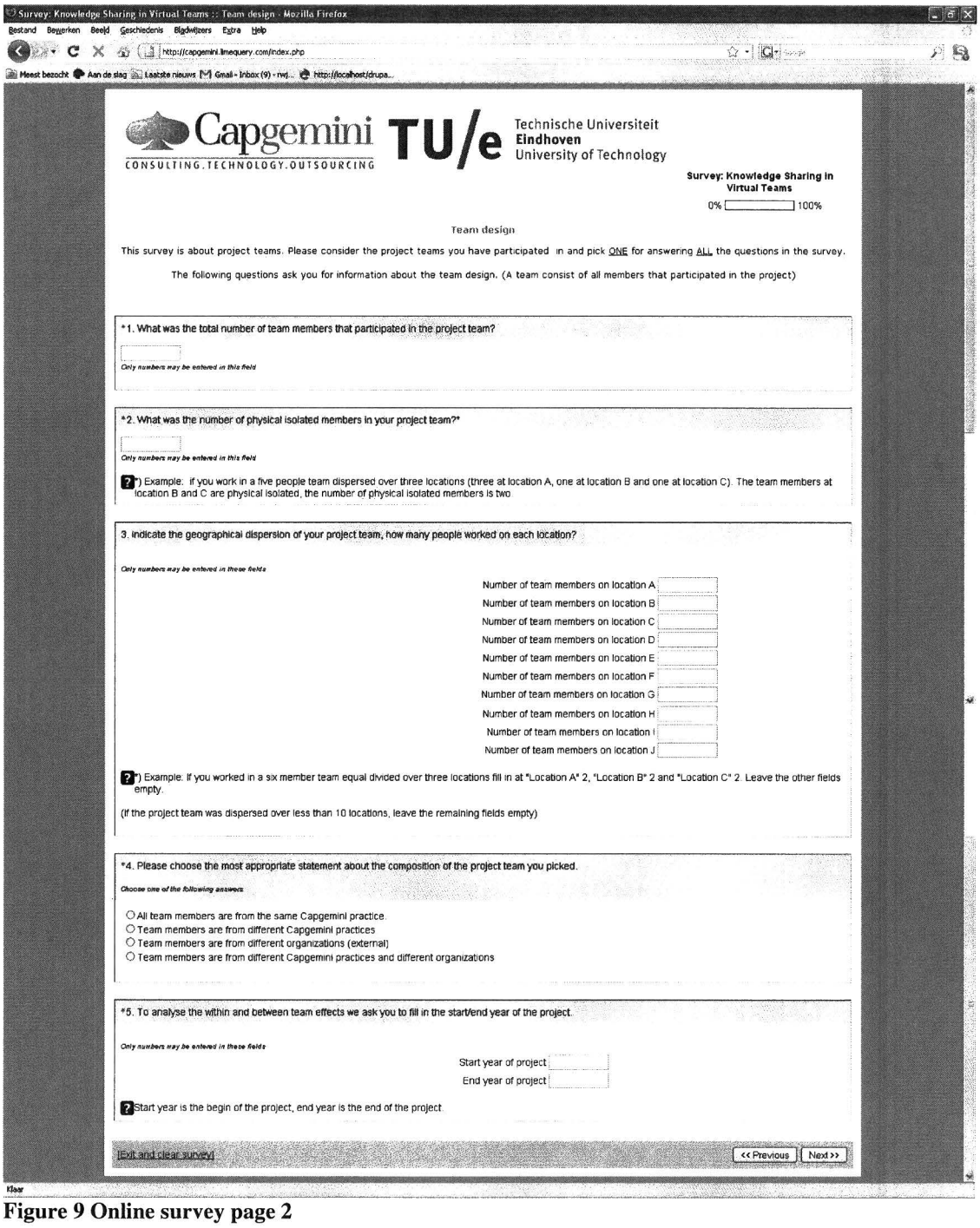

Figure 9 Online survey page 2

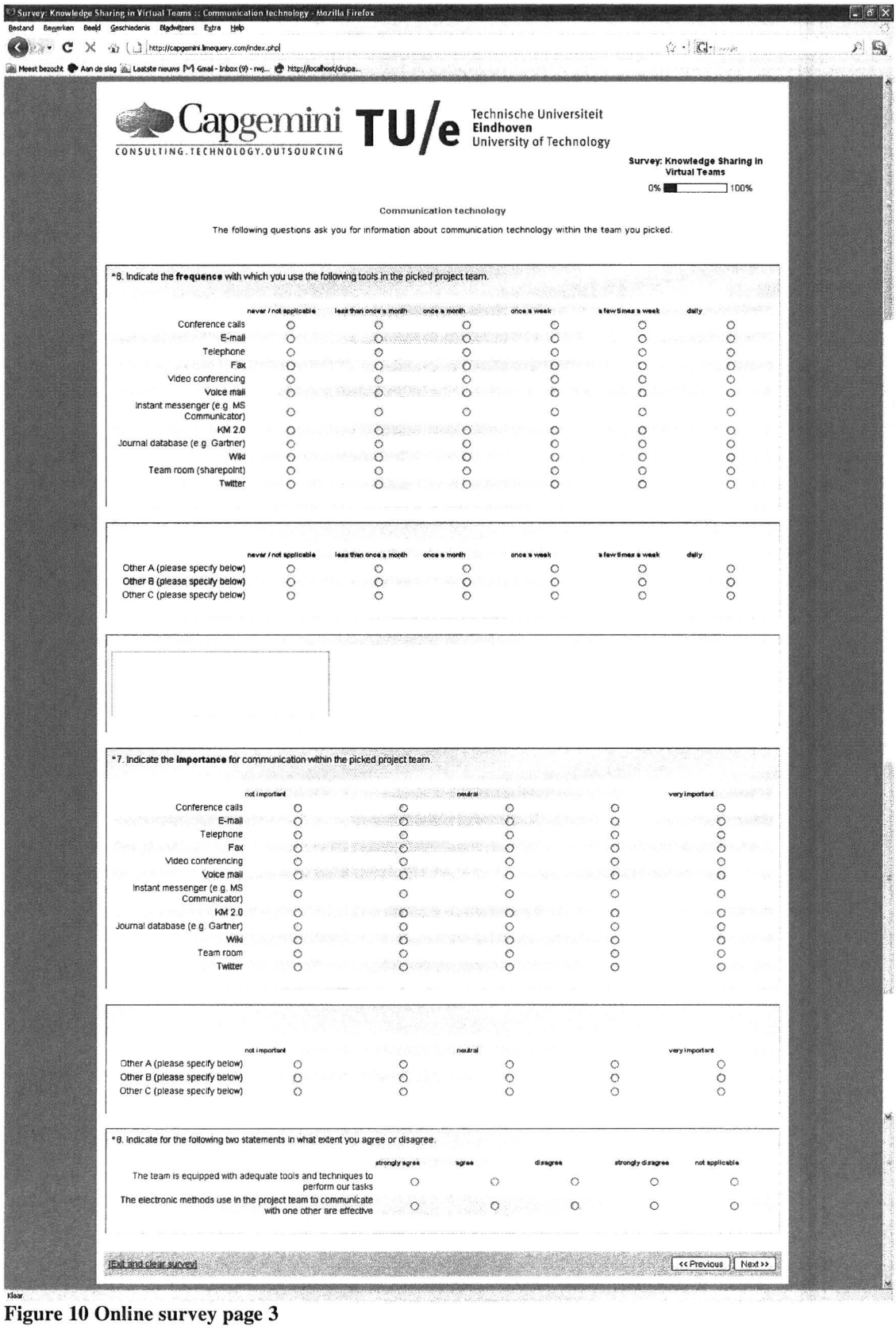

Figure 10 Online survey page 3

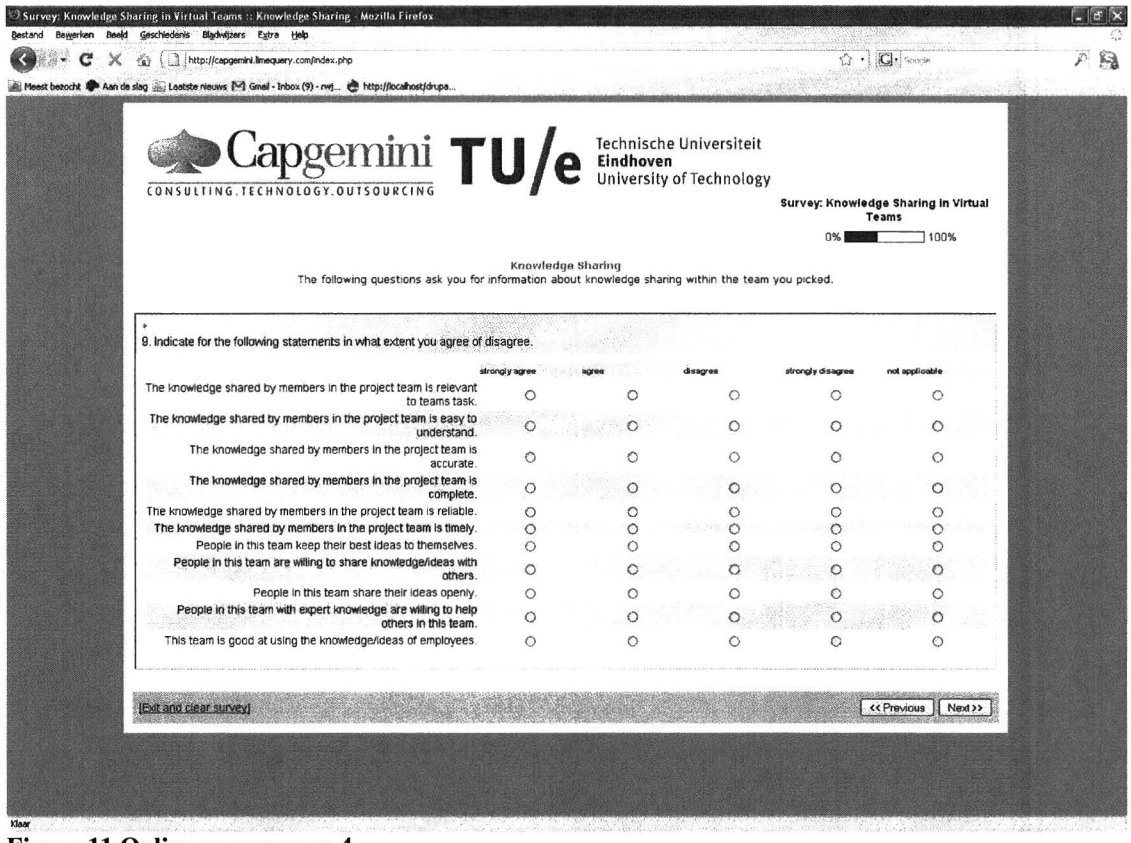

Figure 11 Online survey page 4

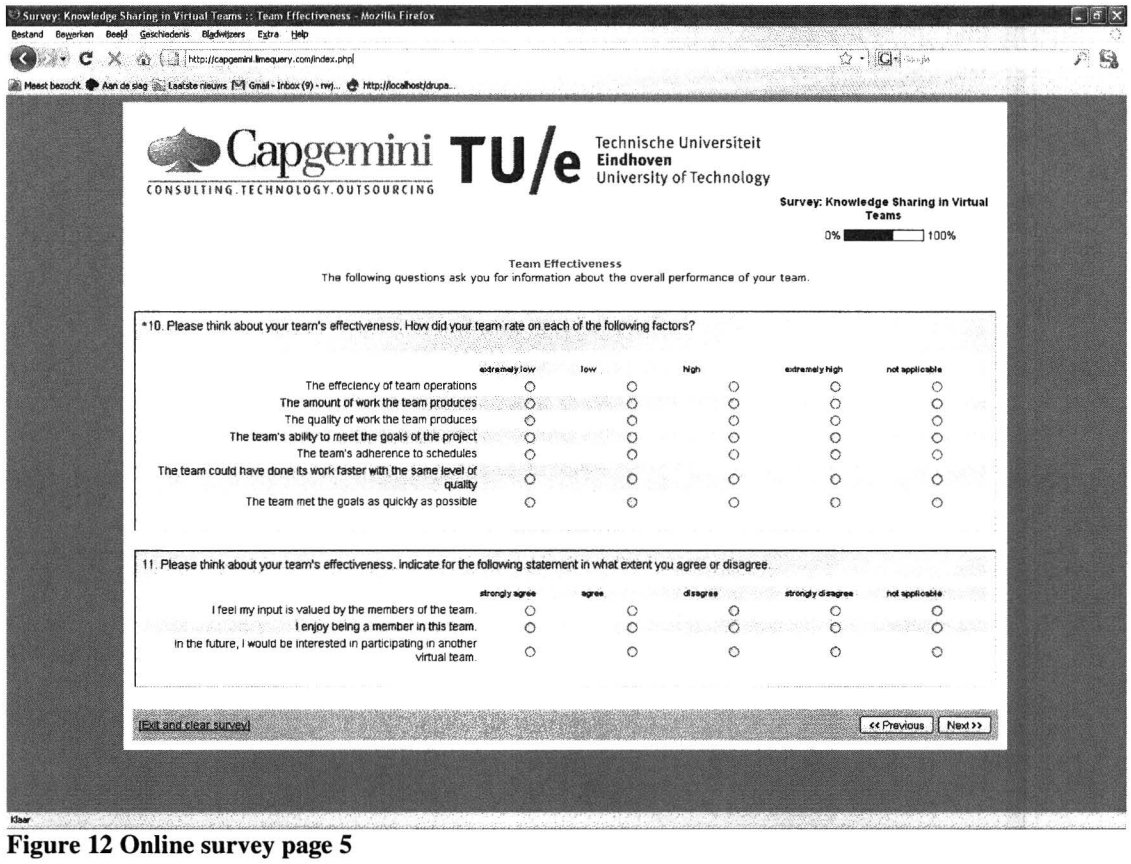

Figure 12 Online survey page 5

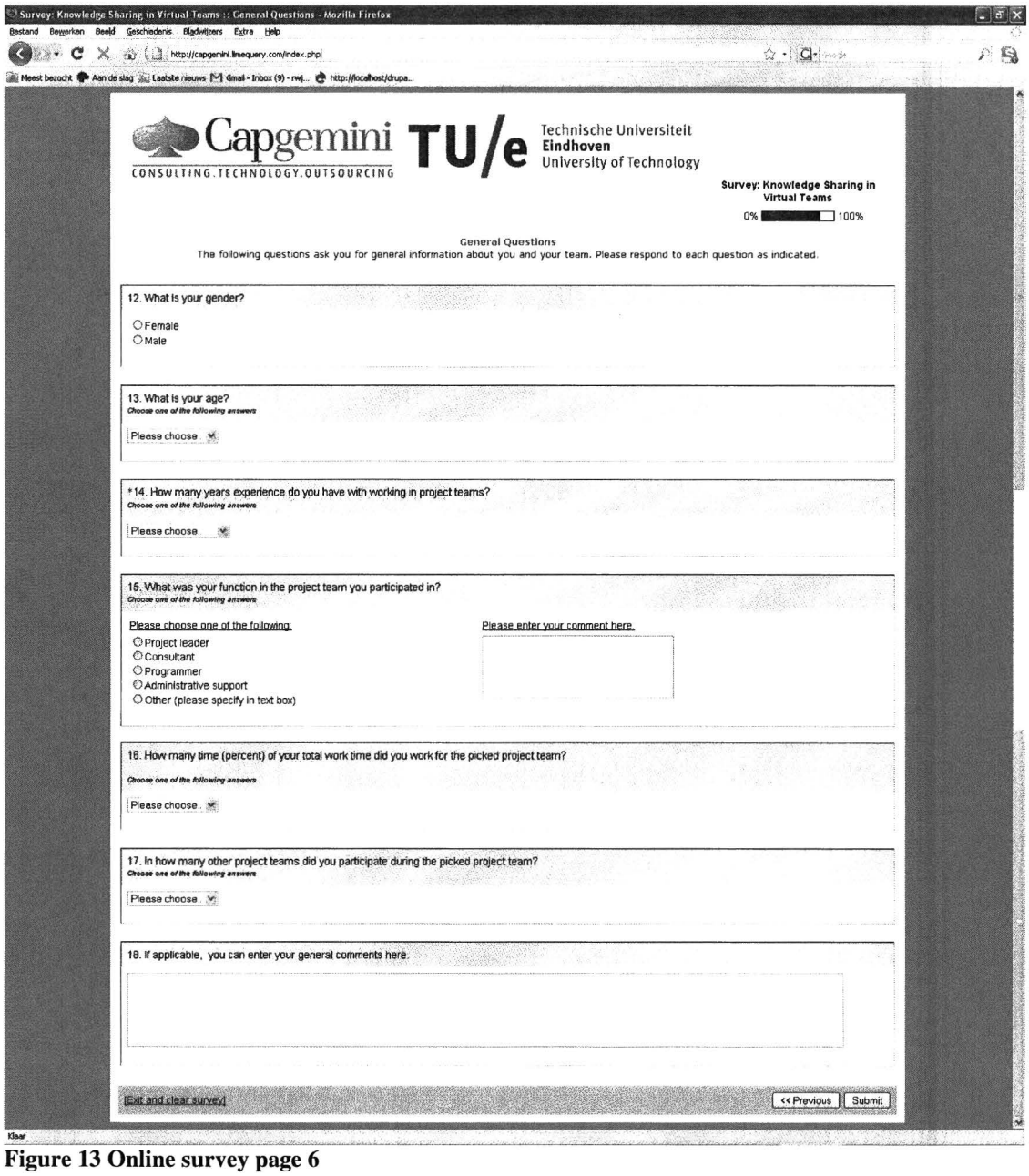

Figure 13 Online survey page 6

Appendix B: T-tests descriptive statistics

Table 14 T-test statistics

		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Isolation index	Equal variances assumed	0,011	21	0,991	0,013	1,154	-2,387	2,413
	Equal variances not assumed	0,019	11,323	0,985	0,013	0,701	-1,524	1,551
