Understanding designers
Designing for understanding
Ingrid Mulder

Like tango dancers who cannot start their dance without a certain amount of shared understanding, design teams cannot begin their work. The combination of distance and a strong reliance on technology makes understanding between dispersed team members less than obvious. This book reports on distributed teams that collaborate on complex design tasks and communicate by means of videoconferencing. The goal is to enhance the potential of distributed teams by providing proper support. For this, a collaborative design approach is advocated. The underlying assumption is that proper support invites team members to learn and work together – similar to the right tango music that evokes the right mood and right tempo for a certain moment. The research concentrated on the assessment of collaborative learning and shared understanding in video-based communication and how it can be supported. It is concluded that not technology is the most obtrusive factor for the success of virtual teams. The most interfering factor is the perceived distance that seems to hamper many distributed team members. However, just as tango couples, distributed team members have the potential to engage in the spirit of collaboration. When support is directed to trigger this spirit, barriers for collaborative learning and shared understanding can easily be removed.

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Ingrid Mulder (1971) studied Management and Organisation (1995), the obtainer her MA degree in Policy and Organisation sciences, University of Tilburg (1998), and graduated in group dynamics and the use of group support systems. Her passion for the design of art and innovative technology was given a theoretical basis at the Interaction Design Institute Ivrea (2001). She worked as a trainer of political education projects and as a teacher in communication and management skills. Since 1998 she has been a scientific researcher at the Telematica Institute where she worked in several projects crossing borders of theory and practice as well as disciplinary borders. As reported in this book she specialised in collaborative learning and the design of innovative technologies from a user-centred perspective. Currently she elaborates on this and concentrates on developing methods and techniques for capturing innovation, experiences, and future user needs.


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Understanding Designers
Designing for Understanding

Collaborative learning and shared understanding in video-based communication

Ingrid Mulder

Enschede, The Netherlands, 2004

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Frank O. Gehry and Vlado Milunic designed this Dancing Building in 1994. The building is also popularly known as the “Ginger and Fred” as it dances like the famous couple Rogers and Astaire around the corner.
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door

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geboren op 4 mei 1971
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en

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Preface

What is true for collaborative learning in general also goes for writing this dissertation. It is not just the final result that counts; it is also the interaction with others that enriched my learning experience. For this interaction, many people walked in and out of my life and I am very grateful to those who somehow contributed.

First of all, I am greatly indebted to Janine Swaak and Joseph Kessels for their constructive, motivating, and critical feedback throughout the whole process. Thanks for making me reflect, and especially for keeping up the spirit to get the best out of me. Also indispensable were the efforts of many others, who performed behind the scenes.

For the experimental study, Mark Graner was an invaluable assistant. Joyce Egberink was a great ‘pre-press and printing’ support, and made me look forward to the final book. Thanks also go to William van Dieten and Mark van Setten for developing the several Q-tools and the collaborative video analysis tool, respectively.

This research would not have been started without the confidence and help of Elske Heeren, Hermen van der Lugt, Chris Vissers, and the late Jeroen Schot. Thank you for setting the stage.

I also would like to thank Charles Steinfield for inviting me into an international distributed research team and for giving me such a rich experience. At the same time, this research would not have been accomplished without the kind cooperation of all the participants of the empirical studies and the design workshop. Thanks for your time and contribution.

In order to use the tango as a metaphor in this research, I owe it to Liesbeth Menken in particular that I understand the magic of the tango somewhat. Thank you for the inspiring discussions and the tango workshops.
Although I cannot be exhaustive, special thanks go to Harry van Vliet, Hugo ter Doest, Henk de Poot, Henk Eertink, Eric Backer, Carla Verwijs, Marjan Grootveld, and Henri ter Hofte for being honest, constructive, and motivating colleagues. That’s what really works!

As described in this dissertation, reaching shared understanding is a rather complicated process. Especially in a multidisciplinary environment as the Telematica Instituut this is not always straightforward. For example, using the same words does not automatically mean understanding each other. I am grateful to my colleagues at the fourth floor’s coffee corner. Not only for making the work environment more sociable and for inviting me in the parlance of computer science, but also for providing a vivid proof that collaborative reflection does exist. Even more, you put into practice that sharing humour leads to higher order reflective behaviour.

Last, but certainly not least, I wish to express my love and gratitude to my closest friends and family who, mostly at a distance, were always there at crucial moments. As said before, many people walked in and out of my life, and have left footprints in my life. However, only true friends have left footprints in my heart. You make me smile, and above all, you love me just the way I am. You are the social and affective influences that complete my learning experience.

Finally, writing this book convinced me more and more that technology really works when it is as easy as a smile, and that passion and humour are the best basis for my future research career. Let’s tango!!

Ingrid Mulder
Deventer, the Netherlands, May 2004
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Chapter 1

Introduction

“The Argentine Tango is the dance of contact, improvisation, and interaction. The leader shows an intention, an impulse for a movement; the follower reacts by starting the movement, and the leader follows her, in such a way that they go together. A good tango leader knows what he wants, knows how to pass something on to someone else. In other words, a leader knows what the follower needs. A good follower presents herself, is a good listener with her body, and gives an own creative answer. This requires self-awareness, being in contact with yourself and with your dancing partner, with the music, the environment and other dancers, and a good division of roles, however, an equal one. To put it differently, performing a tango has all to do with communication and interaction; it requires a clear language, a dialogue. In addition, it is about give and take space, maximal intimacy, keeping your own distance and identity. The tango is also known as the dance of seduction: a good leader seduces his partner to follow him” (Liesbeth Menken, Tango Abrazo).

1.1 It takes two to tango

Tango dancers need to coordinate on both the content and process of what they are doing in order to perform a tango. They need to know which dance they like to perform. They need to coordinate when to start, and adjust to each other’s tempo. Dancing with a different partner results in a different tango performance; the social relationship between partners influences their performance. An ‘ideal’ couple intuitively dances a perfect tango and coordinates in a subtle way. In other words, it can be assumed that such an ‘ideal’ tango couple needs a shared understanding of the content, the process, and their social relationship. Additionally, the music plays a crucial role in supporting the tango. A different choice for music evokes differences with respect to mood and passion, and therefore results in a different show.
In this dissertation the *tango metaphor* is used to understand distributed ad hoc teams working together on complex tasks. A single person cannot solve these complex tasks. It is the (potential) added value of a whole team that makes a team more suitable to perform such tasks. What applies to tango dancers also concerns team members who work and learn together in order to complete a complex task. This study concentrates on collaborative tasks for which it truly takes – at least – two to tango!

In order to work and learn together, distributed team members require effective communication and *shared understanding* amongst them (Clark & Brennan, 1991). Like tango dancers who cannot start their dance without a certain amount of shared understanding, distributed ad hoc teams cannot begin their work. The combination of *distance* and a *strong reliance on technology* makes understanding between virtual team members less than obvious.

As will be explained in more detail, the teams in the current study can be identified as zero-history teams. The team members were not accustomed to working together, and more often than not they did not live in the same city or even in the same country. Most likely they were ‘forced’ to collaborate because their expertise and background were required for the preferred diversity in the teams. This research concentrates on distributed ad hoc teams that rely on technology support for their collaboration and communication processes, and in particular on *video-based communication*. For this purpose, the goal was to enhance the team potential by providing the teams with proper support, taking into account that *proper support* would invite the team members to learn and work together. This can be compared to the right tango music that evokes the right mood and right tempo for a certain moment, and that, consequently, contributes to a ‘tango mágico’.

### 1.2 Background and motivation

Today’s world is becoming more and more complex. Professional work is becoming more knowledge-intensive, and at the same time learning is more often integrated into the workplace. Learning is a new form of labour (Zuboff, 1988, p. 395). In addition, working often needs to be a collaborative effort.

In other words, learning and working are becoming more integrated (Bolhuis & Simons, 1999; Fischer, 2001). Thus people learn within the context of their work and require authentic experience in real-world problems. This is in keeping with the current vision of how learning
environments can be most effective; these learning environments should be problem-based and should involve the activation of prior experience, the demonstration of skills, the application of skills, and the integration of these skills into real-world activities (Merrill, 2002).

One way to cope with this complexity in a knowledge-intensive society is to establish ad hoc expert teams within and across companies. It can be envisioned that small expert teams will cooperate within concrete projects over a limited period of time to an increasing degree (e.g., Katzy, 2002). Both creativity and innovation are considered essential in knowledge-intensive work (Drucker, 1988). Nemiro (2000) states that creativity is increasingly becoming a critical topic for such ad hoc teams, and that perhaps one of the most crucial reasons for organisational life to promote creativity has been global competition. Another reason for integrating such new partnerships, virtual teams, or networks in organisational life is to get products to the market faster. Especially in rapidly-changing markets, research and development departments are being challenged in terms of the speed with which new products and services can be communicated. Knowledge integration is therefore an essential organisational capability (Grant, 1996). Not only with respect to research and development, but also in other domains such as architecture ad hoc expert teams are purposely formed to solve complex design problems for which multidisciplinary views are necessary (De Poot & Mulder, 2003). Such complex tasks are often wicked; they are ill-defined and ill-structured (Arias, Eden, Fischer, Gorman, & Scharff, 2000). In summary, ad hoc expert teams seem to be a good way to survive in today’s knowledge-intensive society because such teams contribute to the organisation’s efficiency and innovative capacity.

In addition, multidisciplinary teams appear to be a good solution for coping with complexity because the team members have different perspectives on the problem, because their individual knowledge and skills differ, and because their approaches to solving the problem are different (Vissers, 2001; Maitland, 2002). In such teams, team members must share their knowledge, views, and perspectives in order to construct new understandings. Most of the time these team members do not know each other beforehand, because they are especially selected based on their expert knowledge, their creativity, and their capacity to be innovative in order to make the team multidisciplinary. Virtual team structures may lead to higher levels of team creativity as a result of more flexibility, diversity, and added access to information as compared to more traditional structures (Mowshowitz, 1997; Nemiro, 2000). Although team diversity can be an asset for dealing with the complexity of knowledge-intensive work, virtual ad hoc teams also face difficulties (e.g., Schrijver & Vansina, 1997).
One practical problem lies in the formation of ad hoc expert teams. Teamwork in the virtual corporation is essential to tap into the best talent to create the highest quality and fastest response to customer needs (Nemiro, 2000). More often than not the ideal expert is not the guy next door. Due to developments in information and communication technology ad hoc expert teams can collaborate across a distance. One such invaluable tool for remote collaboration and distance learning is videoconferencing (Finn, 1997). Nevertheless, videoconferencing has not grown popular yet. Even though videoconferencing has attracted a great deal of new interest since 11 September 2001 (Automatisering Gids, 2002), people still prefer face-to-face collaboration, and seem to be prepared to put up with long travel times and the relevant travel costs (Kuiper, 2002). It can be concluded that virtual teams still seem to differ from face-to-face teams in a negative way. Problems virtual teams cope with include lack of trust, lack of shared background knowledge, coordination difficulties, difficulties resulting from having to learn new ways to behave and interact, and difficulties because there are no face-to-face encounters (e.g., O’Hara-Deveraux & Johansen, 1994; Jarvenpaa & Leidner, 1998). Briefly summarised, understanding each other and reaching agreement is not obvious in distributed ad hoc teams.

Virtual teamwork can be in either synchronous or asynchronous communication. Regarding the issue of understanding each other, the media synchronicity theory (Dennis, Valacich, Speier, & Morris, 1998) states that synchronous communication is more suitable for convergence processes, such as the development of a shared meaning. Asynchronous communication, by contrast, better supports the exchange of information. It has been argued, however, that asynchronous communication is better for reflective activity.

Veerman and Veldhuis-Diermanse (2001) explain that synchronous collaboration has to be fast, and that students therefore have less time to search for information, to produce extended explanations, to evaluate information thoroughly, and to ask elaborate questions. In asynchronous collaboration students have more time to think, to search for information, to elaborate ideas, explain ideas, and reflect on each other’s contributions. Students can take time to reach shared understanding, to create their own ideas, and to formulate points of view as clearly as possible.

Empirical research that studied reflective behaviour in technology-based teams largely concentrated on asynchronous text-based learning environments (e.g., Gunawardena, Lowe, & Anderson, 1997; Baker, Hansen, Joiner, & Traum, 1999; Veerman, 2000; Veldhuis-Diermanse,
However, little reflective behaviour was found. For example, Veerman (2000) studied collaborative learning through argumentation in computer-supported collaborative learning environments. In this study students wrote together using both synchronous and asynchronous text-based communication. Each utterance in this text-based communication was coded as a kind of question or argumentation to assess ‘constructive activity’. Veerman (2000) did not find as much ‘constructive activity’ as expected. Also, Gunawardena et al. (1997) did not find much reflective behaviour in their analyses of online asynchronous discussions: only 2 of the 206 postings involved ‘co-construction’.

Most research on reflective behaviour in technology-based settings has been concentrated on text-based environments in the educational field; far less research studied video-based communication. Despite the growing application of videoconferencing in learning and work settings, little is known about the possibilities of enhancing collaboration in video-based communication. In addition, only a few studies in the field of videoconferencing focused on processes and outcomes in the context of learning (Reiserer, Ertl, & Mandl, 2002).

Ferraris, Brunier, and Martel (2002) concluded that most of the focus in CSCL (computer-supported collaborative learning) research is placed on communication and document sharing: “there is no real study of what could and would be a collaborative learning situation and how the computer could be used to support it” (p. 290).

Within the CSCW (computer support for cooperative work) area, numerous empirical studies were conducted of distributed teams, albeit that these studies scarcely took collaborative learning into account. Most CSCW studies focused on how to support work settings with technology (or groupware), and how to design such groupware, with emphasis on architecture and platform problems. Empirical insights concentrated on the adoption, use and evaluation of groupware (e.g., Orlikowski, 1992; Bradner, Kellogg, & Erickson, 1999). Although most empirical research started from a user-centred perspective, Computer Support still seems to be overemphasised.

Looking across proceedings from the CSCL community, it seems to be the other way around; in this research community Collaborative Learning seems to receive the most attention. In relation to the work done in the CSCW area, less empirical research for the design of such collaborative learning environments can be found in the CSCL community. The CSCL community focuses on knowledge sharing and co-construction of
knowledge, albeit mostly in educational settings, and scarcely in organisational or business settings (Price, Rogers, Stanton, & Smith, 2003).

To date, videoconferencing studies that focused on education mainly aimed at investigating differences concerning videoconferencing and face-to-face communication. Russell (1999) reports on 355 studies that found no significant differences based on a variety of criteria between face-to-face learning and online education. McDonald (2002) wonders what has been overlooked or sacrificed in current research by striving to make remote education as good as face-to-face education.

Concisely formulated, in the field of video-based communication most research either focused on the design and use of video-based communication or tried to reveal differences between face-to-face and video-mediated communication. Virtually no empirical studies on video-based communication showed results with respect to the quality of collaborative learning and shared understanding. What is more, Fischer and Mandl (2002, p. 623) concluded that no systematic studies have been conducted with respect to process and outcome measures of collaborative learning. Furthermore, it can be concluded that although learning and working are increasingly integrated in practice, this integration is not so explicit in research (see also, Fischer, 2003).

1.3 Research scope, objectives, and contributions

The scope of this dissertation is collaborative learning in ad hoc design teams that work together at a distance on complex collaborative tasks during video-based communication. Collaborative learning does not just mean that individual learning is enhanced by participation in small groups; it means that the groups themselves learn. Shared understanding is a product of this collaboration process: it arises through interaction among different perspectives (Stahl, 2002, p. 1). The term collaborative was explicitly chosen rather than the term cooperative, and refers to the distinction defined by Roschelle and Teasley (1995). Collaboration is distinguished from cooperation as follows. Cooperative work is accomplished by the division of labour among participants, as an activity where each person is responsible for a portion of the problem solving. Collaboration involves the mutual engagement of participants in a coordinated effort to solve the problem together. Thus this study concerns collaborative learning while working on collaborative tasks that need to be performed together.
The main aim of this research is to contribute to the apparent niche between the areas of computer-supported working and computer-supported learning. For this purpose, emphasis is placed on collaborative learning in video-based collaboration and how this can be supported. It is presumed that collaborative learning, interaction and understanding are closely related; collaborative learning is learning through interaction (Stahl, 2002), and understanding is achieved through interaction (Veerman, 2000). Moreover, collaboration is often considered to be interchangeable with either interaction or communication. Collaboration is the interaction between people and people learn through interaction with each other (Biggs & Collis, 1982). As indicated earlier, this dissertation elaborates on collaborative learning while working on complex collaborative tasks. In this the concept of shared understanding is central.

**Collaborative learning** is the process team members employ to gain new understanding or to correct, improve, or enrich the existing team understanding.

**Shared understanding** is the outcome of the collaborative learning process.

Although much has been written about the essence of shared understanding, less is known about how to assess shared understanding. This work elaborates on how the concept of shared understanding can be assessed, and therefore contributes to methodologies for studying computer-supported collaborative learning. Mäkitalo, Salo, Häkkinen, and Järvelä (2001) indicated that as this field of study is fairly novel; there is a shortage of established methodologies for analysing computer-mediated communication and the complex phenomena it encompasses.

There seems to be evidence that current methods are not sufficient for studying these new ways of interaction (see e.g., Steinfield et al., 2001; Gaver, Boucher, & Martin, 2003). A multifaceted approach (Steinfield et al., 2001) will be taken, meaning that several methods will be used to collect data, and to use quantitative and qualitative measures in the analyses of collaborative learning.

As introduced earlier, this study suits the field of CSCL, and therefore not only collaborative learning but also computer support will be examined. Stahl (2002, p. 1) also explains computer support: it means supporting forms of collaboration and knowledge building that could not otherwise take place without networked communication media and software tools for developing group understandings. Taking Stahl's explanation into account, this research focuses on a specific type of computer support, namely video-based support. The focus is on support that enhances group performance;
support that stimulates collaboration, rather than technologies that allow individual people to cooperate. In accordance with Roschelle (1992) this support can be referred to as collaborative technology.

In keeping with McDonald (2002), research on videoconferencing should address how to enhance video-based collaborative working and learning, rather than to prove that video-mediated communication can be as good as face-to-face communication. Prior research that attempted to reveal the differences relied on notions such as social presence (Short, Williams, & Christie, 1976), cuelessness (Rutter & Robinson, 1981), and media richness (Daft & Lengel, 1984). Consequently, video-based communication has often been blamed for being less social, less personal, and less rich than face-to-face interaction.

The limited richness should not only be interpreted as a constraint (e.g., Short et al., 1976; Rutter & Robinson, 1981; Daft & Lengel, 1994); it can also be a challenge. Implicit rules based on hierarchies and status are less visible and less evident. It also implies that the undesired effects of hierarchies and habits are not yet established. The challenge here is to support teams in such a way that adopting undesired communication patterns is prevented, and natural ways of interaction are fostered.

Because understanding each other is crucial to effective collaboration, it is a research challenge to make collaboration in distributed ad hoc teams more attractive and more effective, and to elaborate on how to support these distributed ad hoc teams. This work concentrates on videoconferencing in an attempt to stimulate collaborative learning in ad hoc design teams.

This study is aimed to provide distributed ad hoc teams with proper support that not only enables their video-based collaboration, but also stimulates the process of reaching shared understanding and collaborative learning. Support refers to ways of facilitating shared understanding and collaborative learning, thus the design of the learning environment as well as the design of technology.

As indicated earlier, despite the growing application of videoconferencing, little is known about the possibilities of enhancing collaboration in videoconferencing settings. Nevertheless, only a few studies in the field of videoconferencing focused on processes and outcomes in the context of learning (Reiserer et al., 2002). Despite many studies examining the perceived similarities and differences in communication outcomes across media in many areas, fundamental questions about the processes that lead to such outcomes are seldom posed (Tidwell & Walther, 2002).
In order to contribute to the process of collaborative learning in video-based communication, the following questions are addressed in this research:

- How is shared understanding as an outcome of collaborative learning constructed?
- How can collaborative learning and shared understanding be assessed?
- How can the process of collaborative learning and reaching shared understanding in ad hoc design teams that work on collaborative design tasks by means of video-based communication be supported?

Three different approaches were used to gain insight into the process of reaching shared understanding in video-based communication. These are an exploratory, a design, and an experimental approach. By using an exploratory approach, the study aimed to acquire insight into how shared understanding is constructed and how the concept of shared understanding can be assessed. Then, a design approach was taken to search for ways to support shared understanding. Finally, an experimental design was used to investigate whether the provided support truly influenced the process of reaching shared understanding and led to more collaborative learning and shared understanding in the distributed teams. These three approaches – as illustrated in Figure 1-2 – structure this dissertation. The approaches may seem to be described in an isolated way; however, within each approach insights from theory as well as from practice are combined in an iterative way. This study also aimed at using insights from various perspectives and disciplines. Multiple methods were also used to collect data.

### 1.4 Outline

This study starts in an exploratory way. Chapter 2 first explores collaborative learning during video-based communication. For this purpose, studies on video-based collaboration are reviewed. This review concentrates on whether process and outcome measures of collaborative learning are used, and how related concepts of collaborative learning are studied. After that, the concept of shared understanding is explored and ways to assess this concept are sought. The chapter concludes with a conceptual framework for studying and assessing shared understanding in the context of collaborative learning.

Chapter 3 describes the development of instruments for assessing shared understanding using the concepts defined in Chapter 2. These instruments are subsequently applied in a distributed design team that collaborated for a period of four months. Along with this in-depth assessment, the team used
in the study is compared with other teams that collaborated under similar conditions. In this comparison, measures related to the concept of shared understanding (trust, for example), and the use of technology are taken into account.

Based on this exploration in practice, the conceptual framework was revised. Chapter 4 describes these revisions, and elaborates on the role of questioning in collaborative learning and reaching shared understanding. Why this questioning process seems so difficult in video-based communication is also explored. Related studies are described to investigate whether similar difficulties were found, and to search for ways in which this process can be stimulated.

Chapter 5 addresses the design of questioning support that will evoke optimum questioning behaviour. Support that leads to improved collaborative learning and shared understanding is explored. First several design approaches are reviewed. A collaborative design approach to design collaborative technology that enhances human-to-human interaction is then motivated. In this, insights from both the field of groupware design and curriculum design are included. In particular, the involvement of the actual team members is emphasised. This collaborative design approach is applied in designing support for questioning. The entire process of designing a support tool for questioning behaviour is described.

Chapter 6 describes an experimental study to investigate whether the provided intervention stimulates questioning in video-mediated design teams. Twenty teams that performed a complex design task are compared; ten of these teams had the extra questioning support available. Results of the twenty design teams are presented.

Finally, Chapter 7 reflects on the entire research. First an overview of this study is presented. The research questions are answered based on the three research approaches. Next the results of the two empirical studies are compared and discussed. The final chapter reflects on both the assessment of, and the designing for collaborative learning and shared understanding. Whether the conceptual framework needs to be reconsidered is also discussed. The dissertation concludes with interesting dilemmas to study in more detail.
Understanding shared understanding – towards a conceptual framework

This chapter strives to gain insight into the process of collaborative learning in terms of reaching shared understanding. Several perspectives on collaborative learning are described. Then the concept of shared understanding and related terms are elaborated. After exploring collaborative learning and shared understanding on the conceptual level, it is investigated how these concepts can be made operational. For this purpose, several studies on video-based communication are reviewed. Based on these insights, the chapter concludes with a conceptual framework for studying collaborative learning and shared understanding in video-based communication.

Moreover, this framework is used to develop assessment measures and instruments. Worded differently, these measures and instruments are explicitly ‘construct-centred’.

2.1 Exploring collaborative learning

In the previous chapter collaborative learning was introduced as the process of reaching shared understanding. Collaborative learning takes place through processes of shared meaning-making (Stahl, 2003, p. 532), or as Weick and Meader (1993) call it, through sensemaking. Taking this learning perspective into account, the process of reaching shared understanding is viewed as an ongoing collaborative learning process (Figure 2-1). Three perspectives on collaborative learning are described that – rather than simply giving a fixed definition of what collaborative learning means – focus on the distinction of several stages or activities within the process.
The first perspective is the learning cycle (Dixon, 1994), the second is sensemaking (Weick & Meader, 1993), and the third perspective involves the media synchronicity theory (Dennis et al., 1998).

Dixon (1994) views collaborative learning as the construction and reconstruction of meaning, and as such it is a dynamic process. To put it differently, Dixon (1994, p. 6) views collaborative learning as a learning cycle that consists of four recurring processes. The fourth step then feeds into the first to generate new information.

The four steps Dixon identifies are:
- Generate: the widespread generation of information;
- Integrate: integrates the new information into the organisational context;
- Interpret: collectively interprets the information;
- Act: authorises organisational members to take responsible action based on the interpreted meaning.

Also, Weick and Meader (1993) describe a complex, ongoing process, which they label sensemaking. More clearly, Weick and Meader (1993) describe sensemaking as the construction of meaning using five different activities. This perspective on sensemaking is in keeping with Stahl’s view that collaborative learning takes place through processes of shared meaning-making.

The five activities that group members can adopt to reach effective group interaction according to Weick and Meader (1993) are action, triangulation, affiliation, deliberation, and contextualisation.
- Action is the process in which members incorporate the new information into their understanding and adjust their interpretations accordingly.
- Triangulation is the process in which members gain a more holistic (and probably more shared) interpretation of the situation by combining information from many sources.
- The activity contextualisation states the more context available, the better. In other words, the more group members who can provide information links to more contexts, the more likely the group is to arrive at a better understanding of the situation.
- The slow and careful reasoning, which is required to induce plausible patterns from the information gained through action, triangulation, and conceptualisation, is called the activity of deliberation.
- The affiliation activity involves seeking to understand how other individuals interpret or understand information, and coming to a mutually agreed upon symbolic meaning of the shared information.
Although it might seem that the affiliation process is a type of core process, it certainly is not the only important activity for effective group communication in which making sense is the goal. Each of these activities makes a different contribution to the construction of meaning according to Weick and Meader’s view.

Another point of view is the media synchronicity theory, which emphasises the distinction between shared meaning and shared agreement. Media synchronicity is the extent to which a communication environment encourages individuals to work together on the same activity, with the same information, at the same time; in order to have a shared focus (Dennis et al., 1998).

To understand this media synchronicity theory two dimensions are used: immediacy of feedback, this is the extent to which the medium enables users to receive rapid feedback, and concurrency, this is the number of simultaneous conversations that can exist effectively in the medium. While the media richness theory (Daft & Lengel, 1984) has taken a task-centred perspective on task-media fit, Dennis et al. (1998) propose in describing the media synchronicity theory an outcome-centred approach to media selection. More specifically, Dennis et al. (1998) propose that every group communication process is composed of two basic processes of communication: conveyance and convergence.

Conveyance is the exchange of information. It can be divergent, in that not all participants must agree on the meaning of the information. Convergence, however, is the development of a shared meaning to information. Thus all participants must work together to establish the same meaning for each piece of information.

The goal of conveyance is to enable the most rapid exchange of information among the participants as possible, and to enable them to effectively process this information, and arrive at their individual interpretations of its meaning. The goal of convergence is to enable the rapid development of a shared meaning among the participants.

The media synchronicity theory proposes that for group communication processes in which conveyance is the goal, environments providing low synchronicity (low feedback and high concurrency) will be more effective. For teamwork in which convergence is the goal, environments providing high synchronicity (high feedback and low concurrency) will be more effective (Dennis et al., 1998; Swaak, Mulder, Van Houten, & Ter Hofte, 2000).
Each of these three theoretical classifications can be used to acquire more insight into the process of reaching shared understanding. However, it is difficult to explain how these different categories relate to one another. There are no clear one-to-one relations. In Table 2-1 these three views on the collaborative learning process are displayed.

<table>
<thead>
<tr>
<th>The learning cycle (Dixon, 1994)</th>
<th>Media synchronicity theory (Dennis et al., 1998)</th>
<th>Sensemaking activities (Weick &amp; Meader, 1993)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate</td>
<td>Conveyance</td>
<td>Triangulation</td>
</tr>
<tr>
<td>Integrate</td>
<td>Contextualisation</td>
<td>Affiliation</td>
</tr>
<tr>
<td>Interpret</td>
<td>Convergence</td>
<td>Action</td>
</tr>
<tr>
<td>Act</td>
<td></td>
<td>Deliberation</td>
</tr>
</tbody>
</table>

Dennis et al. (1998) suggest a mapping between the basic communication processes in the media synchronicity theory and the sensemaking activities. The authors mention that the first three activities (action, triangulation, and contextualisation) share the same fundamental communication process: conveyance. When the slow and careful reasoning during the deliberation activity is allowed to incubate, it becomes clearer; when information comes too quickly and immediate responses are required, individuals fail to process information, and may automatically fall back on habitual processes and stereotypes. Therefore the fourth activity, deliberation, requires no communication according to Dennis et al. (1998). Hence this activity aims to make sense of the acquired information. The fifth activity, affiliation, is closely related to convergence on a shared meaning of this information; affiliation is the process of negotiating shared understandings.

The processes of the learning cycle (Dixon, 1994) seem to relate to the conveyance and convergence processes. The generate process of the learning cycle is a conveyance process, and the interpret process is a convergence process. How the integrate and act processes relate with the other processes is less clear. Because the steps form a cycle, the integrate process can be viewed as a transition from conveyance to convergence, and the act process as a transition from convergence to conveyance.

To conclude, the classifications defined above are helpful in acquiring more insight into the process of collaborative learning. Collaborative learning can be distinguished in terms of communication, moments of reflection, the exchange of information, and in terms of creating new meaning. In addition, shared understanding can be divided into shared meaning and shared agreement on this meaning.
In other words, collaborative learning involves the exchange of information as well as reaching shared understanding about its meaning. Moreover, the ongoing process of creating new understanding and reaching shared agreement on new meanings seems to be a prerequisite for actual collaborative learning. The next section elaborates on this process by exploring the concept of shared understanding.

### 2.2 Exploring shared understanding

Understanding one another is essential in daily life and everyday communication. It is therefore not surprising that shared understanding is generally considered as crucial for effective communication and for collaborative learning. Moreover, despite agreement on its importance, there is an ongoing debate on the meaning of shared understanding. This section focuses on shared understanding in terms of the outcome of a collaborative learning process (Figure 2-2).

Definitions of the concept of shared understanding and related terms are elaborated. All too often it was found that these terms were not defined clearly. Table 2-2 presents an overview of related terms; however, no claim is made to be exhaustive.

The definitions in Table 2-2 show that some focus on the outcome of shared understanding, whereas others emphasise the process of reaching shared understanding. There seems to be little agreement on how to label the concept of shared understanding. Baker et al. (1999) conclude that whether researchers speak of grounding, negotiation, or intersubjectivity, there is nevertheless common agreement that various forms of linguistic and non-linguistic feedback constitute the basic mechanisms by which the common ground is achieved and maintained.

The list of definitions portrayed in Table 2-2 indicates that shared understanding can be seen as a joint action that goes hand in hand with collaborative learning (see also, Roschelle, 1996). Some definitions emphasise the social group, for example, socially shared meaning, collective interpersonal meaning, or intersubjectivity, whereas others directly refer to discourse, for example, common ground, negotiation, or grounding.