Imbalance Index	Equal variances assumed	1,342	52	0,185	0,04379	0,03262	-0,02167	0,10925
	Equal variances not assumed	1,533	25,884	0,137	0,04379	0,02856	-0,01493	0,10251
Conference calls	Equal variances assumed	0,094	57	0,926	0,0341	0,3634	-0,6936	0,7618
	Equal variances not assumed	0,092	23,414	0,928	0,0341	0,371	-0,7326	0,8008
E-mail	Equal variances assumed	0,755	78	0,453	0,0667	0,0884	-0,1092	0,2426
	Equal variances not assumed	0,579	23,244	0,568	0,0667	0,1152	-0,1715	0,3048
Telephone	Equal variances assumed	-0,197	78	0,844	-0,0333	0,169	-0,3699	0,3032
	Equal variances not assumed	-0,167	25,717	0,869	-0,0333	0,2	-0,4446	0,3779
Fax	Equal variances assumed	0,829	7	0,434	1,0625	1,2815	-1,9678	4,0928
	Equal variances not assumed	.	.	.	1,0625	.	.	.
Video conferencing	Equal variances assumed	1,427	28	0,165	0,6667	0,4672	-0,2903	1,6236
	Equal variances not assumed	1,476	26,232	0,152	0,6667	0,4518	-0,2616	1,5949
Voice mail	Equal variances assumed	0,298	66	0,767	0,0784	0,2632	-0,4471	0,604
	Equal variances not assumed	0,25	21,46	0,805	0,0784	0,314	-0,5737	0,7306
Instant messenger	Equal variances assumed	-1,382	47	0,173	-0,5323	0,3851	-1,3071	0,2425
	Equal variances not assumed	-1,464	17,767	0,161	-0,5323	0,3636	-1,2969	0,2323
Knowledge sharing quality	Equal variances assumed	1,016	78	0,313	0,13125	0,12923	-0,12602	0,38852
	Equal variances not assumed	1,098	37,66	0,279	0,13125	0,11958	-0,1109	0,3734
Willingness to share knowlegde	Equal variances assumed	1,816	77	0,073	0,20593	0,11342	-0,01991	0,43177
	Equal variances not assumed	2,016	40,236	0,051	0,20593	0,10215	-0,00048	0,41235
Team performance	Equal variances assumed	1,451	78	0,151	0,15667	0,10794	-0,05822	0,37156
	Equal variances not assumed	1,409	31,064	0,169	0,15667	0,11117	-0,07005	0,38338
Team member satisfaction	Equal variances assumed	0,756	78	0,452	0,0875	0,1158	-0,14305	0,31805
	Equal variances not assumed	0,84	39,889	0,406	0,0875	0,10423	-0,12317	0,29817

Appendix C: Correlation matrix

Table 15 Correlation matrix

Correlations

		TD02	TD03	CT01	CT02	CT03	CT04	CT05	CT06	CT07	KS01	KS02	KS03	KS04	KS05	KS06	KS07	KS08	KS09	KS10	KS11	TE01	TE02	TE03	TE04	TE05	TE06	TE07	TE08	TE09	TE10
TD02	Pearson Cor.	1	-,025	,015	-,288*	-,205	,031	-,096	,058	-,075	-,008	,040	-,062	,180	-,065	,092	-,129	-,100	-,111	-,042	-,034	,080	-,021	,104	,031	,041	-,245*	,167	-,025	-,085	-,117
	Sig. (2-tailed)		,823	,896	,016	,069	,787	,399	,612	,507	,944	,722	,587	,110	,569	,416	,256	,376	,327	,714	,767	,479	,852	,360	,786	,717	,028	,139	,829	,565	,303
TD03	Pearson Cor.	-,025	1	,344*	,118	,137	,032	,083	-,018	,313*	-,103	,009	,175	,028	,090	-,007	-,192*	-,052	-,014	-,063	-,063	-,141	-,174	-,139	-,086	-,048	,156	-,045	-,038	,065	-,265*
	Sig. (2-tailed)	,823		,002	,296	,225	,781	,465	,875	,005	,365	,937	,122	,803	,430	,949	,088	,650	,900	,581	,578	,211	,124	,220	,448	,674	,167	,693	,735	,570	,017
CT01	Pearson Cor.	,015	,344*	1	,128	,149	-,181	,397*	,255*	,440*	-,192*	-,066	,176	,021	,095	-,071	-,223*	-,154	-,147	-,266*	-,127	-,157	,045	-,099	-,117	-,086	-,002	-,115	-,009	-,050	-,331*
	Sig. (2-tailed)	,896	,002		,257	,187	,107	,000	,023	,000	,089	,559	,118	,851	,400	,533	,047	,174	,194	,017	,262	,163	,693	,382	,303	,450	,984	,311	,936	,663	,003
CT02	Pearson Cor.	-,288*	,118	,128	1	,559*	,090	,085	,183	,323*	,158	-,036	-,059	-,029	-,035	-,046	,073	,071	,075	,023	,019	,050	-,007	-,086	-,059	-,036	,131	,078	,109	,038	-,012
	Sig. (2-tailed)	,016	,296	,257		,000	,429	,455	,104	,003	,161	,754	,602	,801	,757	,688	,520	,530	,510	,836	,865	,660	,952	,450	,603	,750	,246	,493	,334	,737	,918
CT03	Pearson Cor.	-,205	,137	,149	,559*	1	,240*	,164	,294*	,337*	,079	-,005	,164	,056	,196	,022	-,025	,040	,132	-,005	-,093	,060	,089	,016	-,122	-,173	,120	,034	,103	,005	,007
	Sig. (2-tailed)	,069	,225	,187	,000		,032	,147	,008	,002	,488	,967	,147	,620	,081	,845	,824	,721	,242	,968	,410	,594	,431	,890	,282	,125	,289	,763	,362	,965	,949
CT04	Pearson Cor.	,031	,032	-,181	,090	,240*	1	-,034	,015	,087	-,027	-,086	,015	-,104	-,126	,053	,047	,006	-,025	,074	-,084	,103	,007	,082	-,152	-,038	-,044	,082	-,015	,008	-,054
	Sig. (2-tailed)	,787	,781	,107	,429	,032		,763	,896	,445	,815	,449	,894	,360	,267	,639	,678	,956	,827	,512	,571	,365	,950	,468	,180	,737	,699	,472	,895	,945	,634
CT05	Pearson Cor.	-,096	,083	,397*	,085	,164	-,034	1	,033	,356*	-,096	,078	,297*	,188	,248*	,191	-,020	-,110	-,005	-,123	,073	,148	-,119	-,279*	-,098	-,111	,044	-,003	-,056	,028	-,195
	Sig. (2-tailed)	,399	,465	,000	,455	,147	,763		,768	,001	,398	,491	,008	,095	,026	,089	,861	,332	,966	,277	,521	,190	,294	,012	,389	,329	,696	,977	,622	,806	,084
CT06	Pearson Cor.	,058	-,018	,255*	,183	,294*	,015	,033	1	,063	-,045	-,076	-,136	-,102	-,267*	-,205	,183	-,318*	-,300*	-,358*	-,153	-,036	,337**	,186	-,031	-,010	-,017	,123	,038	-,056	-,082
	Sig. (2-tailed)	,612	,875	,023	,104	,008	,896	,768		,578	,695	,500	,229	,366	,016	,069	,105	,004	,007	,001	,175	,754	,002	,099	,784	,928	,881	,278	,740	,620	,469
CT07	Pearson Cor.	-,075	,313*	,440*	,323*	,337*	,087	,358*	,063	1	-,149	,025	,268*	,195	,124	,066	-,093	-,136	,041	-,079	-,126	-,026	-,132	-,047	-,136	-,363*	,036	-,154	-,066	-,050	-,273*
	Sig. (2-tailed)	,507	,005	,000	,003	,002	,445	,001	,578		,188	,826	,016	,083	,274	,559	,411	,230	,721	,488	,266	,821	,242	,681	,228	,001	,751	,173	,559	,662	,014
KS01	Pearson Cor.	-,008	-,103	-,192*	,158	,079	-,027	-,096	-,045	-,149	1	,053	,118	-,067	,137	,207	-,184	,278*	,145	,268*	,107	-,086	,123	-,018	-,142	,125	,102	,180	,212	,379*	,240*