Moreover, some definitions point towards the dynamics between the social group, the joint activity, and shared meaning. Nevertheless, these foci are not so different as Clark (1996) defines language as a joint action.
## Shared understanding: related concepts and definitions

<table>
<thead>
<tr>
<th>Concept</th>
<th>Found description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-construction</td>
<td>Mercer (1996) indicates that co-construction of knowledge can take places when people are engaged in a joint coordinated intellectual activity. Within this process, language is one of the most important mediating tools it can be used to share knowledge and to provide intellectual support (Mercer, Wegerif, &amp; Dawes, 1999).</td>
</tr>
<tr>
<td>Collaborative learning</td>
<td>Collaborative learning takes place through processes of shared meaning-making (Stahl, 2003, p. 532)</td>
</tr>
<tr>
<td>Collective and interpersonal meaning</td>
<td>Social cognition is not limited to individual thought about social objects but is a product of social interchange constructed, shared, and distributed among groups of individuals (Zajonc &amp; Adelmann, 1987)</td>
</tr>
<tr>
<td>Common ground</td>
<td>Mutual knowledge, mutual beliefs, and mutual assumptions (Clark &amp; Brennan, 1991, p. 127)</td>
</tr>
<tr>
<td>Common ground</td>
<td>A set of mutual beliefs of conversational participants about the meaning of their utterances during conversation (Baker, Hansen, Joiner, &amp; Traum, 1998)</td>
</tr>
<tr>
<td>Convergence</td>
<td>The development of a shared meaning (Dennis et al., 1998)</td>
</tr>
<tr>
<td>Grounding</td>
<td>The collective process by which the participants try to reach this mutual belief (Clark et al., 1991, p. 129). The interactive processes by which common ground (or mutual understanding) between individuals is constructed and maintained (Baker, Hansen, Joiner, &amp; Traum, 1999, p. 32). A process that is directed primarily towards attaining mutual understanding of linguistic productions (utterances).</td>
</tr>
<tr>
<td>Intersubjectivity</td>
<td>“It is the joint construction of mutual understanding (Forman, 1992; Rommetveit, 1979, 1985)” (as cited in Baker et al., 1999)</td>
</tr>
<tr>
<td>Negotiation</td>
<td>“The interactive creation of common meanings (e.g., Moeschler, 1985; Rouet, 1991)” (as cited in Baker et al., 1998)</td>
</tr>
<tr>
<td>Shared mental model</td>
<td>The function of shared mental models is to allow team members to draw on their own well-structured knowledge as a basis for selecting actions that are consistent and coordinated with those of their team mates (Mathieu, Heffner, Goodwin, Salas, &amp; Cannon-Bowers, 2000, p. 274)</td>
</tr>
<tr>
<td>Socially shared meaning</td>
<td>How dyads, groups, and larger collectives create and utilize interpersonal understanding (Thompson &amp; Fine, 1999, p. 280)</td>
</tr>
</tbody>
</table>

In keeping with Stahl (2003, p. 523), it can be concluded that meaning-making practices do not merely take place within a context of joint activity, but that this context of joint activity is those practices – the practices form the joint activity, which constructs the meaning. Based on this, Stahl (2003, p. 524) proposed that – particularly in contexts of collaboration – meaning exists in the intersubjective world and is interpreted from personal perspectives.

In the following, the focus is on the joint activity that constructs the meaning. At the same time, this joint activity bridges the differences among team members. Dixon (1994, p. 15) defines this as follows:

“the uniqueness born of individual interpretation has very positive and important consequences as well. It is because we each construct the world, rather than mentally copy or record it, that we are able to generate diverse new ideas and understandings. This diversity, created by each person’s unique construction of the world, makes us, as a species, creative and
intelligent. And, further, it is this difference between these individual interpretations that stimulates further learning”.

The term *shared* is used when team members *perceive* their understanding is shared. Others might refer to this perceived shared understanding using terms such as intersubjective understanding or shared interpretation. Thus, the use of same words does not necessarily mean that team members speak the same ‘language’.

In conclusion, in the current work the term *shared understanding* is used as follows.

*Reaching (and maintaining) shared understanding is defined as the process (multidisciplinary) team members employ to gain new understanding or correct, improve, or enrich the current team understanding, and thus collaboratively learn and collaboratively reflect.*

Understanding what the concept of shared understanding means is one thing, but it is quite another to know when such shared understanding exists among team members.

More specifically, following Wells (1993), it is interesting to study what the successive moves are that make up a conversational transaction and that might lead to a change in the knowledge of one or more of the participants. Because there is no generally agreed approach of how shared understanding can be assessed, the current work elaborates on the assessment of shared understanding as an outcome of a collaborative learning process.

### 2.3 Collaborative learning and shared understanding in video-based communication

One of the research objectives is to develop methods to assess collaborative learning and shared understanding. Therefore, first related studies in which group members worked together on a collaborative task using video-based communication are reviewed. This review concentrates on how concepts related to collaborative learning and shared understanding were made operational and used in video-mediated settings.

As pointed out in the first chapter, research in the field of CSCW and CSCL has scarcely emphasised video-based collaborative learning during work settings. Although both the CSCW and CSCL community have been conducted video-based research, current research is still diverse, making it rather complex to do comparisons across studies (Sellen, 1997).
In this search of empirical evidence on how collaborative learning and shared understanding were made operational in studies on video-mediated communication, it was found that little research has been done on this specific topic (see also, Ferraris et al., 2002; Reiserer et al., 2002). Roughly speaking, research on video-based communication has been devoted to:

1. the comparison of video communication with face-to-face communication;
2. the use and adoption of videoconferencing systems;
3. or the design of videoconferencing systems.

A more detailed look was taken at these research clusters, and those studies that concentrated on issues related to collaborative learning and shared understanding were selected. More specifically, it was investigated whether concepts related to collaborative learning and shared understanding have been made operational.

The next sections describe how the studies were conducted, and what measures were used. It will be concluded how insights from the review might contribute to a conceptual framework of collaborative learning and shared understanding.

### 2.3.1 Face-to-face versus video-based communication

As said earlier, rapid developments in communication technology suggest that videoconferencing will be intensively applied in businesses and educational settings in the near future. Videoconferencing enables synchronous forms of communication, which allow highly-frequent and complex interactions. To date, research in video-based communication has mainly been aimed at proving that videoconferencing is as good as face-to-face communication (e.g., Russell, 1999; McDonald, 2002). It was investigated which measurements were used to compare videoconferencing and face-to-face communication. This section presents several studies that used measurements related to collaborative learning and shared understanding.

The first chapter pointed out that prior research that attempted to reveal the differences between video-based communication and face-to-face communication relied on notions such as social presence (Short et al., 1976), cuelessness (Rutter & Robinson, 1981), and media richness (Daft & Lengel, 1984). O’Conaill and Whittaker (1997) argue that such terms are difficult to measure objectively and are open to interpretation.

Additionally, they aim to quantify these differences in terms of measurable characteristics of speech processes that have independently been shown to be important in face-to-face interaction (O’Conaill & Whittaker, 1997, p. 108).
O’Conaill and Whittaker (1997) argue that high-level phenomena such as cuelessness and lack of social presence are explicable in terms of disruptions in basic conversational processes, such as lack of support for backchannels or interruptions. These disruptions result from definable characteristics of communication channels, such as lags and half duplex audio. In turn, O’Conaill and Whittaker (1997) argue that media richness can be defined in terms of the set of conversational processes supported by a given medium and derived from the channel properties of that medium.

O’Conaill and Whittaker (1997) compared interaction in real meetings that took place in two wide-area videoconferencing systems with that in a face-to-face setting. In this comparative study they concentrated on speaker transitions. More specifically, they looked at (auditory) backchannels (such as positive concurrent feedback that serves several functions, including attention, support, or acceptance of the speaker’s message), interruptions, overlaps, explicit handovers, total numbers of turns and turn length, and turn distribution. Results showed that, compared to face-to-face, in videoconferencing less turns were taken, fewer interruptions occurred, and handovers by naming the next speaker were more frequent.

However, their aim was to diagnose the differences between video communication and face-to-face communication, O’Conaill and Whittaker (1997) came up with objective measures (for example, the number of turns taken) to assess the nature and structure of the communication process. These measures can be seen as a precondition for effective communication rather than as an assessment of the quality of communication.

The following study paid attention to the quality of communication. Anderson et al. (1997) reported results concerning four studies of collaborative problem solving supported by various forms of audio- and video-mediated communication.

They compared these technology-mediated settings with face-to-face interaction. To that end, they analysed task outcome, the process of communication, and the user’s reactions to the technologies. Dialogue analysis was used to assess the quality of communication.

In their study Anderson et al. (1997) used six types of conversational acts:
- **INSTRUCT**: Communicates a direct or indirect request for action or instruction.
- **CHECK**: Listener checks his/her own understanding of a previous message or instruction from the conversational partner, by requesting confirmation that the interpretation is correct.
- **QUERY-YN**: Yes-no question. A request for affirmation or negation regarding new or unmentioned information about some part of the task (not checking an interpretation of a previous message).
- **QUERY-W**: an open-answer Wh-question. Requests more than affirmation or negation regarding new information about some part of the task (not checking an interpretation of a previous message).
- **EXPLAIN**: Freely-offered information regarding the task, not elicited by co-participant.
- **ALIGN**: Speaker confirms the listener’s understanding of a message or accomplishment of some task; also checks attention, agreement, or readiness” (Anderson et al., 1997, p. 138).

Anderson et al. (1997) aimed to discover what communicative functions caused the greater length of audio-only dialogues compared to face-to-face communication. They found that speakers in face-to-face communication check less often to ensure that their listener understands them (align) or that they have understood their communication partner (check) than in audio-only interaction. Anderson et al. (1997) stated that there were significant increases in the frequency with which speakers used ALIGN and CHECK in audio-only conditions, respectively 50% and 28% more often. Anderson et al. (1997) suggested that an explanation for finding more verbal checking might be the lack of visual signals.

As the authors only used this analysis in some of their studies, namely face-to-face versus audio-only, it is not possible to draw conclusions with respect to the quality of communication in video-based communication. Nevertheless, their coding scheme seems to be a good starting point to study the quality of communication.

Another example is the comparative study conducted by Olson, Olson, and Meader (1997). For a subset of the audio and video conditions, they assessed two additional processes related to collaborative learning and shared understanding, namely **engagement** and **critical discussion**.

Engagement was defined as the degree to which individuals invest themselves in and contribute to task-oriented group discussion. Olson et al. (1997) expected that the groups working remotely would have a tendency to be more engaged if they could see each other, with the video providing the social context cues. Engagement was operationalised in several ways:

1. The time spent in sequences of act-response interactions whether the participants agreed with each other or not, including time discussing things written in the shared document;
2. Speaker turn change density, rapid interchange of statements and their responses;
3. Length of time the group met.
The concept of critical discussion was operationalised as the amount of time in which discussion included both positive and negative criteria.

Olson et al. (1997) used above operationalisations to reveal differences between remote audio and remote video teams. No significant differences were found. As they only used these assessments to compare the different conditions, they did not relate the results to the content of communication or to the learning process.

2.3.2 Use and adoption of videoconferencing systems

Another focus in CSCW research is to study the use and adoption of technology. A general conclusion with respect to the use of new technology was summarised by Hettinga, Schippers, and Schuurman (2001, p. 64):

“new technologies are not used in the way and for the purposes they were designed for. Users tend to ‘re-invent’ technology – they develop their own way of using it for their particular purposes, and they may invent completely new purposes”.

Monk, McCarthy, Watts, and Daly-Jones (1996) argued for the use of quantitative measures of communicative process rather than the more usual measures of task outcome. They advocated measuring a variety of process variables such as social orientation, communication breakdown, and conversational structure. A method often used to study such process is the breakdown analysis. “If something goes wrong when a person is using a tool then the user tends to respond by ‘breaking down’ or decomposing the tool and its use to explain the problem” (Monk et al., 1996, p. 130).

Kydd and Ferry (1994) reported on a study of the use of videoconferencing systems by managers. The study was performed to determine what managers have learned about the effective use of videoconferencing systems in recent years. Kydd and Ferry (1994) interviewed managers and performed a content analysis on the interview notes. Although they concluded with some interesting suggestions about preconditions needed to hold a successful videoconference (Kydd & Ferry, 1994, p. 372), their results did not show either measures related to the learning process of those managers or measures related to the learning outcome.

Here, the focus on the use of technology illustrates why it appeared hard to find results with respect to the assessment of collaborative learning and shared understanding. In this case it would have been of interest to study what and how managers learn with respect to their management tasks, rather than what they learn in terms of using a videoconferencing system.
Hettinga (2002) studied evolutionary use of videoconferencing in the context of medical specialists that consulted colleagues at remote hospitals. Using breakdown analysis, Hettinga (2002) focused on very specific moments of the tele-consultation sessions: the moments of reflection, assuming that breakdowns are moments of reflections. During habitual use, a technology is transparent. During a breakdown this routine use is interrupted and becomes explicit. Hettinga (2002) identified a breakdown as an interruption (social, task, or technology) of the routine process.

She concluded that breakdowns mainly concerned process structures, while social, task, and technical structures were far less often the subject of breakdowns. The dialogues in which participants reflected on the involved structures influenced the amount and direction of change (Hettinga, 2002, p. 99). Furthermore, spontaneous reflective dialogues of participants mainly concerned the operation of the equipment. These breakdowns concerned knowledge about the equipment and skills in handling it. Put differently, the medical specialists mainly reflected on technology use.

After the breakdown analysis, a workshop was organised to encourage reflection and to learn how to encourage reflection. Using questionnaires Hettinga (2002) assessed whether people experience a gap between preferred and actual reflection. Indeed, the participants experienced such a gap, and the effect of the questionnaire stimulated reflective behaviour. Though valuable, the work of Hettinga (2002) did not focus on the operational level of assessing collaborative learning and shared understanding.

Ruhleder and Jordan (2001) aimed to acquire better understanding of the dynamics in remote video-based communication with an eye to providing guidelines for developers and implementers. It was hypothesised that the mechanisms through which transmission delay affected trust and confidence between communicants were turn taking, sequence organisation, and repair. In face-to-face communication, when trouble occurs a repair is promptly initiated and carried out. With sequence organisation they considered the notion of adjacency pairs from conversation analysis, such as greeting-greeting or question-answer. Ruhleder and Jordan (2001) conducted an interaction analysis of the communication process and used these concepts to gain more insight into the quality of interaction and, more specifically, in shared meaning-making. Ruhleder and Jordan (2001) found unintended interruptions due to lack of perceived response, rephrasing due to expectation of a disfavoured response, and mistimed and delayed feedback. These findings were illustrated with examples from the transcripts. They concluded that talk was not just about the exchange of information, but also about shared meaning-making on multiple levels.
Even though Ruhleder and Jordan (2001) did not want their analysis to be restricted to the delay in the video-based communication, but rather to be applied to the visual, aural, and spatial cues that enable participants to create shared meaning and mutual understanding, they did not elaborate on measures to assess shared meaning and mutual understanding.

Andrews and Klease (2002) explored the extent to which a virtual faculty using videoconferencing enhances the learning experience. In order to assess learning experience, they performed evaluation by means of surveys, observations of the teaching and learning sessions, student focus groups, staff reflections, and staff interviews. Concurrent with the focus groups, informal interviews were conducted with lecturing staff. These interviews provided invaluable information because they not only highlighted the strengths and weaknesses of the virtual faculty, but also provided insight into the lecturers’ own developing experiences in using videoconferencing as a teaching and learning tool. Although the authors used various ways to carry out their evaluation, it was not clear how they assessed the concept of learning experience.

2.3.3 Design of videoconferencing systems

A third category involves research with respect to the design of videoconferencing systems. Isaacs and Tang (1997) studied how video can be usefully integrated into people’s real work settings. They used a combination of quantitative and qualitative measures of users’ activities, and compared the group’s behaviour using the prototype to group’s behaviour without the prototype. In this way, they could learn how the prototype affects people’s ability to work together. Their review concerned three video-based prototypes that supported remote collaboration.

Issues that Isaacs and Tang (1997) raised with respect to methodology seem to contribute to the current work of assessing collaborative learning and shared understanding. Isaacs and Tang (1997) pointed out that it is important to use a combination of approaches and measures when collecting and analysing data. In particular, they preferred to combine both quantitative and qualitative measures.

Even though Isaacs and Tang (1997) used a variety of measures, it was not clear which outcome measures they used nor whether they used measures related to collaborative learning. They mainly reported on the use of the various prototypes of video communication.
Another study that contributes to both CSCL and CSCW involves telematic support for group-based learning (Van der Veen, 2001). Van der Veen (2001) studied groups of students that worked together on learning tasks. The aim was to explore what problems students experiencing with respect to the planning, operationalisation, and monitoring of the work. In one of the teams students used videoconferencing. These students worked together in an international project on ‘Applications of Information Technology’ (Van der Veen, 2001, p. 143). The provided support – design of telematic support tools and instructional methods – was evaluated. With regard to video communication, a questionnaire was used to evaluate most topics regarding the quality of the videoconferencing. Students were also asked whether they felt videoconferencing might help cooperation between international partners during the project, whether they took part in the discussion, and how much time they devoted to a certain task.

Measures with respect to learning process or learning outcome were not mentioned. Although ‘learning outcomes’ and ‘task efficiency’ were included in the framework, they were unfortunately not explicitly mentioned in this study of Van der Veen (2001).

2.3.4 In conclusion: how to assess learning processes and learning outcomes in video-based communication

Despite the growing application of videoconferencing, only little is known about the possibilities of enhancing collaboration in videoconferencing settings. As yet, only a few studies in the field of videoconferencing have focused on processes and outcomes in the context of learning (see also, Reiserer et al., 2002).¹

A more-detailed look at studies in the field of videoconferencing showed that most research on video-based communication focused either on the design and use of video-based communication or on the comparison with face-to-face communication. Empirical studies that revealed differences between face-to-face and video-based communication mostly used factual measures with respect to (the structure of) the communication process. Sometimes they used measures that can be used to gain insight into the content or the quality of collaborative learning and shared understanding (e.g., Anderson et al., 1997), but no findings were reported with respect to such qualitative measures.

¹ Reiserer et al. (2002) did not mention in which studies learning processes and outcomes were assessed.
In keeping with Fischer and Mandl (2002, p. 623) it can be concluded that “it is unclear to what extent the conditions of videoconferencing have an impact on process and outcome convergence. Up to this point, no systematic studies on this topic have been conducted”.

With respect to studies on the use of videoconferencing, it appeared that an assessment method that has often been used is breakdown analysis (e.g., Monk, McCarthy, Watts, & Daly-Jones, 1996). Breakdowns were identified to diagnose whether the technology caused some problem in the communication process. Moreover, when the concept of learning was mentioned, studies on the use of videoconferencing systems mostly refer to how people’s use of technology changes over time.

In other words: what do people learn from the technology, rather than how or what do they learn with respect to the task for which they communicated by using videoconferencing? With respect to the design of technology, no measurements were found that made concepts of collaborative learning and shared understanding operational.

To conclude, much has been discussed on the conceptual level, although less has been written about how to assess shared understanding. In this search of ways to assess shared understanding, no satisfactory assessment methods were found that study both outcome and process of collaborative learning and shared understanding.

Nevertheless, insights from related research seem to contribute in meeting the assessment goals. Combining qualitative and quantitative measures appeared to be a precondition (e.g., Monk et al., 1996; Isaacs & Tang, 1997).

A multifaceted approach using several methods and instruments to gain insight into the group interaction process, collaborative learning and shared understanding is advocated.

In other words: quantitative as well as qualitative, and objective as well as subjective measures are used to answer questions, such as how the group interacted, how these concepts of collaborative learning and shared understanding were constructed, and whether reflective behaviour took place in the collaborative learning process.

In doing this, it is also aimed to contribute to methodologies for studying computer-supported collaborative learning. There seems to be evidence that current methods are not sufficient to study these new ways of interaction (see e.g., Mäkitalo et al., 2001; Steinfield et al., 2001; Gaver et al., 2003).
Apart from the proposed multifaceted approach, the assessments are explicitly ‘construct-centred’ (Swaak, 1998). According to Swaak (1998) an important prerequisite in measuring concepts that are hard to assess is that a conceptual framework guides the development of assessment measures and instruments.

The next section attempts to do so and describes the concepts that will be used to study collaborative learning and shared understanding.

2.4 A conceptual framework on collaborative learning and shared understanding

Collaborative learning involves both social or group, and cognitive or individual processes. On the one hand, learning has primarily been seen as an individual cognitive process; on the other hand collaborative learning is a joint activity. Put differently, in addition to learning individually, it is the group that explicitly enhances collaborative learning by means of interaction.

Sfard (1998) distinguished two metaphors of learning: the acquisition metaphor and the participation metaphor. The acquisition metaphor represents the traditional view on learning, in which learning is an individual construction of knowledge. The participation metaphor examines learning as a process of participating in various cultural practices and shared learning activities. Within the participation metaphor, learning is a matter of participation in a social process of knowledge construction (Vygotsky, 1978; Greeno, 1997). These metaphors illustrate the individual or cognitive, and social or interactive aspects of collaborative learning. Socio-cognitive theories view (collaborative) learning as an interactive group process in which learners actively construct and create new knowledge (Vygotsky, 1978).

Therefore, in the current study of collaborative learning and shared understanding, aspects of social and cognitive theories are included. The main concepts used for studying collaborative learning and shared understanding are: questioning, conceptual learning, feedback and expression of affect. In addition, the nature of interaction is examined.

The remainder of this section describes these conceptual ideas, which are used to develop measures to assess collaborative learning and shared understanding.
First, the nature of interaction is described. Team members need a shared understanding of the content – what they work on - the process – how they work together - and each other – with whom they work together. Additionally, the technology aspect, as the focus is on teams that have to rely on technology. Therefore task-related (content), social (relation), process, and technology aspects are used to get a grasp on group interaction.

Content and relation are aspects that are often used to characterise communication (Bales, 1950; Remmerswaal, 1982; Johnson & Johnson, 1987; Gramsbergen & Van der Molen, 1992). Content is the subject of the communication; here the content aspect is used for interaction that concentrates on the task or the domain. The relation aspect involves the relation between team members, and influences social interaction.

Within a team, a distinction can also be made between the content the team is discussing and the process by which the discussion is being conducted. Content is what is being discussed; process is how the group is functioning (Johnson & Johnson, 1987, p. 25). Task-related and process-related interaction try to capture this distinction. Process aspects refer to regulation and structuring of the interaction, such as turn taking and making appointments.

Veereman (2000) examines collaborative learning as a process of knowledge construction in text-based computer-mediated communication (CMC) systems. In the analysis of the online debate, interaction was distinguished as follows:

“Messages could contain explicit expressions of task-related knowledge construction such as new ideas, explanations or evaluation. In addition, messages could contain information about planning the task, technical problems considering the CMC system, conversational rules and references to other facts, issues, summaries or remarks elsewhere in the discussion. Moreover, some messages only referred to non-task related issues such as the weather, joke etc” (Veereman & Veldhuis-Diermanse, 2001, p. 626).

Task-related, social, process-related, and technology-related interaction are used to acquire more insight into the nature of interaction. Although these four aspects seem to split up interaction, these aspects also influence one another. Making a distinction is therefore not always clear. However, these aspects are strongly intertwined and reciprocal; mostly there is focus on a certain aspect. Sometimes the focus will be more on the content or on the technology; other times the relation or the process aspects are more central. In case teams focus on only one kind of interaction, it is referred to as unbalanced interaction.
Knowing each other and having insight into each other’s background make it easier to understand each other’s interpretations. However, a shared language is not a guarantee for shared understanding. Questioning is considered important by many to check each other’s intentions and understanding (e.g., Gramsbergen & Van der Molen, 1992; Veerman, 2000; Mäkitalo & Häkkinen, 2001; Van der Meij & Boersma, 2002).

Mäkitalo and Häkkinen (2001) conclude that feedback and questions offer evidence of each other’s understanding. Questioning plays a central role in capturing miscommunication, and in preventing both cognitive and affective conflicts.

Van der Meij and Boersma (2002), who coded e-mail communication, distinguished three kinds of speech acts. Assertions are statements of facts, principles, choices et cetera, whose main intent is to inform the other team members. Questions are explicit requests for information. Many of these are signalled by a question mark. Reactions are responses. They include answers to questions and remarks to assertions.

Following Van der Meij and Boersma (2002) this triad is used to get more insight in the team communication, assuming that the process of reaching shared understanding is suboptimal when assertions or questions were not followed by reactions. Moreover, these concepts show similarities with breakdown analysis (e.g., Monk et al., 1996; Hettinga, 2002) and conversation analysis (e.g., question-answer adjacency pairs by Ruhleder and Jordan, 2001).

Conceptual learning refers to the exchange of facts and concepts, reflection on them, and fine-tuning. Norman (1993) distinguished various modes of learning which form the basis of the assessment of shared understanding. While Norman emphasised skills, in the current work concepts and understanding are emphasised. The modes distinguished by Norman are adapted and redefined as follows.

Accretion is used when concepts and facts are added. Tuning refers to the fine-tuning of these concepts and facts: thus, when utterances involve more specifics or more detail, or when they define more boundaries or make the scope explicit. Restructuring is used when new relations between concepts or a new conceptual framework are being created. Only after restructuring can understanding be updated.

The goal is to analyse the construction of shared understanding among the team members. Thus, the focus is on collaborative learning instead of individual learning. For this purpose co-construction (of knowledge) is added to Norman’s troika (Van der Meij, 2000).
The main difference between the latter two modes of conceptual learning is that restructuring involves individual reflection while co-construction concerns the restructuring of the whole team. Put differently, co-construction involves the joint reflective action.

Feedback mechanisms are used to structure the communication process and also to encourage reflection (e.g., Gramsbergen & Van der Molen, 1992). Giving and receiving feedback contributes to reaching shared understanding because listeners understand better when more feedback is provided (Schober & Clark, 1989; Krauss & Fussell, 1991). Baker et al. (1999) point out that feedback is necessary in the grounding process. When things are going smoothly, this feedback may be simple acknowledgements. However, feedback can also take the form of repairs (Baker et al., 1999) to correct misunderstanding (Ruhleder & Jordan, 2001). Moreover, some researchers view feedback as a specific type of learning (Argyris & Schön, 1978). Based on the functions of feedback in communication (Gramsbergen & Van der Molen, 1992), and the specific goal to measure shared understanding, the following distinct feedback mechanisms are defined: confirm, paraphrase, summarise, explain, reflect, check understanding, and check action. Inspired by the coding scheme of Anderson et al. (1997) the latter two variables ‘check understanding’ and ‘check action’ are added to the feedback mechanisms defined by Gramsbergen and Van der Molen (1992).

Learning is also a socially endeavour (Bandura, 1986; Bolhuis & Simons, 1999). Van der Meij, De Vries, Boersma, Pieters, and Wegerif (in press) use the concept of ‘affect’ to assess motivation. The expression of affect is here added in a broader context of drives, and includes evaluative expressions on the usefulness of acquired information. More specifically, it is referred to the expression of certainty and uncertainty, and subjective expressions of the ‘value’ of the situation. In addition, it seems to be of interest whether impasse was made explicit. Therefore, impasse is used when team members express they do not know how to go any further. An impasse can be seen as a moment of reflection.

It is assumed that questioning, conceptual learning, feedback, and the expression of affect are all part of the process of reaching shared understanding. Conceptual learning is more associated with cognition, while the expression of affect involves the motivational and emotional part of learning. Snow (1989) labels this distinction, referring to the cognitive and conative structures in learning.
Finally, feedback relates to both questioning and learning, and focuses on the mechanisms that structure communication. Figure 2-3 reflects the conceptual framework for collaborative learning.

![Figure 2-3: Conceptual framework on collaborative learning and shared understanding](image)

To recapitulate, these conceptual ideas aim to better understand collaborative learning and the process of reaching understanding and, as a start, to develop instruments for assessing collaborative learning and shared understanding. Moreover, the familiar distinction between task-related, social, process and technology-related interaction is used. How to proceed from construct to assessment as well as instruments to assess collaborative learning and shared understanding are described in the next chapter.
Chapter 3

Understanding designers – an exploratory study

This chapter describes how collaborative learning and shared understanding were explored in an international design team. In order to understand what designers actually did, instruments were developed to assess collaborative learning and shared understanding. These instruments were based on the conceptual framework presented in the previous chapter, and applied in a design team that collaborated for four months and communicated via videoconferencing. Next to this in-depth assessment, the current team was compared with other teams that collaborated under the same conditions. In this comparison measures related to the concept of shared understanding and technology use were taken into account. The major conclusion was that little reflective activity took place. More specifically, it was found that hardly any questions were raised and answered. With regard to the teams’ technology use, it was concluded that all teams used their technology in a suboptimal way.

3.1 Method

The process of reaching shared understanding was explored in an international design team. The objective of this study was to follow a distributed ad hoc team for a longer period of time, to see how the developed instruments were applicable and useful, and to find out to what extent the conceptual framework was helpful to understand collaborative learning and shared understanding.

This study was embedded in a larger project called International Networked Teams for Engineering Design (INTEnD), developed by an international consortium of universities and industry partners whose principal aim is to conduct research on the evaluation of a geographically-
dispersed team of engineers. By participating in an international research project, it was possible to profit from both the quality of an in-depth study and the comparison across teams. This chapter describes the results of the in-depth study (Section 3.2) as well as the comparison across teams (Section 3.3). The following subsections outline the method used in the empirical study.

3.1.1 Exploratory questions

In order to explore the concepts of collaborative learning and shared understanding in video-mediated design teams, the following questions were investigated.

- How do distributed team members communicate?
- Do they interact on task-related, social, process-related, or technology-related topics?
- What are the roles of questioning, conceptual learning, feedback, and the expression of affect in collaborative learning and shared understanding?
- What happens to the perception of shared understanding during the project?
- Is there a relation between shared understanding and the final result?

3.1.2 The dispersed team

A team of seven mechanical engineering students participated in the current study. This dispersed team collaborated for four months on an engineering design project, and relied on video-based communication to bridge the distance. These students came from two different universities: Delft University of Technology (TUD) in the Netherlands and Michigan State University (MSU) in the United States. In the Delft subteam two Dutch male students participated (26 and 27), along with one American male student (21) who was spending the semester in Louvain, Belgium. The remote American subteam included two female and two male students (all 21). The unit of analysis was the whole team (N = 1) rather than the seven individual students.

Similar to most other teams in the INTEInD project, team members in the current study did not know each other beforehand. In other words, the team was a zero-history group. The students were recruited at their universities to participate in an international design team, and volunteered to work on the engineering design task in the context of an optional assignment. Because the language in the international team was English, Dutch students needed to pass a test on their proficiency in English.
3.1.3 Task

As mentioned above, this study was part of a larger project developed by an international consortium of universities and industry partners. The industry partners provided realistic projects, giving the students a sense that their efforts had a real client and a purpose. The collaborative design task given to this engineering team was to design a prototype to manually form the rear wheel well for a new car type. The students received background information about the automotive industry partner.

Furthermore, the client defined some assumptions and criteria that should be taken into account in the engineering work. Thus the students were performing an authentic task, with a problem statement and basic constraints, although the problem was ill-defined and various ways of tackling the problem were available.

Box 3-1

Description of the collaborative design task

<table>
<thead>
<tr>
<th>Project description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop process, tool design concept and prototype to manually form the rear wheel well opening weld flange 45 degrees on the new car type X (car type Y replacement vehicle).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The current North America/European new car type X production process to form the rear wheel well opening weld flange 45 degrees is done with hard automation. However, for low volume applications in emerging markets, a low-cost, manual hemming process is required to meet investment targets, while maintaining North American/European quality standards.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The following assumptions/criteria need to be followed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Process design must be capable of up to 15 units per hour.</td>
</tr>
<tr>
<td>2. Quality must be equal to (or better than) the N.A./European hem process.</td>
</tr>
<tr>
<td>3. Operator labour wages are negligible, thus low investment cost, high labour content.</td>
</tr>
<tr>
<td>4. Operator ergonomics must be considered.</td>
</tr>
<tr>
<td>5. Total investment should not exceed $100,000.00.</td>
</tr>
</tbody>
</table>

3.1.4 Collaborative technology

Before the team started, the team members received instructions about the various tools they could use. Students were free to decide how often they met with each other, which technology they used, and how to proceed and come up with the final result. With respect to technology, they could ask for help from technical staff as well from the researchers. It was not possible for the whole team to meet face-to-face, although each subteam had face-to-face contact.

In order to fulfil their collaborative design task, the students could choose the technology they preferred from the following options:
1. TeamSCOPE, a web-based collaboration tool (especially made for the INTEnD project), which integrates several functions, such as sharing files, making comments and sending messages. It also includes awareness tools, a calendar, and a chat function (Steinfeld, Jang, & Pfaff, 1999);
2. ISDN desktop videoconferencing (Vtel™);
3. Web-based desktop videoconferencing (NetMeeting™) which includes chat and whiteboard functionality;
4. (hands free) telephone;
5. e-mail;
6. fax.

The ISDN desktop videoconferencing has better image and sound quality than the web-based variant. In order to use the videoconferencing systems, each subteam had a web cam installed on top of their monitors. Figure 3-1 shows an example of TeamSCOPE, giving details of each team member’s activity (such as who has been downloaded which files, and when). Figure 3-2 shows the team’s calendar and the message board.
This set of collaborative technology both allowed the students to work together at the same time (synchronous communication), as well as allowed each individual team member to work on the engineering design task at a preferred moment (asynchronous communication).

3.1.5 Data collection

Several methods were used to gather both rich, qualitative and more numerical, quantitative data in all the design teams: namely, observations, transcripts, interviews, questionnaires, weekly communication diaries, log files of system usage, and expert judgement of performance (Table 3-3). The rating scales and the coding scheme were added to assess collaborative learning and shared understanding in particular. This way of data collection is part of the multifaceted approach (Steinfield et al., 2001).