	Sig. (2-tailed)	,944	,365	,089	,161	,488	,815	,398	,695	,188		,640	,296	,558	,226	,065	,145	,012	,201	,016	,346	,449	,277	,873	,208	,270	,370	,111	,058	,001	,032
KS02	Pearson Cor.	,040	,009	-,086	-,036	-,005	-,086	,078	-,076	,025	,053	1	,492*	,459*	,424*	,164	-,185*	,019	,145	-,107	,091	-,200	-,159	-,180	-,126	-,131	,023	-,141	-,069	-,040	-,105
	Sig. (2-tailed)	,722	,937	,559	,754	,967	,449	,491	,500	,826	,640		,000	,000	,000	,147	,101	,869	,198	,345	,424	,076	,160	,111	,265	,248	,842	,212	,542	,727	,353
KS03	Pearson Cor.	-,062	,175	,176	-,059	,164	,015	,297*	-,136	,268*	,118	,492*	1	,630*	,569*	,436*	-,414*	,173	,309*	,073	,087	-,412*	-,226*	-,299*	-,448*	-,350*	,067	-,127	-,085	,214*	-,157
	Sig. (2-tailed)	,587	,122	,118	,602	,147	,894	,008	,229	,016	,296	,000		,000	,000	,000	,000	,126	,005	,521	,442	,000	,043	,007	,000	,001	,553	,260	,454	,056	,165
KS04	Pearson Cor.	,180	,028	,021	-,029	,056	-,104	,188	-,102	,195	-,067	,459*	,630*	1	,508*	,452*	-,327*	,098	,215	,066	,104	-,252*	-,197	-,265*	-,218	-,311*	-,010	-,116	,024	,173	-,219
	Sig. (2-tailed)	,110	,803	,851	,801	,620	,360	,095	,366	,083	,558	,000	,000		,000	,000	,003	,385	,055	,563	,358	,024	,080	,018	,052	,005	,933	,306	,836	,125	,051
KS05	Pearson Cor.	-,065	,090	,095	-,035	,196	-,126	,248*	-,267*	,124	,137	,424*	,569*	,508*	1	,458*	-,354*	,229*	,281*	,214*	,168	-,237*	-,195*	-,354*	-,266*	-,310*	,032	-,123	,116	,293*	,075
	Sig. (2-tailed)	,569	,430	,400	,757	,081	,267	,026	,016	,274	,226	,000	,000	,000		,000	,001	,041	,012	,056	,137	,034	,083	,001	,017	,005	,780	,276	,305	,008	,507
KS06	Pearson Cor.	,092	-,007	-,071	-,046	,022	,053	,191	-,205	,066	,207	,164	,436*	,452*	,458*	1	-,139	,337*	,117	,224*	,224*	-,182	-,088	-,110	-,223*	-,201	-,050	,029	,243*	,351*	-,067
	Sig. (2-tailed)	,416	,949	,533	,688	,845	,639	,089	,069	,559	,065	,147	,000	,000	,000		,219	,002	,302	,046	,046	,106	,436	,330	,047	,074	,660	,795	,030	,001	,554
KS07	Pearson Cor.	-,129*	-,192*	-,223*	,073	-,025	,047	-,020	,183	-,093	-,184*	-,185*	-,414*	-,327*	-,354*	-,139	1	-,177*	-,174*	,021	,129	,139	,209*	,088	,103	-,106	,180	,079	-,119	-,197*	,130
	Sig. (2-tailed)	,256	,088	,047	,520	,824	,678	,861	,105	,411	,145	,101	,000	,003	,001	,219		,116	,122	,856	,253	,219	,063	,440	,362	,351	,110	,486	,295	,080	,250
KS08	Pearson Cor.	-,100	-,052	-,154*	,071	,040	,006	-,110	-,318*	-,136	,278*	,019	,173*	,098	,229*	,337*	-,177*	1	,618*	,518*	,531*	-,296*	-,166*	-,209*	-,239*	-,158	,176*	-,096	,172	,410*	,135
	Sig. (2-tailed)	,376	,650	,174	,530	,721	,956	,332	,004	,230	,012	,869	,126	,385	,041	,002	,116		,000	,000	,000	,008	,099	,063	,033	,163	,118	,396	,127	,000	,232
KS09	Pearson Cor.	-,111	-,014	-,147	,075	,132	-,025	-,005	-,300*	,041	,145	,145	,309*	,215	,281*	,117	-,174*	,618*	1	,547*	,522*	-,191*	-,090	-,195*	-,200*	-,164	,270*	-,170	,121	,254*	,034
	Sig. (2-tailed)	,327	,900	,194	,510	,242	,827	,968	,007	,721	,201	,198	,005	,055	,012	,302	,122	,000		,000	,000	,089	,426	,083	,076	,147	,015	,131	,286	,023	,768
KS10	Pearson Cor.	-,042	-,063	-,266*	,023	-,005	,074	-,123	-,358*	-,079	,268*	-,107	,073	,066	,214*	,224*	,021	,516*	,547*	1	,470*	-,015	-,049	-,123	-,070	-,184	,152*	-,197	,233*	,324**	,310*
	Sig. (2-tailed)	,714	,581	,017	,836	,968	,512	,277	,001	,488	,016	,345	,521	,563	,056	,046	,856	,000	,000		,000	,892	,665	,279	,537	,102	,178	,080	,038	,003	,005
KS11	Pearson Cor.	-,034	-,063	-,127	,019	-,093	-,064	,073	-,153	-,126	,107	,091	,087	,104	,168	,224*	,129	,531*	,522*	,470*	1	-,113	-,022	-,184	-,229*	-,109	,075	-,011	,004	,212	,018
	Sig. (2-tailed)	,767	,578	,262	,865	,410	,571	,521	,175	,266	,346	,424	,442	,358	,137	,046	,253	,000	,000	,000		,318	,844	,102	,041	,335	,506	,926	,974	,059	,877