<table>
<thead>
<tr>
<th>Measures</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team process</td>
<td>Interviews</td>
</tr>
<tr>
<td>Team process</td>
<td>Questionnaires</td>
</tr>
<tr>
<td>Team process</td>
<td>Observation</td>
</tr>
<tr>
<td>Participants experiences</td>
<td>Communication diaries</td>
</tr>
<tr>
<td>System usage</td>
<td>Log files</td>
</tr>
<tr>
<td>Quality of final design</td>
<td>Expert rating (faculty)</td>
</tr>
<tr>
<td>Perception of shared understanding</td>
<td>Rating scale (self-score)</td>
</tr>
<tr>
<td>Collaborative learning and shared understanding</td>
<td>Analysis of transcripts using a coding scheme</td>
</tr>
</tbody>
</table>
Semi-structured interviews (at the individual as well as at the group level) were conducted, and were repeated three times (pre-term, mid-term, and final). These interviews solicited team members’ feedback on their general team experience, in terms of issues such as technology use, cultural difference, misunderstanding, and lessons learned.

In addition, web-based questionnaires were employed, at the start, halfway through, and at the end of the engineering project. Pre-test questionnaires were used to compare levels of interest, experience, and skills among team members, as well as to assess expectations about working with their remote counterparts. Post-test questionnaires assessed measures such as the degree to which students were satisfied with their experience, their comfort with the team’s communication, their trust in other team members, the usefulness of the communication and the collaboration tools provided, and their assessment of the team’s output.

The team members completed communication diaries every week using web-based forms. On the form they reported whether they had communicated with their team, and if so, via which medium. They also answered a few brief questions assessing aspects of team progress and communication for that week, and whether they had faced any problems.

Furthermore, log files were made to monitor the system usage; these included the frequency of use of TeamSCOPE and the number of e-mail messages sent and received.

Another source of collected information was the expert judgement of the team’s engineering work by the engineering faculty.

To get rich insight into the actual process of team communication, observation studies were performed. During synchronous team communication – the video meetings – the team was observed at both locations (semi-structured). The verbal communication during the ISDN desktop video meetings was recorded.

These data sources were used in all the INTEnD teams. In order to satisfy the wish to assess collaborative learning and shared understanding, the data collection set described above was extended. For this purpose, rating scales to assess the perception of shared understanding and a coding scheme to code the transcribed team communication were developed.
An (self-scoring) instrument to measure the perception of shared understanding was added (Mulder, 1999). This instrument measured how team members perceived their understanding concerning content, process, and relational aspects. The students indicated their understanding on 6-point and 7-point rating scales (Likert), which referred respectively to their understanding of the several aspects on a specific moment (now) and how this understanding has evolved (evolve). An example of the rating scale for measuring perceived understanding of the content is shown in Box 3-2.

<table>
<thead>
<tr>
<th>How well do you understand the definition and requirements of the problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poorly (1) --- (2)--- (3)--- (4) --- (5) --- (6) Completely</td>
</tr>
<tr>
<td>To what extent has your understanding of the group’s definition and requirements of the problem changed since the previous meeting?</td>
</tr>
<tr>
<td>Understanding has decreased a lot (1) --- (2)--- (3)--- (4) --- (5) --- (6) --- (7) Understanding has increased a lot</td>
</tr>
<tr>
<td>To what extent does your group hold a shared interpretation / shared understanding of the definition and requirements of the problem?</td>
</tr>
<tr>
<td>No shared understanding at all (1) --- (2)--- (3)--- (4) --- (5) --- (6) --- (7) Completely shared understanding</td>
</tr>
<tr>
<td>Since the previous meeting, to what extent has a common understanding of the definition and requirements of the problem emerged in your group?</td>
</tr>
<tr>
<td>Understanding has decreased a lot (1) --- (2)--- (3)--- (4) --- (5) --- (6) --- (7) Understanding has increased a lot</td>
</tr>
</tbody>
</table>

Furthermore, the (recorded) team communication was fully transcribed. The main objective of these transcripts was to study the entire communication process in more detail. These transcripts were coded by means of a coding scheme, which is described below. Coded transcripts gave insight into the team interaction, communication patterns, and the process of collaborative learning and reaching shared understanding.

### 3.1.6 Coding team communication

Raw data were collected from the sources described above. All data were integrated to analyse the results of the current study. The richest sources were the observations and transcripts of the video meetings. However, in order to get results that better allow comparison across studies, a coding scheme was developed to code the transcripts of the team communication.

#### Coding scheme

Based on the conceptual notions presented in the previous chapter, a coding scheme was derived that might be helpful in finding answers concerning how collaborative learning and shared understanding have been constructed.
The purpose of a coding scheme was to acquire objective measures from the rich and qualitative transcriptions. A two-step procedure with segmentation preceding categorisation was followed (Van der Meij & Boersma, 2002).

First, the transcripts were divided into segments (utterances). Segmenting was based on turn taking. Utterances from both subteams were separated in order to diagnose effective communication and miscommunication between the local and the remote team. Communication is effective if one person presents an utterance and another accepts this utterance. The coding of ‘presents’ and ‘accepts’ appeared to be quite clear, and was helpful to identify miscommunications. In order to assess collaborative learning and shared understanding, it was necessary to focus on smaller segments – a smaller unit of analysis. The turn taking distinction was sustained with the adjustment to divide smaller segments within the turn taking segments into subsegments consisting of approximately a sentence. Thus when referring to utterances or segments it is alluded to the latter segment: the sentence.

Each segment was subsequently categorised on a certain dimension. Table 3-4 displays the categories and dimensions used in the coding scheme derived from the conceptual ideas described in Chapter 2.

These conceptual notions include that questioning, conceptual learning, feedback, and expression of affect are part of collaborative learning and shared understanding. First, the more-general category ‘nature of interaction’ was coded, then utterances were assigned to the ‘learning-oriented’ categories: questioning, conceptual learning, feedback, or expression of affect.

<table>
<thead>
<tr>
<th>Nature of interaction</th>
<th>Questioning</th>
<th>Conceptual learning</th>
<th>Feedback</th>
<th>Expression of affect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task/domain</td>
<td>Assertion</td>
<td>Accretion</td>
<td>Confirm</td>
<td>Uncertainty</td>
</tr>
<tr>
<td>Social</td>
<td>Question</td>
<td>Tuning</td>
<td>Paraphrase</td>
<td>Evaluation</td>
</tr>
<tr>
<td>Process</td>
<td>Reaction</td>
<td>Restructuring</td>
<td>Summarise</td>
<td>Impasse</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td>Co-construction</td>
<td>Explain</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Check</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>understanding</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Check action</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reflect</td>
<td></td>
</tr>
</tbody>
</table>
First, each segment was coded according to the nature of the interaction, whether it dealt with task/domain, social interaction, process, or technology.

- Utterances that involved the task or the project description were coded as task/domain.
- Utterances that did not involve the task, but were more personal and cultural, were coded as social interaction.
- Process included planning of a next meeting and structuring the current meeting.
- Finally, utterances related to technology use or technology choices were placed in the category technology. It might be confusing to code specific task-related technology, for instance AutoCAD. Such task-specific technology was codes as task/domain, because even in face-to-face project meetings team members would have used this technology.

In addition, each segment was coded on a specific category as identified in the conceptual framework, namely questioning, conceptual learning, feedback, and the expression of affect.

All segments were coded on the category questioning. Each segment was coded as either assertion, question, or as a reaction.

- **Assertions** are statements of facts, principles, choices etc. et cetera, the main intent of which is to inform the other team members.
- **Questions** are explicit requests for information and requests used to check understanding, critical reflections, and requests for explanation.
- **Reactions** are responses including answers to questions and responses to assertions.

Conceptual learning was used when the content of the information was being manipulated. Of course, only explicit learning could be coded. With respect to conceptual learning it was distinguished whether an utterance involved accretion, tuning, restructuring, or co-construction.

These learning types were coded as follows:

- **Accretion**: adding or repeating concepts and facts;
- **Tuning**: fine-tuning of concepts (making them more specific, adding detail, adding boundaries or making the scope more explicit);
- **Restructuring**: providing new relations between concepts or a new conceptual framework;
- **Co-construction**: restructuring of the whole team.
To analyse the use of feedback, the following categories were defined: confirm, paraphrase, summarise, explain, check understanding, check action, and reflect.

In the manual (Mulder, 2000) the following definitions were given:

- **Confirm**: Reaction that can be indicated as an agreement. The understanding is shared;
- **Paraphrase**: Summarising using one’s own words. This is also a form of reflection;
- **Summarise**: One of the team members summarises what has been said previously;
- **Explain**: Reaction on other utterances, providing new information or increasing the understanding;
- **Check understanding**: Checking self-understanding or another team member’s understanding of a previous utterance;
- **Check action**: Checking whether an action has been understood by another team member;
- **Reflect**: This code represents a feedback mode to indicate meta-communication, which is not necessarily process or technology related. This code should be used as a kind of evaluation and a feedback mode;
- **Other**: an extra category was added in case the feedback categories did not cover all feedback. In other words, if an utterance involved feedback, but it was difficult to assign it to one of the categories mentioned above, this utterance was coded as ‘other’.

Finally, in order to indicate motivational and emotional aspects, categories for expressions of affect were added to the coding scheme. It was distinguished between evaluation, uncertainty, and impasse.

- **Evaluation** was chosen when there was an opinion stated, or when something was evaluated; **uncertainty** was related to the expression of confusion or doubt; and an **impasse** was indicated when the team expressed that they did not know how to go any further.

In order to calculate the reliability of the coding scheme, a random sample of 128 segments (of every other meeting) was coded independently by two experienced raters who had been instructed on the basis of the manual (Mulder, 2000). These 128 segments were coded for all categories. This represented 5% of the segments of the current study (i.e., 2531 segments).

To calculate the interrater reliability – the equality of coding by the two raters – coefficient kappa was used. This coefficient indicates the amount of agreement, corrected for the agreement expected by chance. The overall average value of the interrater reliability was .839, which is considered ‘almost perfect’ by Landis and Koch (1977, p. 265).
The next section describes the results of the in-depth study of the international design team. In Section 3.3 this team is compared with other design teams in the INTEnD project.

3.2 Results

First, a general overview of the results from the coding of the nature of interaction and questioning is presented. Thus, the first two subsections highlight the results of the coding scheme. Then, collaborative learning and shared understanding are elaborated using the coded transcripts as well as the results from other data collection methods.

For this exploration, collaborative learning and shared understanding are described in an elaborate way for task-related interaction, social interaction, process-related, and technology-related interaction, respectively.

All these insights are combined in the subsequent sections. Section 3.2.7 summarises the nature of interaction, and determines whether the interaction was ‘balanced’ or imbalanced. After that, it is discussed whether questioning, conceptual learning, feedback, and the expression of affect played a role in the process of reaching shared understanding (Sections 3.2.8 and 3.2.9). Finally in Section 3.2.10 the average perceived shared understanding of the students during the project is portrayed.

3.2.1 General overview: nature of interaction

First attention was devoted to the nature of interaction. It was distinguished between four kinds of interaction: task-related interaction, social interaction, process-related interaction, and technology-related interaction. The analysis started with the coded transcripts of the eleven video meetings. Each utterance was coded in one of the four categories.

Figure 3-3 shows the total number of utterances and the number of those utterances assigned to the four categories. In the first column of every meeting, the total (overall number) of utterances are displayed. The second column shows those utterances which are devoted to the category task/domain, the third column social interaction, the fourth column the process-related utterances, and the fifth column those utterances which are devoted to technology. In other words, the first column represents a sum of the other four columns.
Figure 3-3 shows that the total number of utterances was high in the beginning, and then decreased in the second part of the project, with the exception of meeting 9. Another observation is the prevalence of task-related interaction. The amount of social interaction seems to be low, but increased during the project. Overall, the students paid more attention to process-related interaction than to technology-related interaction, except for meetings 6 and 9.

### 3.2.2 General overview: questioning

With respect to the team’s questioning behaviour, Table 3-5 displays how many assertions, questions, and reactions were coded in the transcripts.

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Assertion</th>
<th>Question</th>
<th>Reaction</th>
<th>Total</th>
<th>Meeting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting 1</td>
<td>105</td>
<td>41</td>
<td>65</td>
<td>211</td>
<td>18:31</td>
</tr>
<tr>
<td>Meeting 2</td>
<td>106</td>
<td>54</td>
<td>99</td>
<td>259</td>
<td>25:50</td>
</tr>
<tr>
<td>Meeting 3</td>
<td>110</td>
<td>44</td>
<td>79</td>
<td>233</td>
<td>35:54</td>
</tr>
<tr>
<td>Meeting 4</td>
<td>186</td>
<td>42</td>
<td>69</td>
<td>297</td>
<td>31:23</td>
</tr>
<tr>
<td>Meeting 5</td>
<td>102</td>
<td>41</td>
<td>97</td>
<td>240</td>
<td>48:15</td>
</tr>
<tr>
<td>Meeting 6</td>
<td>70</td>
<td>37</td>
<td>42</td>
<td>149</td>
<td>29:11</td>
</tr>
<tr>
<td>Meeting 7</td>
<td>70</td>
<td>29</td>
<td>46</td>
<td>145</td>
<td>28:19</td>
</tr>
<tr>
<td>Meeting 8</td>
<td>79</td>
<td>28</td>
<td>46</td>
<td>153</td>
<td>26:17</td>
</tr>
<tr>
<td>Meeting 9</td>
<td>197</td>
<td>97</td>
<td>100</td>
<td>394</td>
<td>48:29</td>
</tr>
<tr>
<td>Meeting 10</td>
<td>118</td>
<td>34</td>
<td>48</td>
<td>200</td>
<td>22:08</td>
</tr>
<tr>
<td>Meeting 11</td>
<td>80</td>
<td>32</td>
<td>46</td>
<td>158</td>
<td>16:43</td>
</tr>
</tbody>
</table>
These results indicate that most utterances involved assertions, and that relatively few questions were raised. Also, the number of utterances that were identified as a reaction was low compared to the assertions.

In order to get more insight in the questioning and answering process, and the nature of interaction, the process of reaching shared understanding is elaborated in more detail in the following four sections.

3.2.3 Task-related interaction and shared understanding

Figure 3-3 shows the total number of utterances and the number of those coded in one of the four categories. In Figure 3-4 the percentage of utterances that were devoted to task-related topics are shown.

![Figure 3-4](image)

The prevalence of task-related interaction is especially apparent in sessions 3, 4, 7, and 10. In the third video meeting a big miscommunication was observed and diagnosed. The Dutch part of the team discovered that the problem was simpler than they had thought. From the (mid-term) interviews, observations, transcripts, and weekly diaries, this apparent misunderstanding between the two teams was diagnosed. One of the American students stated in the weekly diaries:

“We talked to our team mates again this week and they now understand more about the project.”

In the mid-term interview one of the Dutch students suggested that they would have reached a shared interpretation on the problem definition much sooner if they communicated face-to-face. Also, the misunderstanding of
the problem statement can be found in the following quotation retrieved from the raw transcripts (Box 3-3).

<table>
<thead>
<tr>
<th>Explicit misunderstanding diagnosed in the third meeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tymen (NL): OK. What we try to figure out is what is the shape of the wheel well … before the shaping process?</td>
</tr>
<tr>
<td>Lionel (US): You mean the whole frame itself or you just mean the thing that we trying to bend back?</td>
</tr>
<tr>
<td>Tymen (NL): No, just the product, ya</td>
</tr>
<tr>
<td>Lionel (US): …just the half moon or what it is. And………………wait. You have that picture right here? This part itself…. Is……. I don’t know. Can you see this part right here?</td>
</tr>
<tr>
<td>&lt;Lionel shows the picture in front of the camera&gt;</td>
</tr>
<tr>
<td>Stijn/Tymen (NL): ya ya</td>
</tr>
<tr>
<td>Lionel (US): OK……that’s a 90 degrees, coming straight out like this.</td>
</tr>
<tr>
<td>Tymen (NL): OK</td>
</tr>
<tr>
<td>Lionel (US): And such, we need to bend it back like that</td>
</tr>
<tr>
<td>Tymen (NL): Ya, OK, that’s one.</td>
</tr>
<tr>
<td>Lionel (US): it is basically shaped</td>
</tr>
<tr>
<td>Tymen (NL): So it is only one bending process?</td>
</tr>
<tr>
<td>Lionel (US): ya</td>
</tr>
<tr>
<td>Stijn (NL): that’s it?</td>
</tr>
<tr>
<td>Tymen (NL): Heeeeh?!20?? That’s everything!? That’s itI!?</td>
</tr>
<tr>
<td>Stijn (NL): oh, it is easy!</td>
</tr>
<tr>
<td>Tymen (NL): We thought that we have to take more steps in the process. More bending and shaping.</td>
</tr>
</tbody>
</table>

In addition, the results on the scores on the content rating scales (Box 3-2) confirmed that after session 3, students perceived a relatively high shared understanding (5.5 on a 6-point scale) on task-related aspects (this was the highest score indicated by the students).

The raw transcripts showed that sessions 4, 7, and 10 were initiated for special task-related reasons. Because the problem was (re)framed in session 3, brainstorming on possible solutions was the subject of the fourth session. The students devoted their seventh meeting to choosing the best design concept. In this meeting they worked out several concepts, and ranked each concept based on certain criteria. They planned the tenth meeting to check their activities and results before holding their final presentation.

Table 3-6 shows the total number of utterances, and the number of task-related utterances, as well as how many of these utterances were dedicated to conceptual learning, an expression of affect, or feedback.
In addition to the prevalence of task-related interaction in sessions 3, 4, 7, and 10, Table 3-6 indicates that the number of task-related utterances scored high in session 9 (only meeting 4 scores higher). The transcripts pointed out that this session also had specific task-related goals. The students defined the (final) subtasks needed to fulfil their design, and divided these among each other.

Looking at the highest values in Table 3-6 it appeared that both meetings 4 and 9 had the highest rankings on task-related utterances (232 and 197 utterances, respectively), on task-related feedback (133 and 127), and on the expression of affect (53 and 57). These results show that on average, conceptual learning prevailed in the beginning of the project, and that conceptual learning reached the highest score in meeting 4 (100 utterances). Remarkable is the fact that the second-highest ranking of learning was not found in meeting 9.

### Table 3-6

<table>
<thead>
<tr>
<th></th>
<th>Total utterances</th>
<th>Total task - conceptual learning</th>
<th>Total task - expressions of affect</th>
<th>Total task - feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting 1</td>
<td>223</td>
<td>121</td>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>Meeting 2</td>
<td>275</td>
<td>150</td>
<td>47</td>
<td>40</td>
</tr>
<tr>
<td>Meeting 3</td>
<td>268</td>
<td>176</td>
<td>49</td>
<td>33</td>
</tr>
<tr>
<td>Meeting 4</td>
<td>300</td>
<td>232</td>
<td>100</td>
<td>53</td>
</tr>
<tr>
<td>Meeting 5</td>
<td>243</td>
<td>87</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Meeting 6</td>
<td>146</td>
<td>63</td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td>Meeting 7</td>
<td>148</td>
<td>115</td>
<td>37</td>
<td>33</td>
</tr>
<tr>
<td>Meeting 8</td>
<td>159</td>
<td>77</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Meeting 9</td>
<td>407</td>
<td>197</td>
<td>34</td>
<td>57</td>
</tr>
<tr>
<td>Meeting 10</td>
<td>203</td>
<td>119</td>
<td>15</td>
<td>36</td>
</tr>
<tr>
<td>Meeting 11</td>
<td>159</td>
<td>62</td>
<td>1</td>
<td>14</td>
</tr>
</tbody>
</table>
Figure 3-5 illustrates the percentage of the task-related utterances that were coded as conceptual learning, expressions of affect, and/or feedback. This figure shows also the ratio between conceptual learning and expressions of affect in meetings 4 and 9. In meeting 4 a lot of conceptual learning went hand in hand with fewer expressions of affect (this is half as much as the types of conceptual learning). In meeting 9 the expressions of affect were about twice the number of the conceptual learning types. In order to get more insight into what made the difference in those meetings, a closer look at what kinds of conceptual learning and expressions of affect were used in meetings 4 and 9 is necessary.

Table 3-7 summarises the numbers of all conceptual learning and expressions of affect in those two meetings.

<table>
<thead>
<tr>
<th>Conceptual learning</th>
<th>Meeting 4</th>
<th>Meeting 9</th>
<th>Expression of affect</th>
<th>Meeting 4</th>
<th>Meeting 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accretion</td>
<td>49</td>
<td>21</td>
<td>Evaluation</td>
<td>34</td>
<td>37</td>
</tr>
<tr>
<td>Tuning</td>
<td>45</td>
<td>10</td>
<td>Uncertainty</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Restructuring</td>
<td>6</td>
<td>3</td>
<td>Impasse</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Co-construction of knowledge</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total utterances</td>
<td>100</td>
<td>34</td>
<td>Total utterances</td>
<td>53</td>
<td>57</td>
</tr>
</tbody>
</table>

In meetings 4 and 9 the patterns of affect were comparable. Evaluation was used most in both meetings (34 and 37). 17 utterances of uncertainty were noticed in meeting 4, and 19 in meeting 9. In meeting 4 an impasse occurred twice, in meeting 9 only once.
However, in elaborating the types of conceptual learning, in both meetings accretion happened most (49 and 21 utterances, respectively), and tuning occurred 45 and 10 times, respectively. Restructuring took place 6 times in meeting 4, and 3 times in meeting 9. In both meetings there was no co-construction of knowledge.

Because conceptual learning prevailed in the beginning of the project, it seems that the students learned more in the first part of the project. The difference is most clear with regard to the conceptual learning type tuning. The amount of tuning utterances devoted in the fourth meeting was about four times more than the utterances devoted in the ninth meeting. Both accretion and restructuring were about twice the amount in the fourth meeting as in the ninth meeting.

Apparent was that the fourth meeting was the first one after the ‘big miscommunication incident’. This fourth meeting was also the meeting after the students had indicated the highest ranking on shared understanding of the content on the rating scales.

These results seem to indicate that a certain amount of shared understanding, in this case, enough shared understanding on the problem formulation, is necessary in order to learn. In addition, it was determined that task-related utterances prevailed during the project. Of these task-related utterances, a relatively high number of utterances was devoted to feedback and conceptual learning. Most conceptual learning that occurred was coded as accretion and tuning.

3.2.4 Social interaction and shared understanding

In the pre-test questionnaires students indicated that learning from others and from other cultures was a major reason for them to participate in the study. Box 3-4 shows the answers that were obtained when the students were asked why they participated in this project.

<table>
<thead>
<tr>
<th>Teamwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of different cultures</td>
</tr>
<tr>
<td>I want to learn more about the lives of those from a different country. I know that we have so much more than most countries and I wanted to see how it has affected people. Also I know I would gain so much experience by designing and building a project. I need that for when I graduate.</td>
</tr>
<tr>
<td>This is an interesting project to build up some skills for communicating with foreign people about technical matters.</td>
</tr>
<tr>
<td>Experience in communicating with an international team.</td>
</tr>
</tbody>
</table>

Remarkable was the time devoted to social interaction in the first meeting: although the reasons the team members indicated for joining the international team would argue for high social interaction, the actual time
devoted to social interaction was in the first meeting twenty seconds, namely 2% of the total time.

An interesting question is whether their pattern of social interaction evolved during the other video meetings. Figure 3-6 shows the pattern of social interaction based on the eleven video meetings.

Figure 3-6 shows that, although the number of utterances was quite low in the first session, the amount of social interaction increased in the following sessions. Nevertheless, the highest score was indicated in the second meeting (92 utterances). Although the students paid little attention to social interaction in their first meeting, they paid extra attention to social interaction in the next meeting. This result seems to be evidence for balancing behaviour: the students appear to have corrected the imbalance in their interaction.

Table 3-8 shows the total number of utterances, the number of utterances devoted to social interaction, and how many of these utterances were coded as conceptual learning, affect, or feedback. Relatively many utterances were used for social interaction in meetings 2, 8, and 11.
When looking at the total number of utterances devoted to social interaction, the meetings 2, 8, 9, and 11 prevail. In addition, the transcripts and observations showed that the social aspects were especially attended to at the end of the sessions.

Although the students ended with a social talk in the second meeting, they alternated task-related and social interaction throughout the meeting.

In the eighth meeting they concluded with a short planning for their next meeting. However, preceding this activity the students had a big social talk about what they would do during their holidays, the New Year’s party, and their favourite music. The ninth meeting started with technical problems, but once communication was possible, they had some social interaction: “How was Thanksgiving?”. When the students finished their task-related interaction, one of the Dutch students came back to the subject of Thanksgiving.

Box 3–5 shows some of the conversation devoted to social interaction. This is just the beginning of a long social conversation. After this, they went on to discuss cultural customs and habits, including Santa Claus and the Dutch Sinterklaas.
Throughout their final meeting, the students had social interaction and they concluded the meeting with a social part. This pattern seems to be evidence for using what is referred to as ‘slack time’ for social interaction, because most of the social interaction was especially attended to at the end of the session. If they did not have to hurry for another class, or to catch the (last) train, the students filled this slack time with social topics.

More detailed insight into conceptual learning shows that in addition to the number of utterances devoted to social interaction, conceptual learning, and the expression of affect are also highest in the second meeting (34 and 17 utterances, respectively). Feedback was highest in the second and eighth meetings (27 and 28 utterances, respectively). Figure 3-7 tells more about the number the social-related utterances that were coded as conceptual learning, expressions of affect, and/or feedback.

In the coded transcripts it was found that all five utterances related to conceptual learning in the first meeting were accretion. This is a result of the fact that the students were introducing themselves. Actually there was no feedback and only one expression of affect. This expression of affect involved ‘evaluation’, given at the end of the session: “Nice to meet you!”. According to Figure 3-7, conceptual learning occurred in meeting 4.
without expression of affect or feedback. However, only three types of conceptual learning were coded (Table 3-8). A close look at the coded transcripts of the second and the eighth meetings showed that the 34 utterances coded as conceptual learning involved accretion (29 utterances) and tuning (5 utterances). The utterances coded as conceptual learning in meeting 8 also only involved accretion (12) and tuning (2).

The expressions of affect in meeting 2 involved evaluation (12 utterances) and two utterances of uncertainty. In meeting 8 the ten expressions of affect could be divided into 9 evaluations and 1 utterance of uncertainty. The feedback most used in both meetings was explaining: 9 utterances in the second meeting and 17 in the eighth meeting. In the second meeting the feedback mode check understanding was also used 7 times, in the eighth meeting 5 times.

To recap, little social interaction was found. Although the utterances devoted to social interaction increased during the project, the highest number of social-related utterances were spoken in the second meeting. Interestingly, mostly social interaction took place at the end of a session. In addition to the total amount of social interaction, conceptual learning and the expression of affect were also highest in the second meeting. Types of conceptual learning the students used most were accretion and tuning.

3.2.5 Process-related interaction and shared understanding

Figure 3-8 shows the pattern of process-related interaction, in which a decreasing line can be identified. However, during session 5 a relatively high number of utterances were devoted to process-related topics.
A close look at the transcripts gives a possible explanation for this peak. In the meetings prior to session 5, much attention was devoted to (re)defining the problem of the design task and listing possible solutions for the problem. In session 5, much attention was devoted to the subsequent steps to be taken in order to complete the task. All process-related utterances were coded on either structuring current meeting or planning the next meeting. Figure 3-9 gives detailed insight into these specific dimensions used to code the process-related utterances. A lot of the process-related interaction was devoted to planning a next meeting. In the mid-term interview the students also mentioned that they used videoconferencing for scheduling their appointments.

Figure 3-10 shows the pattern of conceptual learning, the expression of affect, and feedback in process-related interaction. Types of conceptual learning were relatively high in the first meeting.
Not only was the number of utterances of conceptual learning highest in the first meeting (31), but the number of feedback utterances (19) also reached its highest value in the first meeting. The number of utterances is listed in Table 3-9.

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Total utterances</th>
<th>Total process - conceptual learning</th>
<th>Total process - affect</th>
<th>Total process - feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>223</td>
<td>73</td>
<td>31</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>275</td>
<td>27</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>268</td>
<td>31</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>29</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>243</td>
<td>83</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>146</td>
<td>20</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>148</td>
<td>12</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>159</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>407</td>
<td>33</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>203</td>
<td>33</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>159</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In the first meeting the types of conceptual learning involved accretion 18 times and tuning 13 times. The types of conceptual learning used in the other meetings only involved these two types of conceptual learning. Restructuring and co-construction of knowledge never occurred in process-related interaction.

While accretion and tuning were high in the first meeting, the amount of conceptual learning decreased in the course of the project. The number of feedback utterances was high in the first meeting (19), the fifth (13), and the ninth and tenth meetings (15 utterances each). The feedback modes used are shown in Table 3-10.

<table>
<thead>
<tr>
<th>Feedback modes</th>
<th>Meeting 1</th>
<th>Meeting 5</th>
<th>Meeting 9</th>
<th>Meeting 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirm</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Paraphrase</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Summarise</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Explain</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Check understanding</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Check action</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reflect</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
In conclusion, the number of utterances devoted to process-related interaction decreased in the course of the project. An exception was the peak in meeting 5. In the first meeting the participants learned the most and used the most feedback.

### 3.2.6 Technology-related interaction and shared understanding

This section describes the pattern of technology-related interaction during the videoconferencing meetings. Figure 3-11 shows the pattern of technology-related interaction during the video meetings.

![Figure 3-11: Percentage of technology-related interaction of all interaction](image)

According to this figure, the number (percentage) of technology-related utterances increased in the beginning of the project, then decreased, and subsequently increased again. In meetings 6 and 9 the largest share of the interaction was devoted to technology. While the utterances devoted to technology-related interaction were extremely high in the sixth and the ninth meetings, the students also expressed more affect and used more feedback than in the other meetings. The transcripts gave insight into what exactly happened in those meetings. In both of these meetings the students explored other technologies. In the sixth meeting the students tried to use the chat function for mentioning the eight requirements and their rankings. Actually, both teams used a different chat (the chat option in TeamSCOPE versus the chat option in NetMeeting™). Then one of the Dutch students reflected on this and said:

“But why are we doing all of this? What is the purpose? I think it is quicker to write it down.”
In the ninth meeting the students played around with the camera and the whiteboard: making pictures of each other and themselves. Exploring the technology in this way went hand in hand with social interaction.

Figure 3-12 shows the percentage of technology-related utterances that were devoted to conceptual learning, affect, and feedback. Table 3-11 gives an overview of the overall number of utterances, the number of technology-related utterances, and the number of the technology-related utterances that were devoted to conceptual learning, affect, and/or feedback.

![Figure 3-12](image)

### Table 3-11

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Total utterances</th>
<th>Total technology-related utterances</th>
<th>Total technology-related conceptual learning</th>
<th>Total technology-related affect</th>
<th>Total technology-related feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting 1</td>
<td>223</td>
<td>13</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Meeting 2</td>
<td>275</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Meeting 3</td>
<td>268</td>
<td>28</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Meeting 4</td>
<td>300</td>
<td>23</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Meeting 5</td>
<td>243</td>
<td>30</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Meeting 6</td>
<td>146</td>
<td>53</td>
<td>3</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Meeting 7</td>
<td>148</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Meeting 8</td>
<td>159</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Meeting 9</td>
<td>407</td>
<td>109</td>
<td>7</td>
<td>22</td>
<td>41</td>
</tr>
<tr>
<td>Meeting 10</td>
<td>203</td>
<td>25</td>
<td>0</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Meeting 11</td>
<td>159</td>
<td>31</td>
<td>2</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>
In meeting 7 both the percentages for expression of affect and for feedback were high (66%) (Figure 3-12). However, Table 3-11 shows that only two of the three utterances were assigned to these categories. Meeting 9 had the highest scores on conceptual learning (7), expression of affect (22) and feedback (41). Of the utterances of the type conceptual learning, only one utterance was coded as accretion and the other six were coded as tuning; 15 expressions of affect involved evaluation, the other 7 were coded as uncertainty. Of the 41 feedback modes, a majority of the utterances was devoted to check understanding (16) and paraphrase (10).

### 3.2.7 Interaction in balance

By combining results from the different sources (as described in the previous sections), the following main results were found. It was found that task-related utterances predominated during the project. A relatively high number of these task-related utterances were devoted to feedback and conceptual learning. Most conceptual learning that occurred was coded as accretion and tuning. While task-related interaction prevailed during the project, little social interaction was found.

Interestingly, it appeared that when time was devoted to social aspects, this was near the end of the video meetings. Utterances devoted to social interaction increased in the course of the project, with the exception of the second meeting, which contained the highest number of social-related utterances. Also regarding social interaction, the total number of conceptual learning utterances and expression of affect utterances were also the highest in the second meeting. The most-common types of conceptual were accretion and tuning. The number of utterances devoted to process-related interaction decreased in the course of the project. During the first meeting, the participants seemed to learn most on the process and provided the most feedback concerning the process.

Surprisingly, the participants did not learn much regarding technology (use). The team had defined their specific way of communicating early on, which can be seen as their shared understanding of how to use the technology. Later in the project they did, however, try to use other technologies. During those meetings they also expressed more affect and provided more feedback than in the other meetings.

Because the participants in the study employed all four interaction modes, in principle interaction was not imbalanced. Both the lack of social interaction in the first meeting and the absence of utterances of technology-related interaction seem to indicate an imbalanced start. Nevertheless, the relatively high score for social interaction in the second meeting suggests a kind of rebalancing action. Moreover, there seems to be evidence that the
students first tried to reach a certain amount of shared understanding on the four aspects, assuming that there is a relation between a high score on a certain kind of interaction and the amount of perceived shared understanding on that aspect.

From the previous exploration it can be concluded that after the peak on social interaction in meeting 2, there is a high score on task-related interaction in meeting 4. In meeting 5 the highest score on process-related interaction was found, and the peak on technology-related interaction was observed in meeting 9. It can be assumed that after they reached a certain understanding with respect to their relation, they soon reached a shared understanding on the problem definition, and then they focused on how to complete their collaborative design task. The data regarding task-related interaction seem to support that a certain amount of shared understanding – in this case enough shared understanding on the problem formulation – is necessary in order to learn.

In addition, regarding to process-related interaction, there seems to be evidence that the students first learned about the process, reached a certain amount of shared understanding, and then focused on other kinds of interaction. With respect to technology they quickly reached a shared understanding on how to use their technology. Interestingly, the highest score on technology-related interaction came after the highest scores on social, task-related, and process-related interaction, respectively; this might indicate that they started exploring technology after they reached a certain amount of shared understanding on the other aspects.

3.2.8 Questioning in collaborative learning and shared understanding

When assertions and questions were not followed by reactions, miscommunication was prone to occur. A relevant observation in this respect was a ‘miscommunication incident’ in the third meeting. One subteam had been raising questions on the problem statement for weeks. Nevertheless, they did not receive satisfactory answers from their remote team members. Insight into the coded transcripts showed that these questions were not followed by reactions. After the awareness of the team members of the miscommunication during the first three weeks, the communication changed in favour of conceptual learning and feedback (see next section). Also in Meeting 9, some evidence was found that questioning improved collaborative learning and shared understanding in Meeting 9.
In this meeting the most questions were raised (97), at the same time most expressions of affect were uttered (57) and a lot of feedback (127) was given. Only in Meeting 4 feedback was higher. However, Meeting 9 was also the longest meeting. Although some evidence was found that questioning behaviour improves collaborative learning and shared understanding, it can be concluded that communication was not optimal in the current team. Relatively few questions were raised and relatively few reactions to these questions.

3.2.9 Conceptual learning, feedback, and expression of affect in the process of reaching shared understanding

Conceptual learning, feedback, and the expression of affect are part of the process of reaching shared understanding. Although no increase in the utterances devoted to conceptual learning, feedback, and affect was found, there seemed to evidence that the number of utterances devoted to conceptual learning, feedback, and the expression of affect supported the process of reaching shared understanding. For example, of all meetings, in Meeting 4, looking at communication related to the task, most conceptual learning took place (100 utterances) and most feedback (133) was given of all meetings. Also, the number of utterances devoted to affect was high (53). Only in Meeting 9 this was higher (57 utterances).

An important observation was the overall lack of restructuring and co-construction. In other words, the most common types of conceptual learning were accretion and tuning, especially in the beginning of the project. Interestingly, the highest amount of conceptual learning occurred in the fourth meeting, namely 100 utterances (49 accretion, 45 tuning, and 6 restructuring). This was the first meeting after the participants had solved a big misunderstanding and had reframed their problem statement (Meeting 3). Also, in the weekly diaries the students stated that their remote team members understood more about the project.

To put it differently, the amount of conceptual learning seems to go hand in hand with an increasing shared understanding, as shown by the fact that the students indicated the highest ranking on shared understanding of the content on the rating scales. These results seem to support the idea that a certain amount of shared understanding - in this case enough shared understanding on the problem formulation is necessary in order to learn.

It was found that during their second meeting the students devoted the most utterances to conceptual learning, feedback, and affect related to social aspects. After this meeting they all agreed that they felt they knew the other team members better (rating scales). After the first meeting the
students also devoted more time to social interaction (*raw transcripts*). Again there seemed to be evidence that a certain amount of shared understanding was necessary in order to learn and update shared understanding.

A more detailed look showed that conceptual learning was constrained to accretion and tuning, and restructuring and con-construction hardly took place. Analysing types of feedback, it was found that reflection was underrepresented. Finally, with respect to expression of affect, ‘impasse’ hardly occurred. To conclude, all communication that relates to reflective behaviour was underrepresented.

### 3.2.10 The perception of shared understanding increases during the project

As shared understanding was viewed as a result of collaborative learning, perceived shared understanding should increase in the course of a project, at least if the team learns. The tables below reflect the results of the rating scales used to measure the perception of shared understanding. (The rating scales were applied after meetings 2, 3, 4, 5, and 10.)

To indicate the amount of perceived (shared) understanding at a certain moment (*now* scores), a 6-point scale was used, and to indicate the extent to which the perceived (shared) had changed (*evolve* scores) a 7-point scale was used. A score of 4 on the 6-point scales means that understanding is moderate (5 = high, 6 = complete). Negative perceptions of understanding are indicated by scores of 1, 2, or 3; in this, a score of 1 means that there is no understanding at all.

On the 7-point scales, a score of 4 means that nothing has changed. In addition, the first two questions on the rating scale (*now* and *evolve*) refer to the perception of own understanding; the latter two refer to how one perceived whether the group has a shared understanding (*shared now* and *shared evolve*). The instrument for assessing shared understanding on content or task-related aspects was shown in Box 3-2.

Table 3-12 shows the results of the rating scales related to ‘content’. A score of 4 and higher on the *now* scales indicates a moderate amount of shared understanding. A score higher than 4 on the *evolve* scales indicates an improved shared understanding. Only in the second meeting was the *now* score below 4, indicating the understanding regarding the definition and the requirements of the problem (content) was low.

Thus, results of Table 3-12 show that the perceived understanding of content and shared understanding of content increased in the course of the project.
After the third meeting the perceived understanding of the other team members was low in relation to the other scores (now scores are lower than 4, see Table 3-13). Moreover, the perceived shared understanding of the social relation was low after the third meeting. However, the students indicated that their understanding had improved since the previous meeting. Only after meetings 2 and 5 their shared understanding was unchanged (evolve score is 4). Individual understanding did not change in the last meetings (evolve score is 4).

Another interesting observation is that the students scored their understanding of the social relation after the second meeting with a 5 (among the highest scores given). This is high compared with the scores on content (3) and process (4.5). In this second meeting the students devoted relatively more time to social interaction.

Table 3-14 shows the results of the rating scales related to understanding of the process. The lowest score here is seen after the third meeting (3.33), while all the other measurements have a score of 4 or higher. Individual and shared understanding of the process improved in the course of the project; on the evolve scales, the students ranked higher than a 4. Only after meeting 5 had the perceived shared understanding of process not changed.
Table 3-14 presents the scores for overall perceived understanding. A score of 4 on the 7-point scale means that nothing had changed. All scores are higher than 4, namely 5 or 5.5, which implies that overall perceived understanding increased in the course of the project. To conclude, the results of the rating scales indicate that the amount of perceived shared understanding increases during the project.

Table 3-15 presents the scores for overall perceived understanding. A score of 4 on the 7-point scale means that nothing had changed. All scores are higher than 4, namely 5 or 5.5, which implies that overall perceived understanding increased in the course of the project. To conclude, the results of the rating scales indicate that the amount of perceived shared understanding increases during the project.

3.3 Comparison across design teams

The previous section presented results of the exploration of collaborative learning and shared understanding in the current team, what was termed as the Wheel Well A team. In this section the Wheel Well A team is compared with other international design teams that participated in the INTEnD project. Results of collaborative learning and shared understanding across the INTEnD teams (Steinfield et al., 2001; Huysman et al., 2003) are displayed and the teams’ technology use is described.
### 3.3.1 Perceived agreement, trust, and comfort

Using analyses across teams (Steinfield et al., 2001) the focus is on concepts that are closely related to the perception of shared understanding. For this purpose results from the final questionnaire are used that reveal differences in the team’s perceptions about their experiences. More specifically, the following outcome measurements were used:

1. The extent to which team members achieved real consensus on their designs;
2. The extent to which team members trusted their local and remote team members, and;
3. The extent to which they liked and felt comfortable interacting with their local and remote team members.

Table 3-16 (adapted from Steinfield et al., 2001) provides mean scores for each measurement, broken down to the level of the subteam. Each of these scores was measured based on a 5-point scale (1 = lowest, 5 = highest).

<table>
<thead>
<tr>
<th>Team</th>
<th>Location</th>
<th>Size</th>
<th>Agreement with team solution</th>
<th>Trust in local team</th>
<th>Trust in remote team</th>
<th>Comfort with local team</th>
<th>Comfort with remote team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-channel US</td>
<td>3</td>
<td>4.67</td>
<td>4.56</td>
<td>5.00</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaporator US</td>
<td>3</td>
<td>5.00</td>
<td>4.11</td>
<td>4.56</td>
<td>4.89</td>
<td>4.67</td>
<td></td>
</tr>
<tr>
<td>Plate NL</td>
<td>2</td>
<td>4.00</td>
<td>5.00</td>
<td>3.00</td>
<td>4.83</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>Ladder US</td>
<td>3</td>
<td>4.33</td>
<td>5.00</td>
<td>5.00</td>
<td>4.89</td>
<td>4.89</td>
<td></td>
</tr>
<tr>
<td>Mill A NL</td>
<td>1</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>4.00</td>
<td>5.00</td>
<td>4.33</td>
</tr>
<tr>
<td>Ladder US</td>
<td>3</td>
<td>4.67</td>
<td>4.99</td>
<td>4.78</td>
<td>4.78</td>
<td>4.89</td>
<td></td>
</tr>
<tr>
<td>Mill B NL</td>
<td>1</td>
<td>5.00</td>
<td>5.00</td>
<td>2.67</td>
<td>5.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Wheel US</td>
<td>4</td>
<td>4.50</td>
<td>4.92</td>
<td>4.33</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well A NL</td>
<td>3</td>
<td>3.17</td>
<td>4.11</td>
<td>4.11</td>
<td>4.33</td>
<td>4.11</td>
<td></td>
</tr>
<tr>
<td>Wheel US</td>
<td>2</td>
<td>4.83</td>
<td>5.00</td>
<td>4.78</td>
<td>5.00</td>
<td>4.67</td>
<td></td>
</tr>
<tr>
<td>Well B Rus</td>
<td>2</td>
<td>4.50</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Roof US</td>
<td>4</td>
<td>4.50</td>
<td>3.83</td>
<td>4.00</td>
<td>4.83</td>
<td>3.83</td>
<td></td>
</tr>
<tr>
<td>Weld Rus</td>
<td>4</td>
<td>4.50</td>
<td>4.67</td>
<td>4.25</td>
<td>4.75</td>
<td>4.42</td>
<td></td>
</tr>
<tr>
<td>Animal US</td>
<td>4</td>
<td>4.88</td>
<td>4.83</td>
<td>3.58</td>
<td>5.00</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>IC Unit China</td>
<td>1</td>
<td>4.00</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Proc. US</td>
<td>3</td>
<td>4.33</td>
<td>4.33</td>
<td>4.22</td>
<td>4.44</td>
<td>4.44</td>
<td></td>
</tr>
<tr>
<td>Reinig Rus</td>
<td>2</td>
<td>3.50</td>
<td>5.00</td>
<td>4.67</td>
<td>5.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Ladder US</td>
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<td>3.38</td>
<td>4.42</td>
<td>4.33</td>
<td>4.25</td>
<td>4.08</td>
<td></td>
</tr>
<tr>
<td>Mill C NL</td>
<td>2</td>
<td>3.75</td>
<td>4.17</td>
<td>2.67</td>
<td>4.50</td>
<td>4.50</td>
<td></td>
</tr>
</tbody>
</table>
Analyses of variance across all teams show a significant effect for both team and the subteams on degree of agreement with the team’s solution, trust in remote team members, and comfort with local team members. There were also significant team differences for comfort with remote team members, but no differences between the subteams were found (Steinfield et al., 2001, p. 6).

At first sight, the scores of Wheel Well A team seem to fit in the overall team scores as shown above. Interestingly, the Dutch members scored lower than their American counterparts. They scored lowest (3.17) on their agreement with the team solution. The Dutch students also indicated in the final interview that they were not happy with the final design their team came up with; they needed more detailed information, and they felt: “it was not even a design, it was more like a concept”.

Also remarkable was that the American students scored higher with respect to their remote team members than with respect to their local team members. Table 3-16 shows that for the American students, the score with respect to trust in remote team members is higher than the score for trust in local team members; also comfort with remote team members is higher than comfort with local team members. By contrast, the Dutch members felt more comfortable with local team members than with the remote members. Scores of the Dutch team members did not show differences between trust in the local and remote team (both scores are 4.11). This was in keeping with their remark in the final interview that they did not blame the remote team for not having all the detailed information, although they believed the client had not given all the necessary details for fulfilling the collaborative design task successfully.

### 3.3.2 Use of collaborative technology

Already in the first meeting the Wheel Well A members started using the video screen not just to see each other, but also to show things. One of the American students showed a prototype of a wheel well frame in front of the camera (see also the quotation in Box 3-3). After this event of showing things in front of the camera, the team continued to use the technology in this way. Everything they wanted to share with their remote team members was shown by means of the videoconferencing system’s camera. For example, when there was a need to call because the audio was not working, the students wrote down the telephone number and held the piece of paper with the written telephone number in front of the camera instead of using the chat function, for instance. They also took printed versions of digital documents with them to the meeting to show to each other in their favourite way.
Halfway through the project, two MSU professors who were visiting Delft observed the Delft team. During the fifth meeting they joined the team. Because the team had not used NetMeeting™ before, they gave a little (extra) introduction at the start of the video meeting. They showed some features of NetMeeting™, such as the whiteboard, and how one can make a drawing and a snapshot and open it in the whiteboard. Later on during the meeting, the students discussed some drawings (see Box 3-6).

After the NetMeeting™ introduction the students referred to their technology use as ‘the old-fashioned way’. They were aware of their suboptimal technology choice, but they stuck to it.

There seems to be evidence that the team quickly invented a collaborative way to use the new technology. The team members quickly learned how to use a tool, and subsequently mutually adapted the tool and tasks so that they did not need to diverge much from their newly-developed way of working.
However, in their next meeting (meeting 6) and meeting 9, more conceptual learning, affect, and feedback was expressed. In meeting 6 the students tried to use other communication and collaboration tools: using chat to exchange design criteria and their rankings. In the ninth meeting they just played around with the whiteboard to make snapshots of each other. The latter activity could not be performed using their ‘old-fashioned’ way of working.

As said before, the seven mechanical engineering students started their communication by means of videoconferencing. They had never used a videoconferencing system before (pre-test questionnaire), but the mid-term interview revealed that they quickly felt at ease with using it. As one of the students said in the mid-term interview:

“In the beginning it felt quite strange, talking with a remote team with a camera above your head, but very soon we had no fear of the camera anymore”.

The fact that the team quickly defined their way of using the collaborative technology can be seen as a certain shared understanding on how to use technology. Almost every week they held video meetings, but not at fixed times. During these meetings they discussed when they would meet each other again. Figure 3-13 shows that they did in fact meet almost every week.

In week four they had no video meeting, but they had relatively much e-mail contact. The students decided to meet each other again by videoconferencing after they had gathered enough new information to

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2 A remark on the use of the telephone should be made. Half time use of telephone seems to be strange. The line of telephone use displays some ambiguity, because some of the students indicated telephone if they used it instead of the audio channel of the videoconferencing systems, and other team members did not.
clearly define the problem. With this new information they would formulate the problem statement, and would derive tasks and activities from this framed statement. In week nine they met twice (i.e., meetings 7 and 8).

The use of TeamSCOPE was also monitored. It was possible to collect this data because TeamSCOPE was accessed via a web browser, and therefore the server recorded the number of total pages requested by each user. The Wheel Well A team members used TeamSCOPE heavily in the middle of the project. The observations and the raw transcripts showed that at that time, the team members inventoried and reviewed possible solutions using TeamSCOPE as a document server and discussion list.

Results from the comparative analyses across teams revealed quite different usage patterns for the available technology by each of the teams (see for more details Steinfield et al., 2001). Most teams used video meetings quite regularly, with 1 and sometimes 2 meetings per week (Ladder Mill A, Microchannel, Wheel Well A), while other teams used it much less frequently (Evaporator Plate). Some showed heavier use of e-mail, particularly near the final deadline (Ladder Mill A and B), while others interacted more via video at that time (Microchannel). Ladder Mill A increased both video and e-mail use as the final deadline neared, while the Evaporator Plate team did not communicate more heavily near the final deadline. The weekly communication and TeamSCOPE usage data suggest that the teams each developed their own patterns for communication and coordination, choosing to use particular types of communication tools at particular points in the project.

Although different use patterns evolved, it was clear that the teams developed their own styles and patterns of using the collaborative technology. Each team tended to continue using the technology they initially had chosen to use in a consistent fashion over time; a pattern that has been called ‘media-stickiness’ (Steinfield et al., 2001). Some teams started with videoconferencing and continued doing so during the entire project. For example, the Microchannel team gradually used videoconferencing more as a tool to socialise than as a tool to exchange project-related information. Using video each week for a fixed hour became part of their habitual way of working.

On the other hand, the Evaporator Plate team ended the first videoconference with the comment that e-mail would probably suffice to coordinate their work:
Justin (US): At the moment I think we might better think about it ourselves. Have an e-mail first about the ideas, like a brainstorm, with an e-mail within a few days or something.

Edward (NL): Would you want to set a date or something for the next time? (referring to the next videoconference)

Justin (US): Well we still think e-mail is probably our best form of communication so we will keep in contact over that and re-schedule as needed.

After this decision, the team mainly relied on e-mail. Because of such media-stickiness, teams engaged in seemingly irrational behaviour, sometimes failing to take advantage of more efficient communications tools. The Wheel Well A team members were so accustomed to the use of video, that they would not use the whiteboard to exchange drawings. Instead, they tried to show technical drawings to remote team members by holding them up in front of the camera.

Occasionally, breakthroughs occurred leading to a change in technology use patterns. Often such changes came when a team was seeking a ‘work-around’ to a technical problem, or when one location came to realise that the team had to change practices or it would not finish. This happened, for example, in week 10 with the Evaporator Plate team. The Dutch side of the team was not satisfied with the work of their American team members. They realised that their American team members were not responding to e-mails, or were too ambiguous in their e-mail responses. The Dutch students decided to use video as a way to force more action by their remote counterparts.

Qualitative results illustrated an interesting side effect in the Microchannel team that appeared to result from reliance on fixed, weekly one-hour video meetings (Steinfield et al., 2001). Once they completed discussion of the week’s project-related work, slack time remained because all had kept the time free on their schedules. Rather than simply hanging up, this team filled the slack time with social conversation, directing the conversation to more social topics such as discussions about the different cultures, countries, courses, leisure activities, et cetera. In the Wheel Well A team similar use of slack time was noticed. The Wheel Well A team interacted more socially toward the end of meetings. Moreover, they had social interaction throughout their final meeting (see Section 3.2.4).
3.4 Conclusions and discussion

This study gained insight into collaborative learning and shared understanding in design teams by studying video-based communication processes in detail. Using the conceptual framework and the developed coding scheme in an empirical study, the understanding of the process of reaching shared understanding has increased. It was found that the average perceived shared understanding of the team members increased. In addition, insight into task-related, social, process-related, and technology-related interaction was increased. Moreover, a better insight was gained into the role of questioning, conceptual learning, feedback, and the expression of affect in the process of reaching shared understanding. Some rough evidence was found that questioning, conceptual learning, feedback, and the expression of affect have a positive effect on collaborative learning and shared understanding.

One major conclusion is that it was difficult to find reflective utterances in the protocols. In the team under study, little reflective activity was found, and more specifically, hardly any questions were raised and answered. In particular, hardly any co-construction was found in the transcripts. In addition to the fact that little reflective behaviour was assessed in the Wheel Well A team, across the INTEnD teams not much learning and reflection was found either.

In the comparison across teams also attention was devoted to technology use. It was found that the teams scarcely reflected on the use of technology. Already after the first one or two meetings, teams developed a team-specific style of technology use and stuck to it during the rest of the project. As a result, their initial choice of technology use became so much entrenched in the culture of the team that it seemed almost impossible to change it.

Moreover, there seemed to be evidence that the teams first tried to reach a certain amount of shared understanding on all the four aspects, assuming that there is a relation between a high score on a certain kind of interaction and the amount of perceived shared understanding on that aspect.

It should be mentioned that only one study was conducted with one team (N = 1). However, the main intent was to describe and understand the problem of assessing collaborative learning and shared understanding in an empirical study. In order to make this assessment construct-centred, a conceptual model was developed to describe and explain shared understanding in relation to collaborative learning.
As mentioned earlier, this study was part of a larger project called INTEnD, which makes comparative analysis possible. By participating in an international research project, it was possible to profit from the quality of in-depth study as well as the comparison across studies. Between the autumn of 1998 and the end of 2000, a total of nineteen teams involving participants in two or more countries were studied. Although comparative analyses have been made (Steinfield et al., 2001; Huysman et al., 2003), these analyses did not have the same level of detail as the current study. Nevertheless, two general conclusions can be drawn from these comparative analyses regarding:
- the low level of reflection on technology use, and;
- the limited social interaction that took place in the international teams.

As concluded before, it was difficult to find reflective utterances in the protocols. A possible explanation seems to be that it is indeed difficult to assess reflectivity. It appeared in particular difficult to assess co-construction, the restructuring by all team members. This may indicate that another way of assessing may be necessary, and that reflective behaviour needs to be coded across segments.

Another explanation for not finding reflective utterances is that little reflective activity took place. It may be even more difficult to express this kind of utterances in technology-mediated interaction. Virtual teams may have difficulties acquiring, comprehending and acting on internal and external feedback that can stimulate a change in their communication practices. For example, virtual team members may not be well enough acquainted with one another to feel comfortable criticising the others or expressing their feelings to remote team members about problems they see with the team’s communication. They also may have problems interpreting cues from remote team members that would indicate problems. Looking across the INTEnD teams, most participants were unable to directly confront remote team members and express their frustration. In case little reflective behaviour took place, it is interesting to research how reflection may be stimulated.

Internal as well as external forces seem to trigger reflective behaviour (Heeren & Mulder, 2000; Huysman et al., 2003). The lack of reflection with respect to technology use can be seen as a lack of internal feedback; the team members did not reflect on their suboptimal way of using the technology. In the case of little reflection on technology use, external factors could also have stimulated the team’s reflective behaviour. External factors may include contextual influences, such as technological breakdowns, which imply that team members really need to find another
solution. Such technical problems occurred occasionally in the INTEnD teams. Most teams addressed such problems by temporarily using another tool (for example, chat or telephone-based conferencing instead of video). However, these technical breakdowns never resulted in a permanent change in the habitual pattern of technology use. After using an alternative tool, teams switched back to their old routines. External factors can also include a social influence or intervention by a third party. An example of an external social influence was the intervention of the professor when introducing the shared whiteboard functionality in the Wheel Well A team case. Also, this intervention did not leave traces deep enough to make a permanent change in the team’s communication behaviour.

In summary, the current study revealed little reflective behaviour. The issue regarding assessing reflective behaviour seemed to be complex. Additionally, some forces were identified that might have stimulated reflective behaviour in video-mediated teams; however, these forces did not lead to an increase of reflective behaviour. Next to the lack of reflection, the support itself can be seen as suboptimal, as it did not stimulate reflective behaviour. Therefore, this work continues elaborating the need to support and assess reflective behaviour in video-mediated design teams. Support does not only refer to technology support, but also to social or educational support, such as the role of a tutor or a facilitator. As the team members scarcely raised and answered questions, and based on the fact that questioning is one of the most important means of facilitating learning, the next chapter elaborates on the role of questioning support in stimulating reflective behaviour during video-based communication.
Chapter 4

Questioning support –
concepts and tools

This chapter elaborates on the questioning and answering process. It was found that the team members – in the study described in the previous chapter – scarcely raised or answered questions. The conceptual framework will be reconsidered by emphasising the role of questioning in collaborative learning and reaching shared understanding. In addition, it will be explored why this process seems to be (more) difficult in video-based communication. Some related studies are subsequently reviewed to investigate whether similar difficulties were found, and if so, how the questioning and answering process can be stimulated. This search for empirical evidence concentrates on questioning support that evokes collaborative learning and shared understanding in video-based communication.

4.1 Conceptual framework refined

In the previous chapter insight was gained into collaborative learning and shared understanding by exploring video-based communication processes in distributed design teams, using conceptual ideas with regard to collaborative learning and shared understanding. The average perceived shared understanding of the team members appeared to increase. Some rough evidence was found which indicated that questioning, conceptual learning, feedback, and the expression of affect have a positive impact on the process of reaching shared understanding. However, scarcely questions were raised and answered. Moreover, very little reflective behaviour was exhibited by the team members either in their learning modes or in their feedback or expression of affect.
Briefly stated, the empirical study indicated suboptimal question-answer and reflective behaviour. Some evidence also appeared to exist that the questioning and answering process on the one hand and reflective behaviour on the other hand are related. In the remainder of this work the need to encourage reflective behaviour in virtual teams will be discussed. For this purpose, the conceptual framework defined in Chapter 2 is used as a starting point (Figure 4-1). An attempt is also made to define the relationships among the variables more clearly, and therefore reconsider the concepts described earlier.

This chapter concentrates in particular on how team members pose questions and receive answers. The concepts *questioning* and *feedback* therefore have a central position. Because reflective behaviour needs to be encouraged, attention will also be devoted to higher order reflective behaviour. In other words, the current conceptual framework will be adjusted in favour of higher order reflective behaviour, and concentrates not only on collaborative learning and shared understanding, but also on the process of questioning and answering. Social and cognitive functions of the questioning and answering process are discussed.

Questioning is one of the most important means of facilitating learning and understanding, not only for the individual asking the question, but for the group as a whole. It can serve to keep the group focused and prevent it from getting bogged down. It can also help other group members by forcing them to present information and concepts more precisely (Queen’s university, 1999). The complex process of questioning and answering has many facets. In other words, several social and cognitive functions related to questioning and answering can be identified in addressing this complex pattern of interaction. The process of questioning and answering involves joint activities and joint actions (Clark, 1996); this is a social process.
However, cognitive functions can also be identified. For instance, the need for raising a question needs to be notified. At the individual level one first needs to be aware that there is a wish for more information. Secondly, this individual awareness needs to be made explicit in the group. The group members should be aware that someone in the group has a need to pose a question. In face-to-face communication, for instance, hands are raised to express this desire. Thus other group members should recognise that someone in the group has the desire to pose a question. Additionally, this person should be able to pose questions. Consequently, the other group members need to notice that this expression is indeed a question, and supply answers to that question. If the answers given are not sufficient, more detailed questions should be raised. However, when the question has been answered in a satisfactory manner, the entire group should be aware of this as well.

In other words, in an adequate question and answer pattern the following functions can be identified:
1. Need for questioning (at the individual as well as at the group level);
2. Recognising this need;
3. Posing a question;
4. Acknowledging;
5. Answering;
6. Asking more questions;
7. Acknowledging an appropriate answer.

Although these functions can be identified as basic communication skills (e.g., Clark & Brennan, 1991; Gramsbergen & Van der Molen, 1992; Clark, 1996), they seem to be useful in acquiring insight in questioning and answering patterns. It can be assumed that supporting these functions leads to optimal questioning and answering processes, which in turn results in higher levels of reflective behaviour. The next question that arises is which variables of the conceptual framework encourage reflective behaviour. In terms of the conceptual framework, when questioning and feedback are better attuned to one other, this can be visualised by a bigger overlap in the framework (Figure 4-2).
As indicated earlier, the conceptual framework elaborates on the process of questioning and answering on the one hand and reflective behaviour on the other. For that purpose, more detailed insight needs to be obtained into the characteristics of questions. It appears that an interesting distinction can be made between initial questions and follow-up questions. Follow-up questions can be viewed as questions of higher quality. When an initial question leads to more questions that are more specific, it can be expected that more reflective activity will be expressed. In other words, not only the number of questions that are raised matter, but the entire process of questioning and whether questions evoke reflective behaviour. Thus questions being asked should be viewed in relationship to the answers given. In addition, asking for reasons and opinions given should be taken into account as well. This means that group members need to be critically engaged (Mercer, 2000). Such engagement not only promotes thinking together critically and constructively, but also prevents groupthink (Janis, 1982). During groupthink, team members try so hard to agree with one another that they make mistakes and commit errors that could easily be avoided.

In order to acquire more insight into the questioning and answering process on the one hand and reflective behaviour on the other, not only the number of questions is taken into account. Concepts such as conceptual learning, reflection, and feedback are also explored to emphasise the quality of the communication. Feedback plays a crucial role in the answering process. Confirmation is important for acknowledging a question and making an answer explicit.

Although all the conceptual learning modes as defined in Chapter 2 seem to be of interest for collaborative learning and reflection, the revised framework concentrates on those elements that may contribute to collaborative reflection. Hence, learning modes such as accretion and tuning were identified frequently in the previous study, but apparently did not enhance...
the level of reflective behaviour. Accretion and tuning concerned the exchange of facts, whereas restructuring and co-construction concentrated on new relationships between the facts and concepts discussed. Thus in order to concentrate on reflective behaviour, the conceptual learning modes accretion and tuning are not included in the revised conceptual framework, and the distinction between restructuring and co-construction is explored in more detail. In the previous study it appeared difficult to assess co-construction. For that reason more attention will be devoted to the assessment of collaborative reflection. Collaborative reflection takes place when the group as a whole reflects. In other words, expression of reflective behaviour of one person evokes other group members to be more active in being reflective. Moreover, like in the initial framework the expression of an impasse continues to be relevant: when diagnosing an impasse, moments of miscommunication were found.

Concisely formulated, the revised conceptual framework aims at acquiring more insight into the process of questioning and answering, because it is assumed that a team that comes to grips with this process yields more reflective activity. Many authors referred to this kind of reflective activity as higher order reflective behaviour or deep learning. Another question that has not yet been answered is why these question and answer patterns seem to be so difficult in video-based communication. The next section strives to give some explanations.

4.2 Why is questioning so difficult in video-based communication?

In face-to-face communication people “can participate in the formulation of another speaker’s utterance. They can ask questions, paraphrase, or seek clarification” (Krauss & Fussell, 1991). In addition, work by Kraut and colleagues (Kraut, Lewis, & Swezey, 1982; Kraut & Lewis, 1984) and Duncan and Fiske (1977) suggests that participants in face-to-face interaction routinely use a signalling system the function of which is to enable the interacting parties to coordinate with respect to meaning.

However, in video-based communication this seems to be not so obvious. The remainder of this section describes some explanations of why the process of questioning seems to be more difficult in video-based communication.

It was determined that the students in the empirical study did raise questions, though relatively few of these were answered. A possible explanation could be that participants did not observe these utterances as
being a question, and that team members in video-based communication faced difficulties in recognising each other’s questions. To put it differently, such contributions — questions that are not being answered — are incomplete; a contribution is complete when an utterance has been both presented and accepted (Clark & Brennan, 1991).

Another explanation is that in face-to-face interaction specific rules and habits for questioning have been adopted. For instance, people raise their hands (during presentations, for example) or use a time-out sign (in sports, for example) to indicate a necessary moment for questioning. As far as is known, in videoconferencing no such sign is internationally accepted or understood. Interestingly, in formal face-to-face meetings in addition to hand raising ‘important people’ are looked at in a subtle way, to determine whether they have questions or remarks and to check their agreement.

This points to another difference between face-to-face and video-mediated communication. In videoconferencing, subtle signals or non-verbal behaviour frequently remain unnoticed. Interacting by means of videoconferencing systems is often referred to as less rich, less social, and less personal than face-to-face communication (e.g., Short, Williams, & Christie, 1976; Kiesler, Siegel, & McGuire, 1984). A plausible explanation is that non-verbal behaviour and subtle signals scarcely affect questioning behaviour during videoconferencing.