TE01	Pearson Cor.	,080	-,141	-,157	,050	,060	,103	,148	-,036	-,026	-,086	-,200	-,412*	-,252*	-,237*	-,182	,139	-,296*	-,191*	-,015	-,113	1	,250*	,336*	,519*	,488*	-,121	,323*	-,014	-,256*	,222*
	Sig. (2-tailed)	,479	,211	,163	,660	,594	,365	,190	,754	,821	,449	,076	,000	,024	,034	,106	,219	,008	,089	,892	,318		,025	,002	,000	,000	,283	,003	,899	,022	,048
TE02	Pearson Cor.	-,021	-,174	,045	-,007	,089	,007	-,119	,337*	-,132	,123	-,159	-,226*	-,197	-,195*	-,088	,209*	-,186	-,090	-,049	-,022	,250*	1	,345*	,231	,235	-,132	,194	,032	-,063	,087
	Sig. (2-tailed)	,852	,124	,693	,952	,431	,950	,294	,002	,242	,277	,160	,043	,080	,083	,436	,063	,099	,426	,665	,844	,025		,002	,039	,036	,242	,084	,775	,577	,445
TE03	Pearson Cor.	,104	-,139	-,099	-,086	,016	,082	-,279*	,186	-,047	-,018	-,180	-,299*	-,265*	-,354*	-,110	,088	-,209	-,195*	-,123	-,184	,336*	,345*	1	,380*	,313*	-,126	,174	,033	-,254*	,078
	Sig. (2-tailed)	,360	,220	,382	,450	,890	,468	,012	,099	,681	,873	,111	,007	,018	,001	,330	,440	,063	,083	,279	,102	,002	,002		,001	,005	,266	,123	,769	,023	,490
TE04	Pearson Cor.	,031	-,086	-,117	-,059	-,122	-,152	-,098	-,031	-,136	-,142	-,126	-,448*	-,218*	-,266*	-,223*	,103	-,239*	-,200*	-,070	-,229*	,519*	,231*	,380*	1	,577*	-,061	,040	,085	-,206	,111
	Sig. (2-tailed)	,786	,448	,303	,603	,282	,180	,389	,784	,228	,208	,265	,000	,052	,017	,047	,362	,033	,076	,537	,041	,000	,039	,001		,000	,593	,726	,453	,067	,328
TE05	Pearson Cor.	,041	-,048	-,086	-,036	-,173	-,038	-,111	-,010	-,363*	,125	-,131	-,350*	-,311*	-,310*	-,201	-,106	-,158	-,164	-,184	-,109	,486*	,235*	,313*	,577*	1	-,150	,338*	,128	-,050	,136
	Sig. (2-tailed)	,717	,674	,450	,750	,125	,737	,329	,928	,001	,270	,248	,001	,005	,005	,074	,351	,163	,147	,102	,335	,000	,036	,005	,000		,185	,002	,259	,659	,229
TE06	Pearson Cor.	-,245*	,156	-,002	,131	,120	-,044	,044	-,017	,036	,102	,023	,067	-,010	,032	-,050	,180	,176	,270*	,152	,075	-,121	-,132	-,126	-,061	-,150	1	,049	,138	,267*	,110
	Sig. (2-tailed)	,028	,167	,984	,246	,289	,699	,696	,881	,751	,370	,842	,553	,933	,780	,660	,110	,118	,015	,178	,506	,283	,242	,266	,593	,185		,663	,222	,017	,333
TE07	Pearson Cor.	,167	-,045	-,115	,078	,034	,082	-,003	,123	-,154	,180	-,141	-,127	-,118	-,123	,029	,079	-,096	-,170	-,197	-,011	,323*	,194	,174	,040	,338*	,049	1	,053	,066	,252*
	Sig. (2-tailed)	,139	,693	,311	,493	,763	,472	,977	,278	,173	,111	,212	,260	,306	,276	,795	,486	,396	,131	,080	,926	,003	,084	,123	,726	,002	,663		,641	,559	,024
TE08	Pearson Cor.	-,025	-,038	-,009	,109	,103	-,015	-,056	,038	-,066	,212*	-,069	-,085	,024	,116	,243*	-,119	,172	,121	,233*	,004	-,014	,032	,033	,085	,128	,138	,053	1	,491**	,217*
	Sig. (2-tailed)	,829	,735	,936	,334	,362	,895	,622	,740	,559	,058	,542	,454	,836	,305	,030	,295	,127	,286	,038	,974	,899	,775	,769	,453	,259	,222	,641		,000	,053
TE09	Pearson Cor.	-,065	,065	-,050	,038	,005	,008	,028	-,056	-,050	,379*	-,040	,214*	,173*	,293*	,351*	-,197*	,410*	,254*	,324*	,212*	-,256*	-,063	-,254*	-,206*	-,050	,287*	,066	,491**	1	,265*
	Sig. (2-tailed)	,565	,570	,663	,737	,965	,945	,806	,620	,662	,001	,727	,056	,125	,008	,001	,080	,000	,023	,003	,059	,022	,577	,023	,067	,659	,017	,559	,000		,017
TE10	Pearson Cor.	-,117	-,265*	-,331*	-,012	,007	-,054	-,195	-,082	-,273*	,240*	-,105	-,157	-,219*	,075	-,067	,130	,135	,034	,310*	,018	,222*	,087	,078	,111	,136	,110	,252*	,217*	,265*	1
	Sig. (2-tailed)	,303	,017	,003	,918	,949	,634	,084	,469	,014	,032	,353	,165	,051	,507	,554	,250	,232	,768	,005	,877	,048	,445	,490	,328	,229	,333	,024	,053	,017	