Another finding from the empirical study described in the previous chapter indicates that because team members in video-based communication were unacquainted with each other, they might feel less comfortable in posing questions and being critically engaged. Taking all these explanations into account, there seems to be evidence that virtual team members face thresholds with respect to questioning and subsequent reflection.

To recapitulate, a number of explanations as to why the process of questioning and answering seems to be so difficult in video-based communication were explored. The term questioning behaviour refers not only to the frequency of questions being raised, but also to the entire process involved in raising a question. In other words, it is about questions being asked, answers given, and the resulting collective reflection.

The next section devotes attention to stimulating questioning behaviour in video-mediated teams. Studies on video-based communication are reviewed to investigate whether similar difficulties were found, and if so, how the process of questioning can be stimulated. In this search of empirical evidence, focus is placed on the support for questioning.
4.3 Support for questioning

This section concentrates on how to intervene in video-mediated teams in order to enhance the questioning process. As concluded in Chapter 3, support is not restricted to technological support; it also refers to social or educational support in the role of a facilitator or a tutor. Two complete studies are elaborately reviewed to fully understand how questioning behaviour can be supported.

Particularly focus was placed on which functions of questioning behaviour were supported, such as support for expressing questions or support that helps recognising a need to pose questions and answering questions in video-based communication. Moreover, interventions that have low thresholds were sought. The first study concentrated on the role of a facilitator, the second study on technological support. Finally, a third tool is described of which no empirical data was found. However, this tool seems to be easy to use.

4.3.1 A technology facilitator and a meeting facilitator

Mark, Grudin, and Poltrock’s study (1999) focused on the adoption and use of desktop conferencing and application sharing in four geographically-distributed teams. The set-up of their study was comparable to the study on distributed teams described in the previous chapter. Mark et al. (1999) studied teams that existed for six months or longer, and that had experience with desktop conferencing in their real work settings. The team members gave permission to be observed. In order to collect data Mark et al. (1999) observed the team behaviour for three months. Recording the meetings was not permitted.

In addition, after each meeting a questionnaire was distributed by e-mail to all participants containing questions related to ease of using the technology, social aspects of participation, and satisfaction with the meeting (n = 158). Furthermore, data from meeting agendas, minutes and chat windows used during sessions were collected. Finally, in-depth interviews were conducted with 19 team members, lasting approximately 45-60 minutes each. Using content analyses, classes of problems and solutions were identified.

Mark et al. (1999) concluded that teams faced difficulties regarding technology use and coordinating problems, and faced problems with maintaining engagement. They found that uncertainty about turn taking often disrupted the communication flow. Interaction was hardest for remote site members; they often reported not knowing when to interject.
The interviews indicated a profound problem in understanding the expressions of others. Members felt they lacked enough knowledge of others’ intent to make sense of their online behaviour. Their difficulty was reflected in a response to the following questionnaire item (no difference across groups) near the scale midpoint:

“I could not always tell how other people were reacting to the things I or others said.”

Members reported that face-to-face meetings helped them to make sense of online behaviour:

“Reflective looks means they are thinking. Silence on the line doesn’t. People may say things sarcastically, but the expression on-line is confused. Many signals that you have face-to-face are lost.”

One team tried to overcome technology-related problems by creating a technology facilitator role. This person was responsible for all aspects of technology use. This team also created a virtual meeting facilitator who acted as a ‘bridge’ to involve the remote sites in the meeting. This appointed facilitator addressed many of the interaction problems observed in the other groups. First, he established who was present at each site. As with face-to-face group facilitation, he kept order by introducing agenda items and by beginning and adjourning meetings. He continually confirmed that remote sites could see the display, and addressed uncertainty of attendance by continually checking with remote sites. He also identified all speakers, especially at remote sites, and made sure that everyone was heard. In addition, he coordinated speaking turns by recognising body language in the face-to-face setting or by hearing an utterance online.

Furthermore, he encouraged questions at certain points in the presentation, explained to remote participants what was happening at the main site, such as when silences occurred, and kept order during discussions by calling on people. The facilitator, for instance, noticed a difference in problem-solving perspectives. He considered these conflicting perspectives to get everyone ‘thinking on the same page’ and to balance the discussion to suit all parties’ interests, which is important for the technical exchange. Meeting people face-to-face had value for him:

“It helps to know what they mean when they ask a question. For example, knowing their background: Jeff in drilling, Matt in statistics, Hal in vibrations.”

Mark et al. (1999) concluded that distributed meeting facilitation seems valuable in identifying who is speaking, explaining comments for the benefit of remote sites, and facilitating turn taking in speaking.
Another team used an additional chat channel to ease interaction problems. Mark et al. (1999) concluded that competent facilitators and a history of face-to-face interaction might have eased the transition to virtually collocated meetings.

4.3.2 Questionboard

Malpani and Rowe (1997) developed a tool, called Questionboard, that implements floor control to facilitate one person speaking at a time and, more specifically, to facilitate question asking in large-scale MBone seminars. The authors experienced that while the local audience asks many questions, few remote participants ask questions.

One possible reason is the burden of setting up microphones and cameras to allow the remote participants to transmit questions. Another possible reason is the absence of a floor control mechanism. This problem is especially important in seminars with several hundred remote participants. Currently, the only way for a member of the MBone audience (as described in Malpani and Rowe’s study) to ask a question is to speak into the microphone, which often interrupts the speaker, or to type the question on the second whiteboard. Neither method is natural. In other MBone seminars people can also ask questions via chat (IRC) or e-mail.

The interruption with a microphone does not give a remote participant enough feedback to determine whether the moment to ask a question is inhibiting. With the second method, typing a question on a second whiteboard, Malpani and Rowe (1997) experienced that the control whiteboard was mainly used for technical feedback such as problems with receiving MBone packets and acceptable quality audio. Malpani and Rowe (1997) noticed a difference in the frequency of interaction between local and remote audiences, which motivated their attempt to replicate the local environment for remote audiences. Local audience members expressed their desire to ask a question by raising their hand. The moderator

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1 The development of MBone videoconferencing tools has led to a large number of seminars being broadcast over the Internet. MBone basically refers to a many-to-many communication infrastructure (IP multicast) over the Internet. Up to now, ‘MBone applications’ are intended for multimedia broadcasting of large-scale events, such as Internet standardisation meetings or university seminars, and for multimedia conferencing in a small team. Most MBone seminars have little remote participation. One reason might be the absence of good floor control mechanisms. Another reason might be the availability of IP multicast. Since most IP servers on the Internet do not currently support the multicast part of the protocol, the MBone was set up to form a network within the Internet that could transmit multicasts.
‘managed the floor’ by nodding or pointing at members to ‘grant them the floor’.

Malpani and Rowe (1997) focused on the function of expressing the desire to ask a question, similar to hand raising in human-to-human communication.

Malpani and Rowe (1997) developed a distributed version of this function in the Questionboard by allowing remote participants to indicate their desire to ask a question and enabling the moderator to control the floor. The Questionboard tool encourages the raising of questions by returning control to the moderator to recognise the person who wants to pose a question. Remote participants indicate a desire to ask a question by entering a text message into an interface during a seminar. The message can be a request for the floor to ask the question or the text of the question itself. Questions are displayed at all participating sites. The moderator can either read the question or respond verbally, or grant the floor to a remote participant by selecting a question from the displayed list. The latter action generated a pop-up invitation to speak at the corresponding participant’s site. Figure 4-3 shows the participant interface. Lists of questions entered by the participants of the MBone conference are displayed. More information about any question can be obtained by clicking on it.

Then a window (Figure 4-4) pops up, which displays the full question and information about the participant who posed the question. When a participant wants to ask a question, he presses the ‘Enter Qs’ button, which activates a dialogue box as shown in Figure 4-5 in which a question can be entered.

The participant can specify the media (audio, video) for asking questions and whether the question is to be public, private, or anonymous. Public questions are broadcast to all participating sites. Private questions are sent only to the moderator. Anonymous questions are displayed without the participant’s name. They are sent to the moderator who can then decide whether to ignore them, display them locally, or send them out to the whole group.

In summary, the lack of remote participation in the MBone seminar motivated Malpani and Rowe (1997) to develop a tool that would encourage remote participants using the MBone to ask questions. They implemented the Questionboard tool to allow a moderator to control the floor for large-scale loosely coupled MBone seminars and to allow participants to ask questions. Early experimentation suggested that the tool encouraged remote participation. However, according to Malpani and Rowe (1997) some remote participants were still reluctant to ask questions.
without a specific invitation from the speaker. The work done by Malpani and Rowe illustrated the need to develop a culture for asking questions in video-based communication. However, their implementation of the questioning support did not really stimulate people’s questioning behaviour, and therefore did not evoke collaborative learning and shared understanding. Questionboard can be seen as rather complex technological support that was not derived from human-to-human interaction. The tool in the next section starts from the human-to-human perspective, and seems to be more easy and natural. Chapter 5 elaborates on this perspective.

4.3.3 Virtual hand raising tool

In face-to-face communication hand raising is generally accepted as a means to express the desire for asking a question. SKI²L, a Dutch consultancy company, developed a virtual hand raising tool (Van Santvoord, 2000). This tool can be used in virtual meetings; the chairman controls the discussions and decides who is allowed to speak. More than one person speaking at the same time is not possible. Remote participants can virtually raise their hand if they want to speak; a hand button appears on the screen. The chairman can let this button disappear. Participants also have a yes and no button to answer questions quickly. Although this hand raising tool illustrates the need for better handling of questioning behaviour in video-based communication, no results were reported on the use of this commercial tool.

4.4 In conclusion

This chapter concentrated on the role of questioning during video-based communication, because evidence was found that teams collaborating via video-based communication are deprived with respect to their questioning process. Consequently, they faced difficulties in their collaborative learning process and in reaching shared understanding. A main concern was how the process of questioning could be evoked during video-based communication in order to contribute to collaborative learning and shared understanding. For this purpose, first the conceptual framework as presented in Chapter 2 was reconsidered. In the refined framework the concepts questioning and feedback were assigned more prominence. Next, studies of video-based communication were reviewed, which emphasised issues involved in questioning behaviour. Focus was placed on which functions of questioning were supported.
Mark et al. (1999) observed roles that seem to have value for virtual teams, namely what they called a technology facilitator who enhanced display information for remote participants by gesturing with the cursor and zooming, and a meeting facilitator who overcame interaction problems and encouraged questioning behaviour. Malpani and Rowe (1997) stressed the need for proper questioning support during video-based communication to compensate for the lacking questioning culture during videoconferencing. They contributed to this culture by emphasising floor control and the desire for question asking. While Mark et al. (1999) emphasised the role of the facilitator, Malpani and Rowe (1997) concentrated on the role of technological support, albeit with the help of a moderator who structured the communication process. A third tool was described by Van Santvoord (2000). This commercial hand raising tool can be seen as easy and natural technology. In addition, this tool was used in combination with a chairman that structured the discussion.

At first sight, the distributed teams in this chapter seem to resemble those studied in the previous chapter. Interestingly, the ‘remote’ members in the related studies (Malpani & Rowe, 1997; Mark et al., 1999) seem to be more deprived than the local members. In the design teams explored in Chapter 3 there was a symmetric relation between both subteams; the labels remote or local were merely a matter of perspective: local was the own group, others were remote.

In conclusion, these three interventions were not restricted to technological support, and attention was devoted to the role of a facilitator or a moderator. Nevertheless, it must be concluded that these three interventions did not seem to stimulate collaborative learning in a natural and easy way. Therefore this work elaborates on the need to support collaborative learning and shared understanding by stimulating team members in video-based communication to pose questions and receive feedback. For this question-answer behaviour a specific tool was developed. The design process of this questioning tool and its evaluation in a user pilot are described in the next chapter. Chapter 6 investigates whether the designed support stimulates questioning and answering processes, which in turn should evoke reflective behaviour, and consequently enhance collaborative learning and shared understanding.
Chapter 5

Designing for understanding – a collaborative design approach

The previous chapter investigated the process involved in questioning and looked at how questioning can be supported in video-based communication. This chapter focuses on the design of a tool that evokes questioning and answering behaviour, and consequently may lead to improved collaborative learning and shared understanding. First the design approach will be motivated. Insights from both groupware design and curriculum design are taken into account. A collaborative design approach is taken that starts from a human-to-human interaction design perspective. This approach aims at designing collaborative technology that is intuitive and natural, has low thresholds, and makes the collaboration more attractive. Next the entire design process is described according to the proposed approach. A workshop was organised with users to design proper support for questioning. Function-based solutions from the workshop were worked out into prototypes and were evaluated in a user pilot. Based on the results of this user pilot, the final questioning tool was designed.

5.1 Current design approaches

It is generally accepted that systems should be designed using an iterative approach, and that user involvement is crucial in creating usable systems (e.g., Gould & Lewis, 1985; Nielsen, 1993; Gould, Boies, & Ukelson, 1997; Dix, Finlay, Abowd, & Beale, 1998; Kujala, 2003). The principles of design as recommended by Gould and Lewis (1985) have been widely acknowledged. These are: early focus on users and tasks, empirical measurements, and iterative design. In iterative design approaches, a repeating cycle of designing (technology) and testing (with users) is central in order to
incrementally improve the developed technology until it satisfies the users. Nevertheless, groupware design still originates too often from a technical point of view. As a result, existing groupware systems rarely match either the needs of collaborating groups or the dynamics of these groups.

Although many authors refer to the specific requirements of human-computer interaction, social-technical design or user-centred design (e.g., Suchman, 1987; Kuhn & Muller, 1993; O’Day, Bobrow, & Shirley, 1996), little of this has been applied in groupware design. Exemplary is the following joke. “By version three, the product should be worth using” (Nodder, Williams, & Dubrow, 1999, p. 150). Nodder et al. (1999) state that in a perfect world products should be designed using an iterative usability process. This process guides all phases of product development, from conception through the co-evolution of technology, users, and user interface. However, products in real-life are often developed without such a process, and it is not until version three that the users and their tasks are properly taken into account.

Although this vision of the perfect world is in keeping with the key design principles of Gould and Lewis (1985), current design methods often fail to support real-life collaboration. An explanation for this mismatch is given by Bardram (1998), who argues that the problem is a direct result of not looking at the dynamic aspects of work. Bardram (1998) claims that cooperative work is not one thing, but different things at different times and in different places. In designing technology that is able to support real-life interaction processes, attention should be devoted to the fact that real-life situations are dynamic and involve complex tasks.

Complex tasks consist of various smaller tasks that differ substantially and may thus require quite different technical support. In addition, complex tasks such as design problems are wicked; they are ill-defined and ill-structured (Arias et al., 2000).

Generally, task analysis works well for routine and well-structured tasks because task analysis demonstrates the importance of goals, tasks, and task sequences (Kujala, 2003). While analysing complex tasks, one should focus not only on the individual subtasks, but also on the interdependencies between these subtasks (Mulder & Slagter, 1999). Not just tasks are dynamic and evolving; the interaction process as a whole is dynamic. The

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4 Read for more details on iterative design approaches for example Isaacs & Walendowski (2001). This practical guide shows the ideal iterative design process described from the perspectives of both a user interface designer and a software engineer.
way team members collaborate changes over time, which may result in different requirements regarding the technical support. The requirements for technical support will also change as a result of team development. For example, as team members get to know each other better, they will anticipate each other’s behaviour more. Due to these dynamics and task complexity, merely a detailed task analysis is not sufficient to capture requirements for collaborative technology.

Finally, groupware design primarily concentrates on the comparison with face-to-face communication and strives to make support as good as the face-to-face alternative. As concluded earlier, support that meets the requirements of face-to-face communication is consequently the best result. In accordance with McDonald (2002) it can be assumed that innovation is overlooked or sacrificed.

Thus far it can be concluded that using iterative approaches and involving users in design projects enhance the design of usable systems. Nevertheless, according to Agostini, De Michelis, and Susani (2000), outcomes are not adequate from various perspectives, including user satisfaction and technology innovation; too often either non-innovative usable systems or innovative non-usable systems are designed. In addition, Agostini et al. (2000, p. 225) conclude that the distance between social practices and system functionality is a problem that the design of computer-based systems has been facing for almost thirty years. Many approaches to design have been proposed to bridge this gap. Some have become very popular and deserve close attention. Nevertheless, the problem with respect to the distance between social practices and system functionality remains.

Briefly summarised, appropriate support for team collaboration on complex tasks should not only be usable, it should also capture group dynamics and task complexity, and it must devote attention to innovation.

5.2 Beyond usable – designing for understanding

It can be assumed that using iterative approaches and user involvement is not a guarantee for the design of appropriate technology for collaborative work. Agostini et al. (2000, p. 234) explain that the objective to be met in technology design is creating technology that really works, that is appropriate and that is effective for the people who use it. In addition, in keeping with Roschelle (1992), such support should result in collaborative technology.
This is technology that enhances the joint activity rather than technology that simply supports or enables. Similar to the distinction between cooperative and collaborative as referred to in the first chapter, collaborative technology enhances the collaboration in the team instead of technology that merely supports cooperation.

In other words, the terms usable, supportive, and collaborative can be seen as a gradation, in which collaborative technology explicitly tries to enhance human-to-human interaction. Thus proper collaborative technology should be beyond usable.

In addition, this work concentrates on an intensive form of collaboration, namely collaborative learning and reaching shared understanding. Consequently, the collaborative technology in view should not only enhance the team’s interaction, but should stimulate collaborative learning and evoke reflective behaviour as well.

In other words, such collaborative technology can be seen as (part of) a collaborative learning environment. Kirschner (2003, p. 18) refers to such collaborative technology as “technology affording learning and education”.

Plomp (1992, p. 23) looked at design problems in an educational context and formulated several criteria that the design of educational support should meet. He proposed that such support should be:
- specific in order to be effective;
- user friendly — use should not cause new problems;
- acceptable, thus it should not create thresholds, or evoke resistance;
- and feasible — the support should meet the requirements set by time, money, and manpower.


Thinking in terms of interaction among team members avoids thinking in terms of systems functionality (Agostini et al., 2000; Erickson & Kellogg, 2000; Mulder & Slagter, 2002; Thomassen, 2003). By emphasising the functions of human interaction, the chance of being biased by technology-pushed solutions or workarounds defined to handle or to ease current support is expected to be reduced.
The current work therefore prefers a human-to-human interaction design perspective. Interaction design is a relatively new discipline (e.g., McDonald, 2001). As McDonald (2001) points out, interaction design concerns the design of the services these technologies might offer, and the quality of the experience of interacting with them.

In summary, of the agreed upon usability criteria, collaborative technology should be intuitive and natural, should have low thresholds (e.g., Plomp, 1992), and should make the virtual collaboration more attractive (e.g., Norman, 2002).

In the following the terms natural and intuitive technology are used. Natural technology refers to technology that is in keeping with human-to-human interaction. Because the requirements for this technology are derived from ‘natural’ functions of human-to-human interaction, such natural technology can also be expected to be intuitive.

Technology is labelled as intuitive when people are able to use it in a proper way without detailed instructions or a manual. Consequently, when technology is natural as well as intuitive, teams in virtual collaboration can be expected to face fewer thresholds and experience their virtual collaboration as more attractive. It can be assumed that ad hoc expert teams that have no shared history, that are formed quickly and that often lack time for training and social bonding, will be in favour of a design approach that meets these requirements. The next section deals with the search for a design approach that suits the design of collaborative technology, and that meets the criteria for natural and intuitive technology.

5.3 A collaborative design approach

A collaborative design approach seems to be a good starting point for designing collaborative technology (Agostini et al., 2000; Arias et al., 2000; Mulder & Slagter, 2002). Similar to the motivation for ad hoc expert teams in the first chapter, it can be assumed that multidisciplinary design teams are a good starting point for proper technology design. It was motivated that multidisciplinary teams seemed to be a good solution for coping with complexity, because the team members have different perspectives on the problem, their individual knowledge and skills differ, and their approaches to solving the problem are different. In other words, team diversity can be seen as an asset in solving complex design problems.

Although it might be a bit confusing, the ‘design team’ introduced in this chapter differs from the ‘ad hoc expert team’, in the sense that this ‘design team’ aims to design technology that the ‘ad hoc expert team’ needs in order to fulfil their complex design task.
Arias et al. (2000) view collaborative design as an important way to create shared understanding in multidisciplinary teams that work on wicked problems. Agostini et al. (2002, p. 230) propose a ‘seductive design approach’ for designing innovative user-centred systems. According to Agostini et al. (2002, p. 234), “seduction is both asymmetric and reciprocal” in a good relationship; for that purpose, in a design process seduction should help creating a special relation among its participants that couples them together, letting them feel that together they do and understand something that they could not do or understand separately. Inspired by Agostini et al. (2000) as well as by Arias et al. (2000), the collaborative design approach proposed in this chapter benefits from the potential added value of an entire design team rather than concentrating on the involvement of individual users.

In comparison to Damodaran (1996), who points out that user involvement can be seen as a continuum from informative through consultative to participative, the way of team involvement advocated in this work can be seen as the one extreme on the continuum of user involvement. With respect to user involvement, it can be concluded that the crux of successful collaborative technology design lies in the idealism that all the ‘designers’ involved work as a multidisciplinary team together with the prospective users. This means that the members of the multidisciplinary design team are users and the users are designers.

In educational design several insights also emphasise the importance of involving the actual stakeholders, such as teachers and learners, in the design process. As pointed out by Visscher-Voerman (1999b), in ‘traditional’ design models development processes are usually seen as technical, rational, and systematic processes in which analysis, design, evaluation, and implementation activities are conducted successively. However, applying such prescribed systematic design procedures does not guarantee success (Kessels, 1993). Examples of educational design approaches that dissociate from the traditional systematic viewpoints are the deliberative approach (Walker, 1990), the relational approach (Kessels, 1993; Kessels, 1999), and the communicative paradigm (Visscher-Voerman, 1999a; Visscher-Voerman, 1999b).

Kessels’ relational approach provides activities that challenge stakeholders, such as managers, trainers, and trainees, to become involved in the design and implementation process. In addition, these activities reveal the stakeholders’ perceptions of what the central goal is and how it can be achieved (Kessels, 1993; Kessels, 1999). Main concept is ‘curriculum consistency’, both internal and external. Internal consistency refers to the logic
relationships between the needs analysis, objectives, learning environment, and materials, which are also present in the traditional design approaches. In addition, the relational approach looks at external consistency, which refers to the coherence between the perceptions of the stakeholders involved of what the problem is that has to be resolved and how this will be achieved. Thus in addition to being consistent in itself, a curriculum should show external consistency with reference to the stakeholders’ perceptions. In other words, external consistency can be viewed as shared understanding among the stakeholders – thus including developers – in the curriculum design process.

Walker’s deliberative approach starts from a curriculum design team and concentrates on the elaboration of initial ideas. The process of rational argumentation in which possible actions are considered is called ‘deliberation’. Walker (1990) stressed the recognition of the variety of beliefs, aims and images that participants in a design project adhere to. According to Walker, good deliberators are self-critical and actively seek additional knowledge, for example by consulting with appropriate experts. Worded differently, Walker’s design approach is a collaborative approach that fosters multidisciplinarity as an asset – similar to the collaborative design approaches referred to at the start of this section.

Visscher-Voerman (1999b) labelled developers that adhere to traditional models as ‘technical-professional’. In addition, she studied ‘socio-professional’ activities, and found that 22 out of the 24 developers interviewed worked in a team of developers. Moreover, in the interviews it was explicitly mentioned that working in a team and having people with varying expertise in the development team was seen as a quality criterion. This increases the chance that the problem and its solution will be considered more thoroughly and from various perspectives. In her study, Visscher-Voerman (1999b) called developers who highly valued interaction and communication between the team and others communicative.

Thus in the field of both groupware design and curriculum design, the interest in team involvement in design processes is growing. Put to an extreme, designers are users and users are designers. Thus the design process concerns designing with users instead of designing for users.
Table 5-1 summarises the distinctive characteristics of the proposed collaborative design approach for collaborative technology.

<table>
<thead>
<tr>
<th>The collaborative design approach for collaborative technology focuses on:</th>
<th>… instead of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human-to-human interaction</td>
<td>Interface</td>
</tr>
<tr>
<td>Supporting the team</td>
<td>Designing a system</td>
</tr>
<tr>
<td>Technology that invites and stimulates</td>
<td>Technology that supports</td>
</tr>
<tr>
<td>Designing with users</td>
<td>Designing for users</td>
</tr>
<tr>
<td>Social and cognitive functions</td>
<td>System functionality</td>
</tr>
<tr>
<td>Innovation</td>
<td>Current support</td>
</tr>
<tr>
<td>Dynamics</td>
<td>Stable use</td>
</tr>
</tbody>
</table>

The basic idea of iterative design is included. However, unlike most iterative design approaches, the collaborative design approach does not follow strictly-defined steps in design cycles. The characteristics — as summarised in the left column of Table 5-1 — distinguish the proposed approach from other approaches. Although the proposed design approach identifies no sequence of steps or phases in order to complete a design cycle, it deals with several crucial ingredients. These are explained below.

Preferably, the design process starts with the entire team that is expected to collaborate in the near future. If this is not possible, the design process can also start with representatives of the future team. Alternatively, ‘designers’ can be invited that resemble the (future) team that the collaborative technology will be designed for. In addition, people with specific expertise or a certain background can be invited to participate. Thus in an ideal situation the collaborative design team is multidisciplinary, because when multiple perspectives are present in a team, thinking across borders of disciplines and current practices is expected to be easier. After inviting all the participants to contribute to the design process, the collaborative design process can start. In this, the interaction among the team members is central. More specifically, thinking and talking is stimulated to take place in terms of the functions of human interaction instead of the functionalities of technology. An experienced facilitator directs the entire process.

Because this research concentrates on collaborative technology for collaborative learning, the functions of human interaction that are central are both social and cognitive. In the design workshop, social and cognitive functions — of the intended kind of interaction for which the technology is designed — are first made explicit.
In collaborative sessions these functions are explored, discussed, and ultimately ranked according to their importance to the specific situation. After brainstorming, participants are asked to visualise solutions that may support these functions. Although this is difficult, the team explicitly tries to avoid thinking in terms of system functionality. Here again the facilitator plays a crucial role.

Next each function-based solution is presented and motivated. All ideas are discussed and evaluated. Depending on the number of ideas, technological experts investigate system requirements at the application and implementation levels with feasibility studies.

Taking several requirements into account, a selection of the function-based solutions was made. A limited number of these ideas are developed into prototypes. Then a more common iterative design process starts (see for example, Isaacs & Walendowski, 2001). The prototypes are evaluated in user pilots.

Feedback and experiences from these pilots lead to adjusted prototypes. Finally, the resulting collaborative technology is validated in an experimental setting.

Because the social and cognitive functions in terms of human-to-human interaction are emphasised, the ways to intervene in the virtual teams can be expected to enhance the team’s interaction in a natural way. Although this way of designing starts from human-to-human interaction, it should be noted that it does not necessarily aim to simply simulate face-to-face communication. The objective is to support the interaction among the virtual team members rather than designing advanced technology. At the same time, an additional advantage is that the support does not constrain the design process.

Thus far a collaborative design approach that enhances human-to-human interaction in a natural and intuitive way has been advocated. Designing according to this approach is expected to result in technology support that has lower thresholds for users. The next section illustrates the design process for a support tool for questioning, according to the collaborative approach.
5.4 Designing support for questioning

Chapter 4 described the search for collaborative technology that explicitly enhances the questioning and answering processes. Because no appropriate support that satisfied the characteristics as presented in Table 5-1 was found, this section reports on the design process of questioning support. It is expected that when this questioning and answering process is properly supported, it will lead to improved collaborative learning and shared understanding in the team.

5.4.1 Design workshop

A workshop was organised to collaboratively design proper support for questioning. The main question in the workshop was how technology that stimulates people’s questioning behaviour could be designed. The workshop aimed to arrive at a minimum of three ideas for prototypes that could be evaluated in a user pilot.

In this workshop several ‘designers’ with diverging expertise and backgrounds were invited; only one designer had an engineering background. These participants can be considered to be similar to the teams that were scheduled to participate in the experimental study (in Chapter 6). The workshop started by investigating what people actually do when raising a question. Participants brainstormed on what kind of interaction is involved in people’s questioning and answering behaviour. In other words, the participants brainstormed on the social and cognitive functions of questioning behaviour. This brainstorm on functions of questioning behaviour resulted in a list of identified functions, which were then discussed in a plenary discussion, and subsequently clustered. Some of the social and cognitive functions the workshop participants identified were: structuring the process of questioning, collecting answers, indicating that a question has been answered, and indicating the desire for questioning.

Figure 5-1 (in Dutch) displays the identified functions of questioning behaviour. Note that when the required interaction is the starting point, thinking in terms of features and technologies is avoided. Interestingly, workshop participants were able to identify all functions as summarised in the revised conceptual framework (Chapter 4). What is more, they came up with other functions, such as saving questions until a suitable moment for posing questions was identified, and the possibility of posing a limited number of questions (in order to stimulate people to pose only relevant and the most crucial questions).
Then, based on the selected functions, pairs of team members selected and sketched their preferred technology. After this creative design process, each pair presented their function-based solutions to the rest of the team. The figures below (Figure 5-2, Figure 5-3 and Figure 5-4 (in Dutch)) illustrate several designs of preferred technology for supporting questioning behaviour.

Figure 5-2 shows the system control timer, which indicates a moment for raising questions. A window with ‘time for questions’ appears in the middle of the videoconferencing screen. The system control timer then asks whether there are any questions, and whether there are more questions.

A more advanced version could also indicate for whom (team or individual person) the question is intended.
Another function-based solution that the design workshop brought forth were a ‘question token’ that structured questioning and limited speaking to one person at a time, a ‘question box’, a ‘question bucket’ that both collect questions, and a ‘question mark button’ that indicates the need for questions. Figure 5-3 shows the latter.

Figure 5-3
In order to get attention for your question, one can press a button and a blinking question mark appears on the screen of the receiving party.

Figure 5-4 portrays a part of the sketch of the Q-bucket solution. Various questions are collected in a Q-bucket during a (virtual) meeting; this could be in either text, audio, images, or the shape of drawings. When submitting a question to the Q-bucket, one can indicate the priority. When an urgent question is submitted to the Q-bucket, the bucket appears prominently on the screen, and the urgent question pops out.

Other – less urgent – questions can be answered throughout the design process. Team members of the receiving party can look into the bucket and supply answers to the questions. If the bucket overflows (this is after reaching a preset maximum of questions or after a preset time), it empties onto the screen. This implies that the system suggests a questioning moment. All questions are visible on both screens, and can be discussed and answered in a plenary discussion.
5.4.2 Towards a prototype

In addition to a plenary discussion at the end of the workshop, the participants were asked to indicate which of the final ideas they preferred. Individually, they indicated the prototype or function they liked most, and explained the reason why. Based on the workshop results, the individual reflections, and the revised conceptual framework described in the previous chapter, it was concluded that the following functions should be supported: indicating the need for questioning, and explicating a question. Furthermore, it appeared to be important, that the questioning tool should not interfere with the task of the virtual team, and that the tool would not seduce team members to chat. This is because it was assumed that the rich video-based communication should be enhanced, rather than the communication turning into text-based communication.

Summarising, the three function-based solutions that were to be developed into prototypes are a question mark pop-up, a system timer, and a question mark pop-up extended with the formulation of the question. These prototypes are explained below.

Prototype 1: question mark pop-up

The main motivation for the question mark pop-up was that it is extremely simple, and therefore probably less intrusive. The question mark pop-up structures a conversation; a question must be answered before another question can be raised. At the same time it stimulates related questions (see Figure 5-5).
If a person wants to raise a question, he presses the button ‘question’, and a question mark appears on the screen of the remote team. The idea is that the question mark icon is enough to let the remote team realise that they should listen to what kind of questions the others have. When the team or person who raises the question feels satisfied with the answer, he or she presses the button ‘answered’. The question mark disappears, and another person can raise a question. The tool prevents multiple questions being asked at one time while stimulating asking related questions to get the question more focused.

Prototype 2: system timer
The second prototype was based on the previous one, but the main difference was that the system indicated a moment for raising questions (Figure 5-6).

Thus this prototype contributes to building a culture on questioning. The system makes team members aware of questioning by explicitly indicating a moment to raise questions, and thus stimulates team members to raise questions. Every x minutes the question mark prompt appears on the screen, and ‘asks’ if there are any questions.

Prototype 3: extended question mark pop-up
The third prototype was also based on the first one, the question mark pop-up. The difference is that this one was expanded with the possibility of formulating the question more carefully. First a person who wishes to raise a question presses the question button, resulting in a question mark icon appearing on the videoconferencing screen of the remote team. This icon alerts the remote team members to the fact that the others have a question. Below the question mark icon, information on the questioner’s activity is shown: other party is typing the question (see Figure 5-7).
The activity status was shown to avoid situations in which a person is formulating a question very carefully but when this formulated question appears on the remote video screen, the other team members respond with: “where have you been, we just discussed this topic!”

These three prototypes were evaluated in a user pilot, which is described in the next section.

### 5.4.3 Pilot study

A user pilot was conducted to acquire insight into these three distinct ways of evoking questioning behaviour, namely: a question mark pop-up, a system timer, and a question mark pop-up extended with the formulation of the question.

The main aim of this pilot study was to find evidence of which function enabled by one of the three prototypes was most important in support of questioning behaviour while designing together by means of videoconferencing. Based on the results of this pilot study, a final questioning tool was developed.

In addition to the selection and evaluation of the workshop ideas, this pilot study was used to validate the set-up of the experimental study. This experiment – that investigates whether the designed support improves questioning behaviour – will be described in Chapter 6. The pilot participants therefore worked on the same collaborative design task and used the same collaborative technology as provided in the experiment. All assessment instruments that were adjusted for the focus on questioning behaviour were validated in the user pilot.
Participants
Two teams, each of 6 persons that worked together in two subteams, were invited to collaboratively design a university portal. Each team was subdivided and assigned to two different locations, and had videoconferencing and visualisation tools, such as a shared whiteboard, pen, and paper facilities, at their disposal. Teams worked together for one and a half hours. After each half hour the teams were briefly interrupted to install another prototype on their videoconferencing system.

Data collection
To identify which prototype supported questioning behaviour in videoconferencing teams best, the team process and in particular their questioning behaviour were observed. Log files were made to determine how often the distinct prototype question tools were used. At the end of the pilot, the participants were asked which tool they preferred. They were asked to describe positive and negative aspects of the three tools they used in their design task. After the questionnaires were returned, the entire pilot was evaluated in a plenary discussion. This plenary evaluation offered opportunities for asking additional questions on specific topics, such as the ease of use, fun, and obtrusiveness the participants might have experienced.

5.4.4 Results – tool selection

The pilot participants preferred the question mark pop-up because it was easy to use and less intrusive, and there was no need to type. However, they lacked feedback on whether a question mark was still displayed on the others’ screen. They also noticed that a visual alert was not enough, they preferred to also have a sound alert to get the remote partners focused on the screen. The sound alert and the awareness of an awaiting question were added to the final questioning tool (Figure 5-8).

This tool is in keeping with the design criteria defined by Plomp (1992). It is specific because it concentrates on the desire to raise a question and the signalling function of this desire. In addition, as concluded by the pilot participants, the final tool was also user friendly and acceptable. Finally, the...
design was feasible; the total costs for developing in terms of time, money, and manpower were much lower than expected. Thus the final tool could be expected to be intuitive and natural, to have low thresholds, and to make the collaboration more attractive.

The use of this tool is straightforward. Both subteams have the button question next to the video screen. By clicking on this button, one expresses the desire for questioning and a red question mark appears on the video screen of the remote team. Only the subteam that presses the button can remove the question mark by clicking We’ve got an answer.

All data collection methods regarding collaborative learning and shared understanding were used. However, the main intent was to validate these methods rather than analyse collaborative learning and shared understanding. For the latter purpose, the collected data were too limited (N = 2, n = 12).

5.5 In conclusion

This chapter described the design process of a questioning support tool. For this purpose, a collaborative design approach was motivated that aimed to come up with collaborative technology that is beyond usable. Such collaborative technology – that is both natural and intuitive – was defined as technology that has low thresholds and makes collaboration more attractive. More specifically, technology was labelled as collaborative when it invited people to collaborate rather than simply allowing team members to cooperate. In addition, this study concentrated on an intensive form of collaboration, namely: collaborative learning and reaching shared understanding. Thus the study was aimed at designing technology that also stimulated collaborative learning and evoked reflective behaviour.

Because such collaborative technology showed similarities with collaborative learning environments, design approaches from the fields of both groupware and curriculum design were taken into account. Reviews in the field of groupware design showed that it is generally accepted that groupware systems should be designed using an iterative design approach, and that user involvement is crucial. At the same time, it was concluded that groupware failed to support real-life collaboration too often. Although curriculum design is traditionally less technology-biased, the same rational and systemic approaches seem to underlie this design process. Interestingly, various insights from both fields emphasise that the importance of involving the actual team members in the design process is growing.
The proposed approach preferably involves all team members in the design process and starts from a human-to-human interaction perspective. This perspective implies that requirements for the designed support are derived from the ‘natural’ functions of human-to-human interaction. The approach therefore concentrates on the interaction between team members rather than the system’s interface. Because this work places emphasis on collaborative learning, social and cognitive functions of human behaviour were considered key. Furthermore, the collaborative design approach aims at designing with users instead of designing for users.

Using this approach, a workshop was organised to collaboratively design a questioning support tool. The design workshop resulted in three initial prototypes, which were evaluated in a user pilot. Based on the evaluation and selection in the user pilot, a final tool that supports questioning behaviour (Q-tool) was developed.

The next chapter investigates whether the designed support tool improves questioning behaviour. In addition to the role of this technological tool the role of a facilitator is studied.
Supporting questioning –
a quasi-experimental study

This chapter describes a quasi-experimental study to investigate whether a questioning tool and a facilitator supported questioning behaviour, and therefore stimulated collaborative learning and shared understanding in video-mediated design teams. Twenty teams performed a complex design task; ten of these teams had next to audio and video support a questioning tool (Q-tool) available. It was hypothesised that teams with the Q-tool learn and understand each other better than teams without the Q-tool, and that teams with a facilitator perform better than teams without a facilitator. Moreover, it was expected that teams that had both a Q-tool and a facilitator performed best. Although the results of the assessment of perceived shared understanding pointed out in the expected directions, no significant differences between the conditions were obtained. As expected the perception of shared understanding increased significantly, at the same time little reflection was found. One possible explanation is that such behaviour just did not occur. Another explanation is that the coding of (collaborative) reflection was too rigid.

6.1 Method

The experimental setting was made as realistic as possible: university students were working on a complex design task, in two subteams, using collaborative technology. The ‘unrealistic’ part was that teams were not really geographically dispersed, but were working in two different rooms in the same building. The experimental condition was the use of the Q-tool. In other words, the main question was whether this Q-tool is strong enough to encourage questioning behaviour. In addition, it was assumed that the role of the facilitator has an effect on the process of collaborative
learning and shared understanding. As spontaneous facilitator behaviour was observed, teams with and without facilitator were appointed afterwards. As shown in Figure 6-1 the independent variable was the presence and absence of the Q-tool. The dependent variables were the perception of shared understanding (process and final design), the quality of the final design and the quality of team communication. The variable facilitator can be seen as a post-hoc distinction.

In the remainder of this section the hypotheses, the experimental set-up and the technology used are described. In the subsequent sections the results of the quasi-experimental study are displayed; first results with respect to the role of the Q-tool are described, and then the results with regard to the role of the facilitator. Thirdly, results of the role of the Q-tool and the facilitator are combined. Finally, other variables are reviewed; these variables were indicated in the previous study and were taken into account in the pre-questionnaire, although they were not subject of the current study. This chapter concludes with a discussion.

6.1.1 Hypotheses

As questioning is one of the most important means of facilitating collaborative learning and shared understanding, it was hypothesised that stimulating questioning behaviour in video-mediated design teams evokes collaborative learning and shared understanding in those teams. The current study investigates whether either the role of a Q-tool or the role of a facilitator stimulated collaborative learning and shared understanding. It was hypothesised:

...that teams with a Q-tool learn more and understand each other better than teams without a Q-tool, and
...that teams with a facilitator learn more and understand each other better than teams without a facilitator.
Moreover, teams with both a Q-tool and a facilitator learn most and understand each other best.
Several measures were used to assess collaborative learning and shared understanding. These measures and instruments are described in Sections 6.1.5 and 6.1.6. In addition, assumptions of this study were that shared understanding increases over time, and that increased shared understanding leads to better team performance and higher product quality.

6.1.2 Participants

Participants, which were recruited from three universities in the Netherlands, were 20 teams of 4-7 students (N = 20, n = 110). Participants with differences in study background, nationality, age, and motivation for participation (voluntarily or part of the curriculum) were equally distributed across teams with and without a Q-tool to achieve comparable team composition.

6.1.3 Task

The students had to perform a collaborative design task during one and a half hours. This design task involved the creation of an added value service for a university portal. Box 6-1 shows the task description as given to the students.

The design task you have to perform collaboratively involves the creation of an added value service for a university portal. Universities are rushing to replace their home pages with portals. However portals are not just fancy home pages. Like many organisations, universities have several systems available for students and teachers, like the university Intranet, university library, information systems for courses, faculty, exams, and so on. Imagine all these systems are integrated and accessible through one interface, the portal.

The task involves the design of an added value service for a university portal. Hereeto, you should consider (at least some of) the following design issues:

- Provide an added value service to several (different) user groups, like for instance, individual students, group of students, student classes, teachers, administration, and management.
- Consider administrative, technical, didactical, and economical challenges to building portals.
- The design should be creative, innovative, however it should be realistic.
- Design new service interfaces, which improve the overall (aesthetic) quality and functionality.
- Design should integrate several systems (think of common standards).
- Solution for the evolution of communication and information infrastructures.

We suggest formulating concept scenarios for new services, and making prototypes of the final design (both visual and textual sketches are possible). Concentrate on how people experience this portal without building every detail. However, there are no strict procedures. Experts on university campus systems design will review the final concepts. Best service designs will be considered for implementation on a new university portal.
We use the following criteria to judge the final results. We look if you consider administrative, technical, didactical and/or economical challenges, if the design is creative and innovative, and if the design is realistic. We also pay attention to the aesthetic quality and the functionality of service design. The portal design will be rewarded for the compliance with and integration of several systems, if it can be extended with other features and systems, and if it is based on common standards. Finally, we judge the overall result of the service design in order to rank the final designs.

6.1.4 Collaborative technology

All teams had videoconferencing tools available. The teams were provided with a laptop with desktop videoconferencing (Microsoft NetMeeting™), which included chat, shared whiteboard, and file and application sharing functionality. A criterion for technology selection was whether it could be expected to be available to a large audience in the near future. The laptops were connected with a wireless LAN connection at 11Mb/sec. For the video, two Philips ToUcam USB cameras were used. In addition to videoconferencing tools 10 teams had the Q-tool available.

Figure 6-2 shows the Q-tool; both subteams have the button Question next to the video screen. By clicking on this button one expresses the desire for questioning, and a red question mark (image in the middle) appears on the video screen of the remote team. Only the subteam that presses the button can remove the question mark by clicking the button We’ve got an answer.

The other 10 teams could only communicate by means of videoconferencing. Moreover, in order to avoid an audio bottleneck the teams were provided with (two-way) half duplex hands free telephones. Teams also had common visualisation tools at hand: paper, pencils, flipchart, and whiteboard.

Figure 6-3 shows the experimental setting as seen on both laptops during the teamwork. In this figure, the three students in the right hand frame have just pressed the Q-button to get the attention of their remote team members. Therefore, the three students in the left hand frame see a question mark on top of their screen.
6.1.5 Data collection

Several measures were used to collect data to assess aspects of collaborative learning and shared understanding, such as the perception of shared understanding (both process and product), quality of final result, and the quality of the team communication.

Table 6-1 displays the measures and instruments used to acquire more insight into these aspects of collaborative learning and shared understanding. All instruments were tested in a pilot study (see Chapter 5).

<table>
<thead>
<tr>
<th>Measures</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of shared understanding</td>
<td>Rating scale (self-score)</td>
</tr>
<tr>
<td>Perception of shared understanding of final design</td>
<td>Rating scale (self-score and expert rating)</td>
</tr>
<tr>
<td>Team communication process</td>
<td>Coding scheme for video analysis</td>
</tr>
<tr>
<td>Participants experiences</td>
<td>Report</td>
</tr>
<tr>
<td>Prior knowledge and experience</td>
<td>Questionnaire</td>
</tr>
<tr>
<td>Quality of final design</td>
<td>Expert rating</td>
</tr>
<tr>
<td>Facilitating behaviour</td>
<td>Observation scheme</td>
</tr>
<tr>
<td>Use of Q-tool</td>
<td>Log files</td>
</tr>
</tbody>
</table>

One of the main interests lay in the assessment of the perception of shared understanding. For this purpose, the same rating scales were used as in the exploratory study for the assessment of perceived shared understanding of content, relation, and process aspects. Next to the process of shared understanding, perceived shared understanding of the final portal design (product) was assessed.
In addition to these rating scales on perceived shared understanding, measures were used to get more insight into the teams; a pre-questionnaire to identify differences in background and team composition, students were asked to reflect on their experiences afterwards, and the team communication process was videotaped. Moreover a coding scheme was developed to gain more insight in the team performance. This scheme was an adapted version of the one used in the exploratory study.

In order to get insight in the relation between collaborative learning and shared understanding on the one hand and the final result of the teamwork on the other hand, also the quality of the final portal design was measured. Finally, the log files of the Q-tool and the observation of facilitating behaviour were a direct result of the experimental set-up.

**Perception of shared understanding (rating scale)**
A self-scoring instrument to measure the perception of shared understanding was used (see Box 6-2). This instrument measured how team members perceived their understanding concerning content, process, and relation aspects. A 6-point scale was used to measure the (shared) understanding at a certain moment. Even number of points (6-points) forced students to choose either negative (1, 2, or 3) or positive (4, 5, or 6). After each half hour, the team members rated their perceived understanding.

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**Box 6-2**

**Rating scale – Perception of shared understanding**

<table>
<thead>
<tr>
<th>Question</th>
<th>Rating Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>How well do you understand the definition and requirements of the task?</td>
<td>Very badly (1)——(2)——(3)——(4)——(5)——(6) Completely well</td>
</tr>
<tr>
<td>To what extent does your group (both subgroups) holds a shared interpretation/understanding of the definition and requirements of the task?</td>
<td>No shared understanding at all (1)——(2)——(3)——(4)——(5)——(6) Completely shared understanding</td>
</tr>
<tr>
<td>To what extent do you feel you know the other group members (both subgroups), with regard to skills, interests, the way they behave or react in different situations?</td>
<td>Very badly (1)——(2)——(3)——(4)——(5)——(6) Completely well</td>
</tr>
<tr>
<td>To what extent do you feel the other group members (both subgroups) know each other?</td>
<td>Not at all (1)——(2)——(3)——(4)——(5)——(6) Completely</td>
</tr>
<tr>
<td>How certain are you about the process of accomplishing this collaborative design task?</td>
<td>Very uncertain (1)——(2)——(3)——(4)——(5)——(6) Completely certain</td>
</tr>
<tr>
<td>To what extent do you feel the views of the other group members (both subgroups) correspond with your interpretation in order to carry out this collaborative design task?</td>
<td>Do not correspond at all (1)——(2)——(3)——(4)——(5)——(6) Correspond completely</td>
</tr>
</tbody>
</table>
Perception of shared understanding of final design (rating scale)

In addition to the perception of shared understanding (team process), the perception of shared understanding of the final design (product) was assessed. For this purpose, each subject was asked to describe in their own words the final design their team came up with. All descriptions were collected. Two experts judged these individual descriptions, using a 6-point scale (1 = not at all corresponding, 6 = completely corresponding) to indicate extent to which the descriptions of the whole team corresponded. In addition, just after participants finished their description, one description was randomly selected and read aloud. All team members indicated the extent to which the description read aloud corresponded with their perception of the final design. They indicated on the same 6-point scale the extent to which the description corresponded with their own description, and indicated on a second scale the extent to which the description corresponded with their idea of the final result (Box 6-3). Next, a second description was read aloud and one team member was asked to explain in his or her own words what (s)he thought the writer meant. Finally, the ‘description writer’ indicated on the same scale the extent to which the explanation corresponded with his or her description (Box 6-4).

Team communication process (video recording)

The team communication was recorded on videotapes. In order to gain more insight into aspects of collaborative learning and shared understanding in video-mediated design teams, and to acquire results that better allow comparison across the teams, a coding scheme was developed (see next section).

Participants experiences

Several participating students (N = 13) reported their videoconferencing experience. They reflected on matters including the usage of collaboration tools, their expectations, and their collaboration process.
Prior experience on design and project work (questionnaire)

All participants were asked about their knowledge in the domain of the design of services; they filled out a questionnaire at the start of the experiment (Box 6-5).

Name:
Age:
Faculty:
University:
PhD: yes/no
If yes? What is the topic of your PhD thesis?
Experience with designing? yes/no
Please explain:
What kind of design approaches do you know?
Topics or domain of your experience:
What kind of journals, magazines do you read, related to your study or work?
Did you recently read on portals? yes/no
If yes, please explain:
Do you have experience with project work? yes/no
If yes, please explain:
................ years, ............. projects
Do you have experience with collaboration with different disciplines? yes/no
If yes, please explain:
................ years, ............. projects
Do you know the other group members? yes/no
If yes, who do you know?
What is your motivation for participating?
What are your expectations of this collaborative design task?
With what kind of results are you satisfied?

Quality of final design (expert rating)

Experts judged the quality of the final designs based using a 5-point scale (+++, ++, +, 0, -, --). Portals were awarded based on the eight criteria mentioned in the task description (Table 6-2). Finally, all plusses and minuses lead to a total score. Those total scores were ranked.
Table 6-2
Criteria used to judge the quality of the portal designs

<table>
<thead>
<tr>
<th>Criteria</th>
<th>++</th>
<th>+</th>
<th>0</th>
<th>-</th>
<th>--</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design available</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Added value service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Several user groups taken into account</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Several challenges, e.g., didactic, administrative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative and innovative design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality and functionality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration with other systems and standards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of concept scenarios/prototypes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Facilitator role in team (observation)**
Facilitating behaviour of the individual team members during the team communication was observed using an observation scheme. It was counted who was initiating proposals and raising questions with respect to the content and process. Moreover, the number of times a person was paying attention to other team members (social relation and team cohesion) was indicated.

The main objective of observing facilitating behaviour was to classify the twenty teams into teams with and without a facilitator. A team was labelled ‘with facilitator’ if someone in that team appeared to take more than 40% of the initiatives of the whole team. At the same time it was determined whether someone in a team was accounted for more than 50% of the content related or process related initiatives, and whether this percentage corresponded with at least 75 utterances.

**Use of Q-tool (log files)**
Log files were generated by the Q-tool to monitor its usage (frequency), including which subteam was pressing the Q-button, and at what time.

**6.1.6 Coding team communication**
Raw data were collected using the measurements and instruments described above. The richest sources were the observations and videotapes of the team communication. In order to acquire more insights from these sources, a coding scheme for questioning behaviour was developed.

**Coding scheme**
The current scheme was based on the one used in the previous study (see Chapter 3). Because the current goal, in addition to collaborative learning and shared understanding, focuses specifically on questioning behaviour some differences can be seen (Mulder & Graner, 2002).
In the current scheme a more detailed look was taken at reflection and collaborative reflection. Although all the conceptual learning modes distinguished in the previous scheme were still relevant, accretion and tuning were left out in the updated scheme. As discussed in Chapter 4 utterances coded as accretion and tuning concerned the exchange of facts and appeared not distinctive for reflective behaviour. The revised coding scheme concentrated on (higher order) reflective behaviour.

Another goal of the current scheme was to simplify the coding without making it ambiguous. Consequently, some adjustments were made. With respect to the coding category question the previous manual referred to explicit requests for information. Here, it was distinguished between questions and more questions. The first or main question on a topic was coded as question. In case this question lead to more questions – thus group members continued to ask questions which were more specific – these latter questions that elaborated further on a certain topic were coded as more questions on same topic. A new question on another topic was coded as a new question.

The codes check understanding and check action, which were defined as feedback modes in the previous scheme, were currently categorised as more questions on same topic. As defined earlier “Check understanding: one person checks self-understanding or the other group member’s understanding of a previous utterance; Check action: one checks whether an action has been understood by another group member” (see Chapter 3; Mulder, 2000). However, these two checking codes were added to ‘asking more questions’, feedback was re-used from the former scheme. In particular, the feedback codes confirm, paraphrase, summarise, and explain were clustered together to one code feedback.

In the manual used in the exploratory study it was defined as follows. “Confirm: reaction that can be indicated as an agreement. The understanding is shared”. In the current scheme confirm was used only for short answers and short reactions in order to acknowledge. “Paraphrase: kind of summarising but using one’s own words. This is also a form of reflection. Summarise: one of the group members summarises what has been said before. Explain: reaction on other utterances, which provides new information or increases the understanding” (Mulder & Graner, 2002).

For the code reflection the terms restructuring, reflection, and evaluation were combined. Restructuring was defined earlier as new relations between concepts; this is reflection on the individual level. This mode of conceptual learning tends to go with an assertion.
Evaluation: needs to be chosen when there is an opinion stated, or when something has been evaluated. Other (reflection): This code has been introduced as feedback mode to indicate meta-communication, which is not necessarily process or technology related. This code should be used as a kind of evaluation and a feedback mode. Collaborative reflection was when the group as a whole reflects, based on what was attempted to code in the previous study by co-construction.

In the current study, two coding schemes were used; one scheme for categories that could be counted (frequency), such as the number of questions raised (see Table 6-3), and another scheme for categories that lasted a certain period (% of total time), such as collaborative reflection (see Table 6-4).

### Table 6-3: ‘moment’ codes and instructions

<table>
<thead>
<tr>
<th>Code</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(New) Question</td>
<td>Someone raises a question.</td>
</tr>
<tr>
<td>(More) Questions on same topic</td>
<td>If a question (as coded above) leads to more questions, i.e., team members continue in asking questions, these latter questions should be coded as more questions on same topic. A new question on another topic (or not related topic) should be coded as a new question.</td>
</tr>
<tr>
<td>Content/Task Proposal</td>
<td>A proposal concerning the content of the project or the task they need to fulfill, being ideas, initiatives, suggestions raised by the participants.</td>
</tr>
<tr>
<td>Process Proposal</td>
<td>A proposal concerning the process or the procedure of the project, being ideas, initiatives, suggestions raised by the participants.</td>
</tr>
<tr>
<td>Confirm (Disconfirm)</td>
<td>Short answers and reactions to questions or proposals.</td>
</tr>
<tr>
<td>Feedback</td>
<td>Reactions that can be seen as paraphrase, summarise or explain.</td>
</tr>
<tr>
<td>Reflection</td>
<td>Feedback that has more to do with evaluation and meta-communication. It is reconsidering earlier questions, assertions, and remarks, and involves a new perspective.</td>
</tr>
<tr>
<td>Impasse</td>
<td>The team indicates that they do not know how to go any further or when the team communication process breaks down.</td>
</tr>
</tbody>
</table>

### Table 6-4: ‘period’ codes and instructions

<table>
<thead>
<tr>
<th>Code</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subteam communication</td>
<td>The whole team has divided tasks, and they are communicating in subteams. Small remarks and whispering are excluded.</td>
</tr>
<tr>
<td>Collaborative reflection</td>
<td>When the whole team reflects (see definition Table 6-3) together.</td>
</tr>
<tr>
<td>Off-topic communication</td>
<td>The team discusses topics not related to the project task or the technology they use.</td>
</tr>
<tr>
<td>Tech Talk</td>
<td>Communication on technological issues. This kind of communication also involves questions, proposals, feedback, and reflection on technology. Note that a question on technology use is coded as Tech Talk, not as a Question, etc.</td>
</tr>
</tbody>
</table>
A coding tool

A coding tool was designed to facilitate the video analyses. This tool enables coding while watching a video. Using this tool there was no need to fully transcribe the team communication; this was necessary in the previous study. The coding tool is an add-on to VIP, an advanced content-based video retrieval and streaming solution. VIP is an acronym for Video over IP (Internet Protocol). Consequently, using the VIP application it was possible to view and code the videos across a distance. Additionally, collaborative coding in distributed settings was enabled. For the indexing of the videos, automatic metadata extraction, including speech and image analyses, was used (see for more information Tokmakoff et al., 2002 or vip.telin.nl).

Once videos are on the VIP server, one can analyse these videos using the add-on coding tool. First, a program layout must be loaded. In this study, a layout that corresponded with the coding schemes was used.

Figure 6-4 illustrates the number, coding category, and colour combination. In order to indicate a content proposal, one presses number 3 on the keyboard, and an orange mark illustrates this content proposal; Figure 6-5 shows an illustration of the coding process (see also Mulder & Graner, 2002).
In order to calculate the reliability of the coding scheme the scores of the expert rater were compared with the scores of 9 student raters, who coded a half hour of their own meeting (this is 15% of the total time). These students coded the same videos as used by the expert on their own computer using the VIP application.

Two expert raters were collaborating during two weeks and practiced the coding scheme; based on their experiences the manual was adjusted. The calculations in the Sections 6.2 up to and including 6.5 are based on the data of one expert. The students were instructed in a lecture, and used the same manual – though with the difference that the expert was calibrated and the students were not. In other words, most likely the student scores were less precise than the expert scores.

Interestingly, the students seemed to have calibrated each other; as correlations of two student raters that coded the same data set were higher than those scores between student rater and expert rater. The scores between two student raters were .656, .901, .966, and .945; the latter three scores correlated significantly at the .01 level.

Correlations of the student raters and the expert rater are displayed in Table 6-5 (the average Pearson correlation coefficient was .736).
The correlation of the scores of the expert rater and one of the student raters varied between .583 and .929, which implies that these scores correlated substantially. Taken into account these students’ scores, the average Pearson correlation coefficient was a bit higher, namely .776.

With respect to the period codes no reliability score was calculated, as the main intent of addressing ‘period’ codes was to study collaborative reflection, and this code appeared to be not functional. Hence, no collaborative reflection took place.

### 6.1.7 Expected results

In Table 6-6 the hypotheses have been translated into expected results. These expected results are described in terms of the measures used in the current study.

<table>
<thead>
<tr>
<th>Perceived shared understanding increases over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived shared understanding in teams with a Q-tool increases more than shared understanding in teams without a Q-tool</td>
</tr>
<tr>
<td>Perceived shared understanding in teams with a facilitator increases more than shared understanding in teams without a facilitator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The level of shared understanding is higher in teams with a Q-tool than in teams without</th>
</tr>
</thead>
<tbody>
<tr>
<td>The level of shared understanding is higher in teams with a facilitator than in teams without</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The level of agreement on shared understanding increases over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>The level of agreement on shared understanding in teams with a Q-tool increases more than shared understanding in teams without a Q-tool</td>
</tr>
<tr>
<td>The level of agreement on shared understanding in teams with a facilitator increases more than shared understanding in teams without a facilitator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The level of shared understanding of final design is higher in teams with a Q-tool than in teams without</th>
</tr>
</thead>
<tbody>
<tr>
<td>The level of shared understanding of final design is higher in teams with a facilitator than in teams without</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The quality of final design is higher in teams with a Q-tool than in teams without</th>
</tr>
</thead>
<tbody>
<tr>
<td>The quality of final design is higher in teams with a facilitator than in teams without</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teams with a Q-tool raise more questions than teams without</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teams with a facilitator raise more questions than teams without</td>
</tr>
</tbody>
</table>
Teams with a Q-tool raise more questions on same topic than teams without
Teams with a facilitator raise more questions on same topic than teams without
Teams with a Q-tool propose more on the content than teams without
Teams with a facilitator propose more on the content than teams without
Teams with a Q-tool propose more on the process than teams without
Teams with a facilitator propose more on the process than teams without
Teams with a Q-tool confirm more than teams without
Teams with a facilitator confirm more than teams without
Teams with a Q-tool give more feedback than teams without
Teams with a facilitator give more feedback than teams without
Teams with a Q-tool reflect more than teams without
Teams with a facilitator reflect more than teams without
Teams with a Q-tool face less impasse than teams without
Teams with a facilitator face less impasse than teams without

Results are described in the Sections 6.2 up to and including 6.5. First the results of respectively the role of the Q-tool and the role of the facilitator are displayed. Then the results of the tool and the facilitator are combined. Finally, results of other variables that influence questioning behaviour in video-mediated teams, such as the team’s background and the quality of communication are described.

6.2 Results – the role of the Q-tool

In this section the results of the experimental condition, the presence or absence of the Q-tool, are described.

6.2.1 Use of Q-tool

Table 6-7 shows how often the Q-tool was used in the teams. The average use in the 10 teams was 30.9 times; this is about once every 3 minutes. Only three teams used the tool more than 31 times, the other teams used the tool less.

<table>
<thead>
<tr>
<th>Use of Q-tool</th>
<th>51</th>
<th>20</th>
<th>12</th>
<th>16</th>
<th>19</th>
<th>53</th>
<th>18</th>
<th>73</th>
<th>19</th>
<th>28</th>
<th>30.9 (average)</th>
</tr>
</thead>
</table>

Interestingly, the teams that used the tool most (73 times) wrote in the participants’ experiences that they experienced the Q-tool as a very nice way to get the attention of their remote team members. Consistent use seemed to yield positive experiences for this team. However, the team that used the tool 51 times indicated that they used the tool primarily for fun. In conclusion, how to interpret these frequencies is not straightforward.
6.2.2 Perception of shared understanding

The numbers in Table 6-8 increase from T0 to T1 as expected, the perception of shared understanding increased. In accordance with the hypothesis, teams with the Q-tool had a better perception of shared understanding than teams without.

<table>
<thead>
<tr>
<th></th>
<th>T1 Average (sd)</th>
<th>T2 Average (sd)</th>
<th>T3 Average (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-tool + (N=10)</td>
<td>3.48 (.52)</td>
<td>4.02 (.33)</td>
<td>4.71 (.36)</td>
</tr>
<tr>
<td>Q-tool – (N=10)</td>
<td>3.40 (.59)</td>
<td>3.98 (.48)</td>
<td>4.39 (.40)</td>
</tr>
</tbody>
</table>

It was assumed that shared understanding increased over time. A Friedman test, this is the nonparametric equivalent of a one-sample repeated measures design, was used to determine whether shared understanding increased significantly. Shared understanding increased significantly across the 20 teams ($\chi^2 = 38.638$, df = 3, $p < .001$). When looking at this increase across teams without a Q-tool, it was found that shared understanding significantly increased ($\chi^2 = 16.212$, df = 3, $p = .001$). Teams working with a Q-tool also had a significant increase in their perception of shared understanding ($\chi^2 = 23.520$, df = 3, $p < .001$).

A Mann-Whitney test was used to gain insight into the effect of the Q-tool. It showed that regarding the level of shared understanding the Mann-Whitney test obtained no significant differences between experimental conditions ($Z < -.113$, $p > .10$).

To put it differently, the level of shared understanding at Tn is not significantly higher in teams with a Q-tool than in team without a Q-tool. In order to correct for differences at the start of the experiment (T0), also a Mann-Whitney test on the increase of shared understanding ($T_{n+1} - T_0$) was performed, which showed no significant differences between experimental conditions either ($Z < -.076$, $p > .10$).

Another hypothesis was that the extent to which teams agree on the level of shared understanding increases over time; in other words, the standard deviation decreases from T0 to T1 (if team members all indicate the same score on their perception of shared understanding at a certain moment, the standard deviation is 0).
A Friedman test indicated that standard deviations of shared understanding did not change significantly across all the 20 teams ($\chi^2 = 2.638, df = 3, p = .451$), across the teams with a Q-tool ($\chi^2 = .818, df = 3, p = .845$) as well as across the teams without a Q-tool ($\chi^2 = 5.880, df = 3, p = .118$).

### 6.2.3 Perception of shared understanding of final design

The perception of shared understanding of the final design was measured using participants’ descriptions by means of both expert rating and self-scores. Table 6-9 shows how the several measures of the perceived shared understanding of the final design correlated.

<table>
<thead>
<tr>
<th></th>
<th>Your description</th>
<th>Description expert 1</th>
<th>Description expert 2</th>
<th>Your idea</th>
<th>Explanation other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.038</td>
<td>.069</td>
<td>.394</td>
<td>.085</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Rater 1</td>
<td>Pearson Correlation</td>
<td>.467*</td>
<td>1</td>
<td>.737**</td>
<td>.277</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.038</td>
<td>.000</td>
<td>.237</td>
<td>.050</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Rater 2</td>
<td>Pearson Correlation</td>
<td>.414</td>
<td>.737**</td>
<td>1</td>
<td>.090</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.069</td>
<td>.000</td>
<td>.706</td>
<td>.139</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Your idea</td>
<td>Pearson Correlation</td>
<td>202</td>
<td>.277</td>
<td>.090</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.394</td>
<td>.237</td>
<td>.706</td>
<td>.081</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Explanation other</td>
<td>Pearson Correlation</td>
<td>395</td>
<td>.443</td>
<td>.343</td>
<td>.399</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.085</td>
<td>.050</td>
<td>.139</td>
<td>.081</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

* Correlation is significant at the .05 level (2-tailed)

** Correlation is significant at the .01 level (2-tailed)

Two experts independently rated all the individual descriptions. The correlation of the experts’ scores on the description was .737 ($p < .001$), which implies that their ratings corresponded substantially.