Appendix D: Factor analysis statistics

Table 16 Variance explained by knowledge sharing items

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,816	40,228	40,228	2,816	40,228	40,228	2,612	37,308	37,308
2	1,9	27,143	67,371	1,9	27,143	67,371	2,104	30,063	67,371
3	0,647	9,245	76,616						
4	0,497	7,098	83,713						
5	0,452	6,46	90,173						
6	0,36	5,146	95,319						
7	0,328	4,681	100						

Table 17 Unrotated component matrix knowledge sharing items

	Component	
	1	2
KS02 - The knowledge shared by members in the project team is easy to understand.		0,712
KS03 - The knowledge shared by members in the project team is accurate.	0,528	0,683
KS04 - The knowledge shared by members in the project team is complete.		0,693
KS08 - People in this team are willing to share knowledge/ideas with others.	0,757	
KS09 - People in this team share their ideas openly.	0,833	
KS10 - People in this team with expert knowledge are willing to help others in this team.	0,667	
KS11 - This team is good at using the knowledge/ideas of employees.	0,702	

Extraction Method: Principal Component Analysis.
2 components extracted.

Table 18 Variance explained by team effectiveness items

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,594	37,057	37,057	2,594	37,057	37,057	2,565	36,638	36,638
2	1,503	21,47	58,527	1,503	21,47	58,527	1,532	21,889	58,527
3	0,921	13,154	71,681						
4	0,661	9,442	81,124						
5	0,506	7,23	88,354						
6	0,443	6,334	94,688						
7	0,372	5,312	100						

Table 19 Unrotated component matrix team effectiveness items

	Component	
	1	2
TE01 - The effeciency of team operations	0,763	
TE02 - The amount of work the team produces	0,503	
TE03 - The quality of work the team produces	0,664	
TE04 - The team's ability to meet the goals of the project	0,796	
TE05 - The team's adherence to schedules	0,738	
TE08 - I feel my input is valued by the members of the team.		0,874
TE09 - I enjoy being a member in this team.		0,800

Extraction Method: Principal Component Analysis.
2 components extracted.