Also scores of the description by expert 1 and the self-scores on the description correlated significantly ($r = .467, p = .038$). Apart from that, the description by expert 2 and the self-scores on the description did not correlate significantly ($r = .414, p = .069$).
Table 6-9 indicates that the three measures with respect to the description correlated more with each other than with the other outcome measures (‘idea’ and ‘explanation other’); these significant correlations between the description by expert 1 and expert 2 and between the description by expert 1 and your description, and the lack of significant correlations are in keeping with the objective of the measurement. Moreover, it is an indication that assessing different concepts of the perception of shared understanding of the final design was successful.

Average scores either negative (1, 2, or 3) or positive (4, 5, or 6) are displayed in Table 6-10 (1 = not at all, 6 = completely).

<table>
<thead>
<tr>
<th></th>
<th>Description (Expert 1)</th>
<th>Description (Expert 2)</th>
<th>Description (self-score)</th>
<th>Idea (self-score)</th>
<th>Explanation (other)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-tool +</td>
<td>4.05 (.103)</td>
<td>3.84 (.85)</td>
<td>4.47 (1.14)</td>
<td>4.97 (.92)</td>
<td>5.30</td>
</tr>
<tr>
<td>Q-tool –</td>
<td>4.68 (.77)</td>
<td>4.50 (.70)</td>
<td>4.71 (1.08)</td>
<td>4.92 (.97)</td>
<td>5.50</td>
</tr>
</tbody>
</table>

Almost all scores were higher than 4, except the average of the scores of the teams with a Q-tool given by expert 2. Participants were asked to indicate whether the description corresponded with their idea of the final design. These ‘idea’ scores show that teams with a Q-tool had a negligibly higher perceived shared understanding than teams without. A Mann-Whitney test on the measures of shared understanding of the final design showed no significant differences between experimental conditions for your description, description expert 1, your idea, and explanation other (Z < -.303, p > .10).

Only the description by expert 2 appeared significantly different between experimental conditions (Z < -2.121, p = .034). This difference was not in keeping with the expectation that shared understanding would be higher in teams with a Q-tool.

### 6.2.4 Quality of final design

Two experts on portal designs judged the final designs (Table 6-11). A Mann-Whitney test was performed to identify differences between experimental conditions in the quality of the final portal design.

Teams with and without a Q-tool did not come up with final designs that had significantly different quality (Z < -.303, p = .76). Thus, how to interpret the quality of the portal and how these product measurements relate with assessments of shared understanding are not straightforward.
Table 6-11

| Quality of final designs of teams with (Q+) and without (Q-) the Q-tool (portal designs ranked on the number of points (+/-) given by two experts on portal design, and categorised on high, medium, and low quality) |
|-----------------|-----------------|-----------------|
| High quality (N=6) | Medium quality (N=7) | Low quality (N=7) |
| 10 Q+ | 4 Q- | -1 Q+ |
| 9 Q- | 4 Q- | -3 Q+ |
| 7 Q+ | 3.5 Q- | -3 Q+ |
| 7 Q- | 3.5 Q+ | -4 Q- |
| 7 Q- | 3 Q+ | -5 Q- |
| 6 Q+ | 0 Q- | -12 Q- |
| 0 Q+ | -16 Q- |

*No design available.

6.2.5 Team communication process

Results from the video analyses Table 6-12 show a considerable number of content proposals in all teams, and compared to that few process proposals. It seemed that communication was focused on the content, and apparently involved many answers. In relation to the number of content proposals, fewer questions were raised. High scores on ‘confirm’ seem to indicate that team members did listen to each other. With respect to the average frequencies on reflection, it was striking that little reflective activity took place, and that teams without a Q-tool appeared to reflect a little more (approximately 2 instances over a period of one and a half hours).

Table 6-12

<table>
<thead>
<tr>
<th>New Question</th>
<th>More questions</th>
<th>Content proposal</th>
<th>Process proposal</th>
<th>(Dis) confirm</th>
<th>Feedback</th>
<th>Reflection</th>
<th>Impasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-tool +</td>
<td>65.60 (14.26)</td>
<td>30.30 (9.63)</td>
<td>106.50 (32.24)</td>
<td>28.10 (12.52)</td>
<td>206.20 (64.05)</td>
<td>81.00 (20.29)</td>
<td>3.60 (.67)</td>
</tr>
<tr>
<td>Q-tool –</td>
<td>78.70 (13.84)</td>
<td>36.20 (10.82)</td>
<td>119.80 (22.67)</td>
<td>31.70 (5.27)</td>
<td>194.30 (64.44)</td>
<td>100.50 (45.10)</td>
<td>5.80 (.70)</td>
</tr>
</tbody>
</table>

Table 6-13 shows that the amount of subteam communication was more or less the same among teams. Another observation was that no collaborative reflection took place. Teams with Q-tool scarcely discussed irrelevant issues. Finally, Q-tool teams produced more tech talk. High standard deviations pointed out the differences among the teams. This may be one of the reasons why the Mann-Whitney test did not obtain significant differences (Z < 0, p > .10) between experimental conditions.

Table 6-13

<table>
<thead>
<tr>
<th>Subteam communication</th>
<th>Collaborative reflection</th>
<th>Off-topic communication</th>
<th>Tech talk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-tool + 12:46 (14:15)</td>
<td>00:00 (00:00)</td>
<td>00:22 (00:29)</td>
<td>02:39 (05:07)</td>
</tr>
<tr>
<td>Q-tool – 07:15 (09:32)</td>
<td>00:00 (00:00)</td>
<td>03:40 (04:37)</td>
<td>01:09 (00:55)</td>
</tr>
</tbody>
</table>
### 6.3 Results – the role of the facilitator

In addition to the role of the Q-tool, the role of a facilitator was studied. To research this role, a post-hoc distinction of teams with and without a facilitator was made. A team was labelled ‘with facilitator’ if someone in that team appeared to take more than 40% of the initiatives of the whole team. At the same time, it was determined whether someone in a team accounted for more than 50% of the content-related or process-related initiatives, and whether this percentage corresponded with at least 75 utterances. Using this classification only 6 teams were labelled with facilitator, and 14 teams were labelled without facilitator. Below the results of the effect of the facilitator are presented. It should be taken into account that 6 teams that were identified with a facilitator is a limited number of teams.

#### 6.3.1 Perception of shared understanding

The figures in Table 6-14 show an increase from T₀ to T₃; as expected the perception of shared understanding increased. In accordance with the hypothesis it was found that teams with a facilitator had higher scores than teams without. Only the scores on T₀ showed that teams without a facilitator scored higher, however, these scores were indicated before the start of the collaborative task.

<table>
<thead>
<tr>
<th></th>
<th>T₀ Average (sd)</th>
<th>T₁ Average (sd)</th>
<th>T₂ Average (sd)</th>
<th>T₃ Average (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitator + (N=6)</td>
<td>3.23 (.72)</td>
<td>4.20 (.39)</td>
<td>4.31 (.39)</td>
<td>4.80 (.35)</td>
</tr>
<tr>
<td>Facilitator – (N=14)</td>
<td>3.53 (.48)</td>
<td>3.92 (.42)</td>
<td>4.17 (.39)</td>
<td>4.44 (.39)</td>
</tr>
</tbody>
</table>

It was assumed shared understanding would increase over time. It was concluded in the previous section that shared understanding significantly increased across the 20 teams ($\chi^2 = 38.638$, df = 3, $p < .001$). When looking at this increase across teams with a facilitator, it was found that shared understanding increased significantly ($\chi^2 = 16.4$, df = 3, $p = .001$). Teams working without a facilitator also had significant increase in shared understanding ($\chi^2 = 23.288$, df = 3, $p < .001$). A Mann-Whitney test on the level of shared understanding obtained no significant differences between the teams with and without a facilitator ($Z = -.536$, $p > .10$).

In order to correct for differences at the start of the experiment (T₀), another Mann-Whitney test was performed on the increase of shared understanding, which showed no significant differences between teams with and without a facilitator ($Z = -.619$, $p > .10$).
Another hypothesis was that the extent to which teams agree on their level of shared understanding increases over time; in other words, the standard deviation decreases from $T_0$ to $T_3$ (if team members all indicate the same score on their perception of shared understanding at a certain moment, the standard deviation is zero). A Friedman test indicated that standard deviations of shared understanding did not change significantly across teams without a facilitator ($\chi^2 = 1.791, df = 3, p = .617$) and across teams with a facilitator ($\chi^2 = 1.4, df = 3, p = .706$).

### 6.3.2 Perception of shared understanding of final design

Table 6-15 shows that all averages scores were positive. Moreover, the average scores of teams with a facilitator are higher than the average scores of those teams without a facilitator, except for the scores given by expert 1.

However, a Mann-Whitney test on the measures of shared understanding of the final design showed no significant differences between teams with and without a facilitator ($Z < -.083, p > .1$).

### 6.3.3 Quality of final design

Two experts on portal designs judged the final designs. The results displayed in Table 6-16 indicate that teams with a facilitator did not produce high quality portals, which does not confirm the hypotheses. A Mann-Whitney test showed no significant differences in portal quality between the teams with and without a facilitator ($Z < -1.53, p = .126$).
6.3.4 Team communication process

Table 6-17 illustrates, that teams with a facilitator proposed more and give more feedback than teams without a facilitator, which is in keeping with the hypotheses. It should be taken into account that a team was labelled ‘with a facilitator’ if one of the team members raised many questions, and made many proposals. Also as expected teams without a facilitator communicated more in subteams, and talked more about non-related technological issues. Teams without a facilitator also reflected more; this was contrary to the expectations. High standard deviations pointed out the differences among the teams. This may be one of the reasons why the Mann-Whitney test did not obtain significant differences (Z < 0, p > .10) between the teams with and without a facilitator. Finding no significant differences also seems to indicate that team members did not automatically become more active in proposing and questioning, when one member of their team was identified as a facilitator.

<table>
<thead>
<tr>
<th></th>
<th>New Question</th>
<th>More questions</th>
<th>Content proposal</th>
<th>Process proposal</th>
<th>(Dis) confirm</th>
<th>Feedback</th>
<th>Reflection</th>
<th>Impasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitator +</td>
<td>71.83</td>
<td>30.17</td>
<td>118.67</td>
<td>33.67</td>
<td>197.83</td>
<td>97.33</td>
<td>3.83</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td>(N=6)</td>
<td>(13.48)</td>
<td>(29.31)</td>
<td>(10.60)</td>
<td>(25.07)</td>
<td>(55.91)</td>
<td>(3.06)</td>
<td>(.84)</td>
</tr>
<tr>
<td>Facilitator –</td>
<td>72.29</td>
<td>34.57</td>
<td>110.79</td>
<td>28.29</td>
<td>201.29</td>
<td>87.93</td>
<td>5.07</td>
<td>.29</td>
</tr>
</tbody>
</table>

Subteam communication

<table>
<thead>
<tr>
<th></th>
<th>Subteam communication</th>
<th>Collaborative reflection</th>
<th>Off-topic communication</th>
<th>Tech talk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitator +</td>
<td>06:58</td>
<td>00:00</td>
<td>01:25</td>
<td>00:58</td>
</tr>
<tr>
<td></td>
<td>(N=6)</td>
<td>(00:00)</td>
<td>(01:54)</td>
<td>(01:36)</td>
</tr>
<tr>
<td>Facilitator –</td>
<td>11:18</td>
<td>00:00</td>
<td>02:16</td>
<td>02:18</td>
</tr>
<tr>
<td></td>
<td>(N=14)</td>
<td>(00:00)</td>
<td>(04:11)</td>
<td>(04:15)</td>
</tr>
</tbody>
</table>

6.4 Results – the combined role of the Q-tool and the facilitator

In this section insights from the role of the Q-tool and the facilitator are combined. Table 6-19 shows the number of teams that belonged to one of the four resulting groups:
- AV: teams without the Q-tool and without a facilitator;
- AVQ: teams with the Q-tool and without a facilitator;
- AVF: teams with a facilitator;
- AVQF: teams with the Q-tool and a facilitator.
Only two groups appeared to have the Q-tool as well as a facilitator.

<table>
<thead>
<tr>
<th>Q-tool</th>
<th>Facilitator</th>
<th>-</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV* (N = 6)</td>
<td>Facilitator – (N = 14)</td>
<td>AVQ*** (N = 8)</td>
<td>Facilitator + (N = 6)</td>
</tr>
<tr>
<td>AVF** (N = 4)</td>
<td>Q-tool – (N = 10)</td>
<td>AVQF**** (N = 2)</td>
<td>Q-tool + (N = 10)</td>
</tr>
<tr>
<td>Q-tool – (N = 10)</td>
<td>Total (N = 20)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*AV: teams without Q-tool and a facilitator ** AVF: teams with a facilitator *** AVQ: teams with a Q-tool **** AVQF: teams with a Q-tool and a facilitator

### 6.4.1 Use of Q-tool

Table 6-20 shows how often the Q-tool was used by the teams. In AVQ teams (N = 8) the average use of the tool was 28.75 times, in AVQF teams (N = 2) 39.5 times. High standard deviations pointed out the differences in Q-tool usage across teams.

<table>
<thead>
<tr>
<th>Average</th>
<th>sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVQ (N=8)</td>
<td>28.75</td>
</tr>
<tr>
<td>AVQF (N=2)</td>
<td>39.50</td>
</tr>
</tbody>
</table>

### 6.4.2 Perception of shared understanding

Comparable to the results on the perception of shared understanding in the previous sections, the figures in Table 6-21 increase from T\_0 to T\_3, as expected the perception of shared understanding increased. Only the teams with a facilitator (AVF) seemed to have a slight dip on T\_2. In accordance with the hypothesis teams with the Q-tool had a better perception of shared understanding than teams without, and that teams with a facilitator had higher scores than teams without. Teams with both a Q-tool and a facilitator also had better perceived shared understanding than teams without. Averages in Table 6-21 do not show clear differences between teams with only a facilitator (AVF) and teams with only the Q-tool (AVQ).

<table>
<thead>
<tr>
<th>T_0</th>
<th>T_1</th>
<th>T_2</th>
<th>T_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (sd)</td>
<td>Average (sd)</td>
<td>Average (sd)</td>
<td>Average (sd)</td>
</tr>
<tr>
<td>AVQF (N=2)</td>
<td>3.17 (.65)</td>
<td>4.46 (.49)</td>
<td>4.83 (.41)</td>
</tr>
<tr>
<td>AVF (N=4)</td>
<td>3.26 (.36)</td>
<td>4.07 (.36)</td>
<td>4.04 (.35)</td>
</tr>
<tr>
<td>AVQ (N=8)</td>
<td>3.56 (.50)</td>
<td>3.91 (.47)</td>
<td>4.25 (.45)</td>
</tr>
<tr>
<td>AV (N=6)</td>
<td>3.49 (1.15)</td>
<td>3.92 (.23)</td>
<td>4.05 (.26)</td>
</tr>
</tbody>
</table>
Both across teams without a facilitator ($Z < -0.065, p > .10$) and across teams with a facilitator ($Z < 0, p > .10$) a Mann-Whitney test on the level of shared understanding showed no significant differences between experimental conditions.

### 6.4.3 Perception of shared understanding of final design

Table 6-22 displays average results either negative (1, 2, or 3) or positive (4, 5, or 6). Almost all scores are higher than 4, except for the scores rated by the two experts who assigned low scores to the AVQF teams (2.83 and 3.03, respectively). The self-score on the description of AVQF teams was also low (3.83). This was not in keeping with the expectations.

The students were asked to indicate whether the description corresponded with their idea of the final design. These ‘idea’ scores indicate that teams with a Q-tool had higher perceived shared understanding than teams without, and that teams with a facilitator scored higher than teams without.

In addition, AVQF teams had higher scores than AVF teams and AVQ teams, respectively. AV teams had the lowest scores. These scores are in keeping with expectations.

<table>
<thead>
<tr>
<th></th>
<th>Description (Expert 1)</th>
<th>Description (Expert 2)</th>
<th>Description (self-score)</th>
<th>Idea (self-score)</th>
<th>Explanation (other)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVQF (N=2)</td>
<td>2.83 (.73)</td>
<td>3.03 (.05)</td>
<td>3.83 (.156)</td>
<td>5.17 (.115)</td>
<td>5.50</td>
</tr>
<tr>
<td>AVF (N=4)</td>
<td>4.96 (.54)</td>
<td>4.81 (.50)</td>
<td>4.98 (.87)</td>
<td>5.13 (.87)</td>
<td>5.75</td>
</tr>
<tr>
<td>AVQ (N=8)</td>
<td>4.35 (.86)</td>
<td>4.04 (.80)</td>
<td>4.62 (1.04)</td>
<td>4.92 (.86)</td>
<td>5.25</td>
</tr>
<tr>
<td>AV (N=6)</td>
<td>4.50 (.93)</td>
<td>4.29 (.83)</td>
<td>4.54 (1.17)</td>
<td>4.78 (1.03)</td>
<td>5.33</td>
</tr>
</tbody>
</table>

Although these figures pointed out in the expected direction, a Mann-Whitney test across teams without a facilitator showed no significant differences between the experimental conditions ($Z < -0.129, p > .10$).

Across teams with a facilitator, a Mann-Whitney test on the measures of shared understanding of the final design showed no significant differences between experimental conditions for your description (self-score), your idea, and explanation other ($Z < 0, p > .10$); description expert 1 and description expert 2 appeared significantly different between experimental conditions at the .10 level ($Z < -1.669, p = .095$) respectively ($Z < -1.852, p = .064$). This significant difference was not in keeping with the expectation that shared understanding would be higher in teams with both a Q-tool and a facilitator.
6.4.4 Quality of final design

Results of the judgments of the two experts on portal designs were displayed in Table 6-23; teams with both a facilitator and the Q-tool came up with low-quality portals, and the portals of teams without a facilitator were the best, which does not confirm the hypotheses. However, AV and AVQ teams designed portals that were categorised in all the three categories. A Mann-Whitney test showed no significant differences in the quality of the final portal design between teams with a Q-tool and teams without a Q-tool both across teams with (Z < -1.389, p = .165) and across teams without a facilitator (Z < -.130, p = .897). Thus how to interpret the quality of the portal and how these product measurements relate with the assessments on shared understanding are not straightforward.

<table>
<thead>
<tr>
<th>Team</th>
<th>High quality (N=6)</th>
<th>Medium quality (N=7)</th>
<th>Low quality (N=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV02</td>
<td>10</td>
<td>AV4</td>
<td>-1 AVQF1</td>
</tr>
<tr>
<td>AV05</td>
<td>9</td>
<td>AVF1</td>
<td>-3 AVQ7</td>
</tr>
<tr>
<td>AV06</td>
<td>7</td>
<td>AVF3</td>
<td>-3 AVQ8</td>
</tr>
<tr>
<td>AV03</td>
<td>7</td>
<td>AVQ3</td>
<td>-4 AV6</td>
</tr>
<tr>
<td>AV05</td>
<td>7</td>
<td>AVQ5</td>
<td>-5 AVQ4</td>
</tr>
<tr>
<td>AVQ1</td>
<td>6</td>
<td>AVF2</td>
<td>-12 AV1</td>
</tr>
<tr>
<td>AVQ1</td>
<td>0</td>
<td>AVQ1</td>
<td>-16 AVQF2*</td>
</tr>
</tbody>
</table>

* No design available

6.4.5 Team communication process

Results from the video analyses (Table 6-24) identified many content proposals in all teams, and few process proposals in comparison. It seemed that communication was focused on the content, and apparently involved many answers. In relation to the number of content proposals, fewer questions were raised. High scores on ‘confirm’ seemed to indicate that team member did listen to each other, although they seemed to reflect little according to the average frequencies.

Regarding reflection it was striking that teams with neither the tool nor a facilitator reflected the most. The averages indicate that there were few impasses in all teams; however, in the AVQF teams no impasse took place.
Table 6-25 shows that the amount of subteam communication was more or less the same among all teams. Interestingly, teams with facilitator and without a Q-tool communicated less in subteams. Another observation was that no collaborative reflection took place. Teams with Q-tool and AVQF teams scarcely talked about irrelevant issues. Finally, AVQF and AVQ teams produced more tech talk. High standard deviations pointed out the differences among the teams.

A Mann-Whitney test across teams without a facilitator showed significant differences on new question ($Z < -1.807$, $p = .071$) and more questions on the same topic ($Z < -1.682$, $p = .093$) between teams with and without a Q-tool. Thus teams with neither a facilitator nor a Q-tool asked significantly more questions.

Across teams with a facilitator a Mann-Whitney test showed significant differences with respect to confirm ($Z < -1.852$, $p = .064$) and reflection ($Z < -1.879$, $p = .060$) between teams with and without a Q-tool.

In other words, teams with a facilitator that used the Q-tool confirmed more than teams with a facilitator that did not use the tool. Teams with a facilitator that did not use the Q-tool reflected significantly more than teams with both a tool and a facilitator. The latter was not in keeping with
the expectations. With respect to the ‘period coded’ no significant differences were found between the experimental conditions, neither across teams with a facilitator \((Z < 0, p > .10)\) nor across teams without a facilitator \((Z < 0, p > .10)\).

### 6.5 Results – the influence of background and quality of communication

As described in Chapter 2 the background of team members plays a central role in the process of reaching shared understanding. While describing the results in the previous paragraphs, little use was made of the data gathered by means of the pre-questionnaire. The primary objective of this questionnaire was to check for differences in background and team composition. No significant differences were found between teams with and without Q-tool regarding background.

In this section, therefore, some additional analyses are presented, namely regarding experience with project work and with portal design, whether the team members knew each other before, and whether they were native speakers or had to communicate in a second language. Another point of interest is more-specific insight into the quality of the team communication. Although the video-based communication was analysed in detail, using the coding scheme it was not possible to capture all aspects of the quality of the team communication. For example, if teams with a Q-tool raised fewer questions, does this imply that they do not question each other, or does it imply that they raised better and more thoughtful questions that needed no follow-up questions? In the previous study, it was distinguished between content-related, process-related, social, and, technology-related interaction. Moreover, it was assumed that interaction should not be imbalanced. Therefore, additionally a closer look was taken at the start of the videos. It was observed how the groups started the conversation, and labelled whether their first remark was on the content (such as, what is a portal?), the process, or on their social relation (such as, how are you?). Moreover, by observing their first ten minutes, it was labelled whether teams focused on content, relation, or process, or had balanced communication. Finally, teams were classified on how they used their task description; namely, literally, roughly, or not at all.
Table 6-26 shows these additional variables that might influence the differences in team performances, as well as how many teams belonged to that variable.

<table>
<thead>
<tr>
<th>Background</th>
<th>Project experience</th>
<th>Portal experience</th>
<th>Know each other</th>
<th>Native speakers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>A bit</td>
<td>No</td>
<td>N=18</td>
</tr>
<tr>
<td></td>
<td>N=8</td>
<td>N=7</td>
<td>N=5</td>
<td>N=18</td>
</tr>
<tr>
<td></td>
<td>A bit</td>
<td>No</td>
<td>Focus first ten minutes</td>
<td>N=10</td>
</tr>
<tr>
<td></td>
<td>N=7</td>
<td>N=13</td>
<td>Content</td>
<td>Balance</td>
</tr>
</tbody>
</table>

Analyses regarding the influence of background showed the following. Some significant differences were found regarding portal experience, know each other, and native speaker. A Mann-Whitney test showed that teams with no portal experiences raised significantly more questions on the same topic than teams with a bit experience on portal design ($Z < -2.347, p = .019$). Mann-Whitney tests also showed significant differences for content proposal ($Z < -1.766, p = .077$) and tech talk ($Z < -1.764, p = .078$) between teams that did not know each other and teams that knew each other beforehand at the .10 level; team members that knew each other proposed more than team members that did not know each other beforehand. Teams that did not know each other produced more tech talk.

Mann-Whitney tests obtained significant differences on new questions ($Z < -2.797, p = .005$), more questions ($Z < -2.059, p = .039$), content proposals ($Z < -1.705, p = .088$), tech talk ($Z < -3.187, p = .001$), off-topic communication ($Z < -2.454, p = .014$), and as well as on portal quality ($Z < -2.014, p = .044$) between teams with native speakers and non-native speakers. In other words, native speakers raised more new questions and more follow-up questions, proposed more, communicated more on non-related issues, and produced more tech talk. Finally, native speakers designed better portals. A Kruskal-Wallis test on project experience showed no significant differences.
With respect to the focus of the communication during the first ten minutes, Mann-Whitney tests showed significant differences for the perception of shared understanding at T₁ (Z < -1.816, p = .069), feedback (Z < -1.777, p = .076), and for subteam communication as well (Z < -1.676, p = .094) at the .10 level, and for the correspondence of your idea (Z < -1.971, p = .049) at the .05 level. Teams that focused on the content had a higher perception of shared understanding after a half hour of collaboration, and perceived a higher ‘idea’ understanding of their final design than teams that had more balanced communication. However, these ‘balanced’ teams gave more feedback and communicated more in their subgroups than content-focused teams.

6.6 Conclusions and discussion

The current study gained insight into aspects of collaborative learning and shared understanding in video-mediated teams by concentrating on their questioning behaviour. It was hypothesised that teams with the Q-tool would learn and understand each other better than teams without the Q-tool, and that teams with a spontaneous facilitator would perform better than teams without a facilitator. Moreover, teams that had both a Q-tool and a spontaneous facilitator would perform best. Between teams with and without the Q-tool as well as between teams with and without a facilitator no significant differences were found. Although not significantly different the results of the assessment of perceived shared understanding are according the expectations. Furthermore, as expected the perception of shared understanding increased significantly across all teams during the teamwork. At the same time little (collaborative) reflection took place. One possible explanation is that such behaviour simply did not occur. In that case it is a challenge to investigate which incentives can stimulate a team’s reflective behaviour. Another explanation is that the coding of (collaborative) reflection was too rigid.

A limitation of the experimental set-up was that the teamwork only lasted one and a half hours, and that no attention was devoted to team development and diffusion of technology use. Rice, Majchrzak, King, Ba, and Malhotra (2000) performed a longitudinal study of a creative design team for 10 months. They concluded that it was clear that a fair amount of mutual expectations and shared understanding had to be developed before the team could move into a period of a focused design process. This may also be an argument for the finding that it proved to be difficult to assess an improvement in the final result when focusing on team processes. Results of the pre-questionnaire extended with information from informal
observations illustrated that all teams that came up with high quality portals had done project work together before (thus had *project experience* in combination with *knew each other*). It can be assumed that they had their mutual expectations beforehand. As those differences regarding either project experience or knew each other appeared not significant, new questions can be raised regarding studying the combined effects of ‘knowing each other’, ‘working together’, and ‘project experience’ in more detail. Another explanation of the high assessments on shared understanding is that the participants were a bit too positive about their perceived shared understanding. Interestingly, teams’ self-scores were more positive than those of external experts. This may relate to little reflective behaviour of the students in general. Chapter 7 comes back to these results and enters into details regarding reflective behaviour.
Overview and reflection

This final chapter starts with an overview of the two studies conducted on collaborative learning and shared understanding. In this overview the research questions are answered. The two empirical studies are then compared and reflected upon. The second section elaborates on the assessment of collaborative learning and shared understanding. The third section concentrates on the designing of support for such processes. Next the conceptual framework is revisited. Taking all reflections into account, the entire research is seen in the context of scientific knowledge development and society. Dilemmas found are summarised, and interesting future issues are described. The work concludes by discussing how the perceived distance between distributed team members, which seemed to hamper reflective activity in virtual teamwork, can be covered.

7.1 Two studies on collaborative learning and shared understanding

This study focused on virtual ad hoc teams that integrate learning and working. Ad hoc teams seem to be one way of dealing with the complexity of the knowledge-intensive society. In order to let ad hoc teams learn and work together, group members require effective communication and shared understanding amongst them. The combination of distance and a strong reliance on technology makes understanding between virtual team members less than obvious. The tango metaphor was used to understand distributed design teams that had to rely on technology for their collaboration. This work aimed at providing proper support that enhanced the potential of distributed teams. In this, the underlying assumption was that proper support invites team members to learn and work together – similar to the right tango music that evokes the right mood and tempo for a certain moment while dancing a tango.
The research concentrated on collaborative learning and shared understanding in video-based communication, and how this could be supported. The following research questions were studied:

- How is shared understanding as an outcome of collaborative learning constructed?
- How can collaborative learning and shared understanding be assessed?
- How can the process of collaborative learning and reaching shared understanding in ad hoc design teams, which work on collaborative design tasks using video-based communication, be supported?

The research approach and the answers to these research questions are summarised below.

### 7.1.1 Conceptual framework

Collaborative learning involves social as well as cognitive processes. Aspects of both social and cognitive theories are therefore included. The main concepts used for studying collaborative learning and shared understanding are: questioning, conceptual learning, feedback, and expression of affect. Figure 7-1 presents the resulting conceptual framework on collaborative learning as introduced in Chapter 2.

These conceptual ideas were used as a starting point to search for the dynamics of collaborative learning and the process of reaching understanding. They also formed a basis for developing instruments for assessing collaborative learning and shared understanding. Two empirical studies were conducted to acquire insight into collaborative learning and shared understanding in distributed ad hoc teams.
7.1.2 Exploratory study

The first study – described in Chapter 3 – was an exploratory study to observe a distributed ad hoc team for four months, to see whether the developed instruments were applicable and useful. The study was also intended to find out whether the conceptual framework made sense. By studying video-based communication processes in detail, insight was gained into collaborative learning and shared understanding. It was found that the average perceived shared understanding of the team members increased over time. There was also a preliminary indication that questioning, some types of conceptual learning, feedback, and the expression of affect have a positive impact on the process of reaching shared understanding. However, questions were scarcely raised or answered. What is more, very little reflective behaviour was found either in the learning modes, the feedback, or the expression of affect of the team members.

It should be noted that this evidence was based on only one study with one team (N = 1). However, the main intent was to tackle the problem of better comprehending collaborative learning and shared understanding by assessing collaborative learning and shared understanding in an empirical study. Summarising, in the first study suboptimal question-answer and reflective behaviour was found. There also seemed to be some evidence that the two are related.

7.1.3 Conceptual framework revised

Thus the results of the first study showed suboptimal question-answer and reflective behaviour. Consequently, in Chapter 4 more attention was devoted to higher order reflective behaviour and to questioning behaviour in particular. The conceptual framework was adjusted: the concepts questioning and feedback acquired a central position (Figure 7-2).
The revised framework aimed at acquiring more insight into the process of questioning and answering, because it was assumed that having a better grip on this process could yield more reflective activity. In keeping with that assumption, the changing role of support was emphasised. In particular, the need to evoke reflective behaviour was elaborated by supporting the video-mediated design team members in posing questions and formulating feedback. A tool was developed for this ‘question-answer’ behaviour. Section 7.3 reflects upon the design process of this Q-tool.

7.1.4 Experimental study

In a quasi-experimental study (Chapter 6) two things were tested. The first question was whether the intervention (the Q-tool) strong enough to support questioning behaviour; the second was whether this led to higher order reflective behaviour, and consequently to improved collaborative learning and shared understanding. The experimental setting was made as realistic as possible: students were asked to work on a complex design task, in two subteams, using collaborative technology. The ‘unrealistic’ part was that the teams were not really geographically dispersed, but were working in two different rooms in the same building. The experimental condition was the use of the Q-tool. It was hypothesised that teams that worked together with the Q-tool developed better questioning and answer behaviour, and as a result reflected more, learned better, and had a higher shared understanding than teams that worked together without the Q-tool. This hypothesis was based on the assumption that the Q-tool supported the question-answer process in the teams, and that therefore teams with a Q-tool had optimal questioning and answering patterns, and that this would result in more reflection. Consequently, teams with a Q-tool learned and understood more. Other assumptions included that shared understanding increased over time, and that increased shared understanding led to better team performance and product quality.

This study offered insight into learning and understanding in video-mediated teams by focusing on their questioning behaviour. However, results of the assessment of the perception of shared understanding did not confirm the hypotheses. Although not significantly different, teams with a Q-tool indicated a higher perceived shared understanding than teams without a Q-tool. In the teams with the questioning support, no better question-answer behaviour or more reflective behaviour was found. Moreover, the quality of the resulting designs was not rated differently for the two groups.
7.1.5 Two studies revisited

In both the exploratory study and the experimental study, the perceived shared understanding increased over time. However, in both studies suboptimal questioning behaviour and limited reflective activity were observed. In the following sections, the main results of the two empirical studies will be compared and reflected upon, respectively.

Similarities and differences in the studies

In the comparison of the two studies, similarities as well as differences were found. Main difference in the research designs was the exploratory versus experimental focus, and consequently the broader research questions used to explore versus the a priori defined hypotheses that were tested. Except for these differences, the methods used in the studies were comparable. In both the exploratory study and the experimental setting, distributed design teams worked on a complex collaborative design task. The participants in both studies were students who communicated via videoconferencing, and data were collected using multiple sources.

However, the collaborative design tasks in the two studies were different. In the exploratory study, students worked on a prototype design for the automotive industry, while the students in the experimental study needed to come up with a design for an added value service for a university portal. There were also differences with respect to the time in which the students had to complete their collaborative task. In the first study students worked together for four months; in the second study students collaborated for 90 minutes. Another difference was that in the exploratory study team members could choose from a larger set of collaborative technology, which also included asynchronous communication tools. In the experimental study 10 of the 20 teams not only had videoconferencing but also a Q-tool that they could use.

All teams in the exploratory study were international, in the sense that both subteams were from two different countries. Consequently, one of the subteams was not able to speak their native language. In the experimental study the teams were not really dispersed, but distributed between two rooms in the same building. Most teams consisted of two Dutch subteams, and therefore involved only native speakers. Some international teams participated in the experimental study, although all participants in these teams were non-native English speakers. Moreover, these non-native speakers took part in an international university program, and were accustomed to communicating with other international students in their second language.
Looking back on the research designs

With regard to the participants in the empirical studies, one could question whether students working on real-life tasks can be seen as experts. Contrary to experts, it can be assumed that students are more often accustomed to following instructions rather than coming up with their own ideas and being creative. At the same time, it can be expected that students are less experienced than experts in their communication and management skills. Generally, professional behaviour, such as chairing and structuring a meeting, and experience with teamwork are seen as profitable for successful project work. In particular, such experience might be crucial to dealing with the deficits of virtual teams.

Although students are less experienced than experts with reference to the process and relational aspects of virtual team collaboration, when it comes to portal design they might be able to ‘compete’ with content experts. It can be assumed that students — in general — have reached a certain level of experience in portal design which might not apply for other fields of designing, such as designing for industry. In the current curriculum of many studies, Internet skills are often seen as a basic skill. Think, for instance, of the number of courses for which electronic portfolios need to be updated, or exercises that must be submitted through web-based communities. It can be expected that even under unfavourable conditions, a student team will be able to design a portal that meets some basic criteria of portal design. However, the actual collaborative task in the experimental setting was to develop an added value service for a university portal. With hindsight, none of the teams developed an innovative and creative added value concept that satisfied all the defined criteria.

Nearly all the teams were able to come up with a final design, except for one team that did not hand in their design. The best and the weakest portal appeared to differ not so much. Due to the low variance in portal quality, it was a rather difficult exercise to distinguish between the portals.

All portals were ranked by two experts according to eight criteria, and then categorised in portals of high, medium, or low quality. The small differences in the quality of the portals might explain why no significant effects regarding the final portal design were found across teams with and without a Q-tool.

The kind of collaborative task and the available time differed between the two studies; however, task complexity was aimed to be in proportion to the time necessary for task completion. Despite the fact that task complexity and available time seemed to be related, one could question the extent to which these design tasks were authentic in the eyes of students.
the tasks were meant as authentic and ambiguous tasks that require a multidisciplinary approach, as indicated earlier students could be viewed as experts on portal design.

In addition, the short period of time in the experimental study could also have hampered reflective activity. Due to time pressure, students might have focused on task completion rather than on learning collaboratively and reflecting upon innovative portal designs. Consequently, it might be difficult to improve collaborative learning and shared understanding at the same time.

This raises the question of whether an experimental design was the right design for assessing reflective behaviour. Generally, experimental settings are used to control as many variables as possible. Thus a short-term experimental design scarcely leaves room for the increase of sustainable effects on team development. Even if the time of the experiment was extended, the artificial flavour of the experimental set-up affects spontaneous group dynamics. The compulsory conditions of an experimental design in combination with time pressure seem to hamper reflective behaviour.

It can be assumed that a more ethnographic design that gives attention to team development and the dynamics of ad hoc teams would enable a more favourable setting for achieving more positive effects of the Q-tool intervention.

Before elaborating on conceptual issues (Section 7.4), the following two sections reflect upon the assessment of, and the designing for collaborative learning and shared understanding, respectively.

### 7.2 Assessing collaborative learning and shared understanding

In both the exploratory study and the experimental study, the perceived shared understanding increased over time. However, in both studies suboptimal questioning behaviour and limited reflective activity were observed. This section elaborates on the assessment of collaborative learning and shared understanding.

For this purpose, results of the communication process in the two studies are compared.
Table 7-3 shows the main figures regarding the quality of the team communication processes in the exploratory as well as in the experimental studies. All data displayed are averages per 90 minutes. Although no hard proof can be found, these comparisons indicate some differences and similarities.

<table>
<thead>
<tr>
<th></th>
<th>Exploratory study (N = 1)</th>
<th>Experimental study with Q-tool (N = 10)</th>
<th>Experimental study without Q-tool (N = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Questions vs. new and more questions)</td>
<td>130.6</td>
<td>114.9</td>
<td>95.9</td>
</tr>
<tr>
<td><strong>Question – answer pairs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(reactions vs. feedback and confirm)</td>
<td>201.0</td>
<td>294.8</td>
<td>287.2</td>
</tr>
<tr>
<td><strong>Feedback</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(feedback vs. feedback and confirm)</td>
<td>274.9</td>
<td>294.8</td>
<td>287.2</td>
</tr>
<tr>
<td><strong>Reflective behaviour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(reflect, restructuring, and evaluation vs. reflection and feedback)</td>
<td>104.5</td>
<td>106.3</td>
<td>84.6</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(reflect vs. reflection)</td>
<td>11.5</td>
<td>5.8</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Collaborative reflection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(co-construction vs. collaborative reflection)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Impasse</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(impasse vs. impasse)</td>
<td>3.8</td>
<td>.4</td>
<td>.3</td>
</tr>
</tbody>
</table>

With regard to ‘reflection’ and ‘impasse’, there are differences in favour of the exploratory study: more ‘reflection’ and more ‘impasse’ were found. The latter finding needs some explaining because it is ambiguous. In the exploratory study more often than in the experimental study, team members indicated that they ‘did not know how to go any further’; at the same time, by indicating an impasse more often, more moments for reflection were created.

However, the results in Table 7-3 that the questioning and answering process seems to have developed better in the experimental study. ‘Collaborative reflection’ was not found at all in either study. Another remarkable finding is that the least reflective behaviour occurred in the teams with a Q-tool. This is contrary to the expectations.

A final observation is that the precise way of coding the utterances matters: when coded strictly, hardly any reflection took place in either of the two studies (from 3.6 to 11.5 times in 90 minutes). With less stringent coding, the number of utterances related to reflective behaviour was substantial (from 84.6 to 106.3 times in 90 minutes). There were two reasons to adapt the coding scheme between the first and the second study: to simplify the
coding process, and to concentrate on higher order reflective behaviour. For example, facts and remarks that were coded in the first study as assertions or accretion were not taken into account in the experimental study. More specifically, in the second study only ‘feedback to questions’ or ‘short confirms to questions’ that indicated that the question had been understood were coded. In the first study all reactions to questions were coded as ‘question-answer pairs’, as shown in Table 7-3. Taking this adjustment in favour of higher order reflective behaviour into account, not only were more question-answer pairs found in the experimental study, but these pairs could also be viewed as being of a higher quality. Nevertheless, the experimental groups did not show more question-answer pairs than the control groups.

It can be concluded that subtle adaptations in definitions and relevant operationalisation of reflective behaviour can lead to substantial differences in the results of the two studies. It was also difficult to define a relationship between question and answer patterns on the one hand and reflective behaviour on the other. Although the coding scheme was helpful in distinguishing between categories of reflective behaviour, no insight was gained, for example into which questions were of a higher quality or what kind of utterances triggered more reflective behaviour.

An explanation for not finding as much reflective behaviour as expected could be traced to the stringent coding method. It should be taken into account that the use of a manual with detailed instructions reinforces structured coding. This is in keeping with the high scores of the interrater reliability: the equality of coding by two raters. These scores indicate that following the instructions yields almost the same scoring of reflective behaviour. Thus in the first study a reliability score of .839 (Cohen’s kappa) was found, which could be considered ‘almost perfect’.

One may wonder how this work reached such a high reliability score, while subtle adaptations in the scheme already resulted in substantial differences in the results of the two studies. In the first study, all team communication was segmented first and coded afterwards. For this purpose, a coding scheme and an accompanying manual were developed. The coding manual gives detailed instructions on how to distinguish between the many categories in the scheme (see Chapter 3).
Coefficient kappa was used to calculate the interrater reliability. This coefficient is defined as:

\[ \kappa = \frac{(P_o - P_e)}{(1 - P_e)} \]

- \( P_o = \) the number of segments that are coded identically as a percentage of the total segments.
- \( P_e = \) 1 / the number of categories defined in the coding scheme.

The formula for Cohen’s kappa shows that a high interrater reliability can be seen as an artifact of statistics. More categories automatically lead to higher statistical values. In addition, the coding manual involved detailed instructions on how to distinguish between categories. In other words, the strictly defined coding method did not leave room for creative interpretation and therefore, in combination with the detailed scheme, resulted in high agreements on coding results. In keeping with Strijbos and Martens (2003), this indicates that coding a larger number of smaller segments leads to higher reliability scores.

In the first study it was concluded that collaborative reflective behaviour might be more accurately coded across segments. Therefore, the scheme used in the second study did not segment before coding. Furthermore, the second study focused on higher order reflective behaviour while the first study also included more ‘equivocal’ categories, such as assertion, or accretion and tuning. The first study also distinguished between task-related, social, procedural, and technology-related interaction. These ‘equivocal’ categories were less ambiguous and clearer, and were expected to be misinterpreted less often. Consequently, including more equivocal categories in a coding scheme yields higher reliability scores.

Contrary to the first study, the second study concentrated on higher levels of reflective behaviour, and the utterances were not divided into segments. In addition, not all interaction was coded. Because different schemes require different ways of coding, different reliability coefficients were also calculated that suited the measured concepts. While a Cohen’s kappa suits the first scheme because it calculates how many segments were equally coded, the adjusted coding method used in the second study requires a different reliability coefficient. In the second study the question was raised of whether different raters will identify the same types of higher order reflective behaviour (and the same number of these types) within a certain period. Pearson’s correlation coefficient was used to calculate whether the two variables (the scores of rater 1 and those of rater 2) were related.
More specifically, the extent to which the number of questions identified by rater 1 correlated with the number of questions identified by rater 2 was calculated, for example. The resulting Pearson scores correlated substantially.

It could be assumed that the use of less-stringent coding schemes might lead to more creative interpretations of coding of reflective behaviour. Interrater agreements would therefore be expected to be less reliable. This also explains why in the experimental study the interrater agreement of the two experts\(^6\) – with respect to judging the perceived shared understanding of the final design and the final design itself – were not that high. Judging individual descriptions on a rating scale is less objective and precise than using a manual with detailed instructions for distinguishing between categories. Coding on a rating scale is more subjective than coding clearly defined categories, and therefore yields lower agreement scores.

In conclusion, this discussion stresses an interesting dilemma, namely: more conceptual accurate coding of collaborative reflection requires coding across segments, and presumably requires more room for expert interpretation, but more conceptual accurate coding in combination with less objective coding instructions detrimentally affects the reliability scores.

### 7.3 Designing for collaborative learning and shared understanding

The two studies showed that teams, whose communication is video-based, face thresholds in their collaboration. At the same time, they experience difficulties in developing reflective behaviour. An obvious solution seemed to be improving the technology support for such virtual teams. For the purpose of designing such technology, current design approaches were studied. The review showed that systems are generally designed using an iterative approach, and that user involvement is crucial to creating usable systems. Consequently, the best result obtained by these approaches is a usable system. Nevertheless, it appeared that current groupware systems rarely satisfy either the needs of collaborating groups or the dynamics of such groups. In other words, most technology that supports distributed teams allows them to cooperate rather than stimulating team members to collaborate.

\(^6\) These experts were not the same as those raters that coded the team communication.
It should be noted that this work concentrates on an intensive form of collaboration, namely collaborative learning and shared understanding. Therefore, collaborative technology in view should not only enhance the collaboration, but should also stimulate collaborative learning. This means that collaborative technology should be beyond usable.

To design such collaborative technology and overcome shortcomings in current design approaches, a collaborative design approach was proposed. This approach was based on generally agreed upon usability criteria, and it aimed at designing collaborative technology that is natural as well as intuitive, has low thresholds, and makes collaboration more attractive.

In addition, the reason for labelling the proposed approach a collaborative approach was that it stressed the importance of team involvement in the design process. Worded differently, the collaborative design approach started with the team. This is in keeping with recent approaches in both curriculum design and groupware design. In both of these fields, the importance of involving actual stakeholders is growing.

Apart from that, a human-to-human interaction design perspective was leading. This design perspective was applied in order to stay close to natural behaviour and concentrate on the interaction between team members. Using this approach, a workshop was organised to collaboratively design proper support for questioning. The main question was how questioning behaviour in video-mediated design teams could be improved. The design workshop resulted in three solutions. These ideas were worked out into initial prototypes, and evaluated in a user pilot. Based on the evaluation and selection in the user pilot, a final tool that supports questioning behaviour (Q-tool) was further developed.

Looking back on the design process and the resulting tool, a first reaction could be whether such a collaborative design process is not too much a waste of time. At first sight it seemed to require intensive effort to organise a workshop with several participants. However, although it might seem time consuming to get started, when looking at the complete design process from need identification to product development, it could be concluded that this took place in a relatively short period of time.

Thus the real collaborative team sessions were only planned in the beginning of the design process. After the creative collaborative workshop, the approach followed a common iterative design approach with targeted participants.
At the same time, one could argue that the more participants, the more difficult the decision-making processes became. It is because of this, as pointed out in Chapter 5, that the role of the facilitator is a crucial one. The facilitator is expected to enhance the team discussion, to ask the right questions at the right moment, to keep team members from thinking and talking in terms of system functionality, and thus to facilitate the entire creative process.

Because the role of the facilitator can be seen as crucial, it is also a limitation of the approach applied in this study. Accurate and just-in-time reactions by the facilitator are a prerequisite. Also, alternative plans needed be ready when major questions – to be answered in the workshop – did not provide enough feedback or reactions, did not make sense to the participants, or turned in ‘unexpected’ directions.

Not only the facilitator, but also the participants play a crucial role. The participants volunteered to take part in this design workshop; they were accustomed to participating in multidisciplinary project work, and appeared to be constructive in their feedback in order to get the best ideas out of the team. The various backgrounds and perspectives seemed to result in more ideas as well as less-biased ideas. It can be assumed that this might have had a positive effect on the outcomes of the workshop.

By contrast, if the participants had been forced to participate, had all the same disciplinary background, had a shared history, and were not open to new ways of working, this could have been a barrier for creative and constructive results. In other words, the success of the proposed approach depends on the quality of the team and the facilitator.

Another remark should be made regarding experts. It was argued that experts were sometimes invited to join the team. It should however be noted that all team members were invited to participate as a team member and not as an expert, and that it was discouraged that experts simply participated to advocate their roles and expertise. Instead, several experts were invited to contribute to the multidisciplinary nature of the team.

While elaborating on social and cognitive functions of questioning behaviour, it was explained that the workshop participants identified the same functions that had been included in the conceptual framework (Chapter 4). In addition to the functions identified in the conceptual framework, the workshop participants came up with new functions, such as saving questions until a proper moment for posing those questions was identified.
Furthermore, the visualisation process turned into a creative process. Both the brainstorming and the design of function-based ideas resulted in more ideas than expected. It can be concluded that participants in such design processes were able to think across disciplines and current practices, and that they came up with new ways of support. Furthermore, the enthusiastic atmosphere seemed to be a good way to stimulate team forming. This was an additional advantage to the proposed design approach when designing with ad hoc teams that did know each other and who planned to collaborate in the near future with the developed technology.

Last but not least, it seemed that the workshop participants became less negatively biased against virtual collaboration. Perceived problems of virtual collaboration actually became challenges. Although no hard evidence was found, it can be expected that team members that participated in such a collaborative design process had less problems regarding technology use, because they reflected on their collaboration beforehand. In addition, it can be assumed that team members are more committed because they choose the support as a team. This collaborative choice might be a valuable advantage, considering the fact that a main finding in the exploratory study was that all teams used their offered support technology in a suboptimal way.

In addition to the positive experience of the workshop participants and the large amount of ideas, the low costs of system development should be taken into account. It was concluded earlier that the total time involved in developing a tool to support the questioning process was relatively short. The final product appeared simple to design and easy to use. This might be a direct result of staying close to human-to-human interaction. Consequently, the total costs were much lower than expected. Thus the positive results in combination with the short time for developing and evaluating the final Q-tool seemed to be evidence that the proposed approach is a fruitful contribution for the design of collaborative technology.

The feedback in the user pilots was also positive. With respect to usability, no negative feedback was found in either the user pilot or the experimental study. The use of the prototypes and the Q-tool received no negative comments. This is far from trivial, especially when considering that current design approaches largely concentrate on designing for usability.

In conclusion, there seemed to be evidence that a collaborative design approach as proposed in this work did in fact contribute to the design of collaborative technology that takes the requirements of human-to-human interaction into account. These observations are quite similar to those
reported in related design processes (see for more evidence Mulder, 2002; Mulder & Slagter, 2002; Ter Hofte, Mulder, De Poot, & Langley, 2003; Van Barneveld, 2003). Although the collaborative design approach seemed to have positive effects on the design of collaborative technology, no statistical evidence was found that the Q-tool was strong enough to support questioning behaviour or that it lead to higher order reflective behaviour, and consequently to improved collaborative learning and shared understanding. Results of the experimental study indicated that the questioning tool was not strong enough to influence the team’s reflective behaviour; in the experimental setting no significant differences across conditions were found. Here an interesting question is raised: to what extent can technology remove thresholds, or can technology influence behaviour; a possible explanation is that the role of the technology has been overestimated. In Section 7.1.5 explanations were given as to why no significant differences were found in the experimental study. The next section attempts to reveal why the effects of such a promising approach were less successful than expected, by reflecting upon the conceptual framework of collaborative learning and shared understanding.

7.4 Conceptual framework revisited

The main question reflected upon in this chapter was why the intervention of the questioning support did not evoke the expected patterns in either the question and answering process or the reflective behaviour. Earlier sections looked back on the research design and (the design of) the technology itself; this section reconsiders the conceptual framework of collaborative learning and shared understanding.

In this conceptual framework, both cognitive and social aspects were included. On the one hand it was stated that above all, learning is an individual cognitive process, on the other hand collaborative learning was seen as a joint activity. For that purpose, it was assumed that questioning, conceptual learning, feedback, and the expression of affect are all part of the process of reaching shared understanding. Using this initial framework, collaborative learning and shared understanding were studied in an exploratory study. This study observed suboptimal question-answer and reflective behaviour. Some evidence was also found indicating that the questioning and answering process on the one hand and reflective behaviour on the other were related. Consequently, more attention was subsequently devoted to (higher order) reflective behaviour. The conceptual framework was modified: the concepts of questioning and feedback were brought into prominence. The revised framework aimed at acquiring better
insight into the process of questioning and answering, because it was assumed that having a better grip on this process would yield more reflective activity. As indicated earlier, based on this assumption, the need to stimulate reflective behaviour was elaborated by supporting the design teams in the process of questioning. A tool was developed for this question-answer behaviour. Below explanations are elaborated as to why the intervention of the Q-tool did not evoke the expected patterns in either the question and answering process or the reflective behaviour.

The revised conceptual framework concentrated on the questioning and answering process on the one hand, and higher order reflective behaviour on the other. Although questioning and reflection were studied in a broad sense, it was discovered that questioning does not always lead to more reflection. It can be interesting to discuss whether any kind of questioning can be perceived as useful in terms of learning and reflection. In the first study, many utterances were coded as accretion and tuning; it would appear that sharing facts and fact-seeking questions are not that difficult in virtual teams. It can be assumed that making inquiry questions that seek deeper explanations for the phenomena under study is more difficult but would also be more beneficial in terms of learning than posing fact-seeking questions. At first sight, it might seem that the study concentrated on the amount of questions, although the main reason for using a coding scheme was to focus on the quality and nature of the questioning.

Both social and cognitive aspects were taken into account in the conceptual framework. Nevertheless, while supporting questioning behaviour, cognitive interaction was emphasised. It seems to be justified to consider whether the formulation of questions and the reasoning process in answering is enough for reaching shared understanding, and for being reflective. Especially for collaborative reflection and collaborative learning, social aspects seem to play a major role. It is generally known that being a great team depends on many factors. Concepts including trust, commitment and mutual engagement have been studied for years (e.g., Forsyth, 1990). What is more, it takes time for a bundle of individuals to become a great team. Most theorists on group dynamics and group development assume that groups pass through several phases as they develop. Forsyth (1990, p. 77) presented an overview of the stages used in most models. The five stages he found were labelled forming (orientation), storming (conflict), norming (cohesion), performing (performance), and adjourning (dissolution) (Tuckman, 1965; Tuckman & Jensen, 1977). Ad hoc teams that meet for the first time are at the start of this group development cycle. Teams are not expected to perform optionally until the fourth phase.
In other words, the teams that participated in the two empirical studies did not reach this performing stage. Interestingly, in the experimental study it was found that teams that had done project work together earlier came up with better portal designs; however, this finding did not appear statistically significant. It was also determined that teams that knew each other beforehand proposed significantly more on the content than teams that did not know each other.

Furthermore, it was found that the teams in the current study felt uncomfortable expressing their feelings and their initial ideas. Social bonding in teams can be expected to be a prerequisite for collaborative learning and reaching shared understanding in general. This might be even more crucial in virtual teamwork. Kreijns, Kirschner, and Jochems (2003) examined the pitfalls of social interaction in computer-supported collaborative learning environments. They concluded that social interaction was taken for granted too often, and they wondered why social aspects are not (well enough) supported in collaborative learning environments.

Thus a distinction should also be made between social, cognitive, and affective aspects. However, all three aspects were included in this work, it is of interest to devote additional attention to the role of affect. Questions arise such as why team members are willing to participate in ad hoc teams, what drives them, and what motivates them.

In keeping with the tango metaphor, searching for passion and mutual attractiveness are essential for collaboration in a knowledge-intensive work environment (Kessels, 2001; Keursten, Kessels, & Kwakman, 2003). Keursten et al. (2003) stressed that in order to compete in a knowledge-intensive society, it is important to acquire skills to regulate motivation, affinities, emotions, and affections concerning working and learning. Other important characteristics are reciprocal respect, appreciation and integrity, sufficient safety, and openness for constructive feedback and confrontations.

Additionally, sharing humour has a positive effect on reflective behaviour (Morkes, Kernal, & Nass, 1999). Nemiro (2000, p. 115) drew similar conclusions: “Sharing humour was another way virtual team members established a personal bond. Even for one of the teams that had never met face-to-face, humour helped to build a sense of community”.

In overview and reflection
This work started with the definition that shared understanding is the outcome of collaborative learning. At the same time, one could claim that shared understanding is a prerequisite for collaborative learning. This is in keeping with the previous discussion. In order to perform optimally, there needs to be some cohesion in the team; this can be seen as shared understanding.

Looking back on the experimental study, the virtual teams collaborated for 90 minutes; one could question whether such a period is long enough to develop a shared understanding. It can be assumed that virtual teams need to develop some cohesion like in the ‘norming’ stage before they get started in their virtual collaboration. Whether teamwork restricted to virtual collaboration is beneficial for either the reflectivity in the team or the team outcome also remains questionable.

The next section continues by summarising other relevant research dilemmas that surfaced in the current study.

### 7.5 Dilemmas and future work

In answering the research questions, some dilemmas were found. These dilemmas lead towards relevant questions for future research and are summarised below.

*How is shared understanding as an outcome of collaborative learning constructed?*

It was assumed that both cognitive and social aspects were important in studying collaborative learning and shared understanding. To explore collaborative learning and shared understanding in video-based communication, concepts such as conceptual learning, questioning, feedback, and expression of affect were studied. The first study observed that questioning and feedback were suboptimal. Consequently, the second study concentrated on these two processes (see Section 7.1.5).

A question to study in more detail is whether any kind of questioning behaviour can be related to learning and reflection. It would be interesting to elaborate on the distinctive roles of questioning in virtual teams: what kinds of questions lead to reflective behaviour and which questions do not. In addition, more insight is required in what kinds of questions are particularly difficult to express in virtual teams.
The dilemma between social and cognitive aspects also needs to be explored in more detail. Although affective aspects were included in the conceptual framework, in order to thoroughly understand collaborative learning in ad hoc expert teams, social, cognitive, and affective aspects need to be studied in relation to another.

**How can collaborative learning and shared understanding be assessed?**

Based on the current work, it can be assumed that concepts such as collaborative learning and shared understanding are difficult to operationalise and therefore difficult to assess. Even though collaborative learning is a group process, a characteristic of reflective behaviour is that it is first and foremost an individual cognitive process that often remains implicit. Such implicit reflections are hard to assess. In this dissertation, collaborative reflective behaviour was approached as explicit reflection that individuals shared in the team, and as a consequence, such reflective behaviour was expected to evoke other team members to be more reflective. In other words, only utterances of learning and reflection that were shared among the team members, and were expressed explicitly, could be assessed.

Apart from the distinction between implicit and explicit reflection, it seems to be of interest to investigate whether individual or collaborative measures were used. Many studies that attempted to assess collaborative learning based their assessments on individual measures. Fischer and Mandl (2002) pointed out that the psychology of knowledge acquisition to date has dealt first and foremost with the single individual. Even when analysing cooperative learning processes, the focus of attention was on how individuals represent their knowledge. Nevertheless, in their own work these researchers used individual pre-tests and individual post-tests to assess cooperative learning.

Thus, to date it has appeared difficult to assess concepts like collaborative learning and shared understanding in video-based communication. Although only a limited number of studies have been conducted on collaborative learning and shared understanding in video-based communication, related research that concentrated on reflective behaviour in technology-supported teams also found little reflectivity (e.g., Gunawardena et al., 1997; Baker et al., 1999; Veerman, 2000; Veldhuis-Diermanse, 2002; Ludvigsen & Mørch, 2003; Van der Pol et al., 2003).
One possible explanation for the poor evidence for reflection is that such behaviour simply did not occur in those studies. Expectations might have been too high: being genuinely reflective appears to be very difficult. In that case, it is a challenge to better understand reflection and to investigate which incentives can stimulate a team’s reflective behaviour.

Another explanation is that current researchers (not excluding this research) were not able to apply appropriate assessments for collaborative learning and shared understanding. As to this study, for example, it can be assumed that the coding procedure to assess (collaborative) reflection was too rigid. Regarding the coding of higher order reflective skills, an interesting dilemma was found. More conceptual accurate coding of collaborative reflection requires coding across segments, and apparently also requires more room for expert interpretation, which in turn is less objective; however, this choice for more conceptual accurate coding in combination with less objective coding detrimentally affects the reliability scores.

Another dilemma with respect to the assessment of collaborative learning and shared understanding was discussed earlier, namely: is an experimental set-up the proper research design to capture long term aspects related to group dynamics (Section 7.1)? It was suggested that a more ethnographic design that devotes attention to team development (over time) would enable a more favourable situation for acquiring more positive effects from the Q-tool intervention. It follows that reconsidering data collection methods and research designs on collaborative learning, shared understanding, and reflective behaviour (and related concepts) are a major research challenge (similar conclusions were drawn by Häkkinen, Järvelä, & Mäkitalo, 2003). An interesting research question is how new ways of interaction can be assessed.

How can the process of collaborative learning and reaching shared understanding in ad hoc design teams that work on collaborative design tasks using video-based communication be supported?

A first conclusion was that proper technology support for collaborative learning should be designed from a human-to-human interaction design perspective. Evidence seemed to indicate that starting with the team and concentrating on social and cognitive functions of human behaviour was not only fruitful for the development of appropriate technology support, but also seemed to have a positive effect on the team itself.
Another point to reflect upon is that groupware design primarily aims at copying face-to-face settings. Also with respect to the design of videoconferencing systems, it was concluded that many strive to make video-based communication as rich as face-to-face communication.

According this perspective, solutions to support collaborative learning and shared understanding could comprise large video walls and three-dimensional audio that emphasise the presence of remote partners in the conversation, just like in real-life conversations.

On the contrary, using the collaborative design approach, an explicit attempt was made to concentrate on the social and cognitive functions of human-to-human interaction, and thus the objective was not to simulate the face-to-face alternative. Of course, the question always remains whether face-to-face communication is not preferred above all. It should be remembered that focus in the current work was placed on dispersed ad hoc expert teams that need technology to collaborate. In other words, face-to-face communication was not possible. Therefore, an attempt was made to find appropriate technology under these conditions.

Best practices that concentrate on the functions of collaborative work were at hand. For example, electronic meeting systems have been designed for brainstorming. Brainstorming using electronic meeting systems which emphasise anonymity and idea generation appears to be more efficient and successful than face-to-face brainstorming (e.g., De Vreede & Briggs, 1997). Unfortunately, when investigating collaborative learning and reflection in dispersed teams, no best practices were found.

Apart from the question of whether the face-to-face situation should be imitated, an interesting research dilemma is how collaborative learning and shared understanding can be supported. The current work concentrated on intuitive and natural support with reference to both the design of technology support and the instructions given.

A point for further discussion is whether such an intuitive approach is strong enough to promote higher order reflective behaviour in video-based communication. The extent to which an intervention can be labelled intuitive and natural can be set to contrast with the following dimensions: directive, obligatory, or structured. For instance, the intervention of Van der Pol et al. (2003) can be seen as a less intuitive approach, because it structures the communication process. Van der Pol et al. (2003) studied the use of a structured discussion system ('anchored discussion') in facilitating ‘grounding’. Another example of a highly structured approach that was implemented in an obligatory and directive way is the study by Weinberger, Fischer, and Mandl (2003), who studied the use of collaboration scripts in order to facilitate ‘knowledge convergence’.
Although studies from the educational field have tried to promote reflective behaviour in a less intuitive and natural way, their results are also not straightforward (e.g., Veerman, 2000; Van der Pol et al., 2003; Weinberger et al., 2003). It can be concluded that whether support should be intuitive and natural still remains a subtle question. To that extent, there is much work to be done regarding support for collaborative learning and shared understanding in ad hoc expert teams.

A final thought is that technology is not the most obtrusive factor for the success of virtual teams. The most interfering factor could be the perceived distance. Many distributed team members perceive distance in virtual collaboration as a threshold and prefer face-to-face communication. The final section envisions how this distance could be bridged.

### 7.6 Building bridges to cross disciplines

The objective of the current work was twofold. On the one hand, it attempted to make a proper start in understanding, and enhancing collaborative learning and shared understanding; on the other hand an attempt was made to develop methods for assessing the process, and outcome of collaborative learning and shared understanding. The present work did indeed give insight into the assessment, design and support of collaborative learning and shared understanding in distributed ad hoc teams that collaborate on complex design tasks using video-based communication.

Although learning and working seemed to be integrated in practice, this integration was not so explicit in research. The literature study revealed that research to date on collaborative learning has emphasised the educational fields, while far less research has been focused on business settings. Most empirical research that has attempted to capture insight into processes as complex as collaborative learning and reaching shared understanding concentrated on students in text-based discussions. Little is known about collaborative learning processes in video-based communication.

Since the introduction of videoconferencing, it has been argued that videoconferencing bridges time and place, and therefore enables cooperation in virtual teams. Nevertheless, it was determined that there is still a gap that needs to be bridged to understand collaborative learning and working in video-based communication. Bridges across disciplines are necessary.

Insights gained in the current work show that thoroughly understanding collaborative learning and shared understanding in virtual teams requires cross-domain research. Theoretical insights, methods, best practices, and
experiences from several disciplines, such as constructivist theories, behaviour sciences, educational science, computer science, ethnography, discourse, and sociology, should be combined. These bridges are necessary, not only between theory and practice or between education and business settings, in order to assess collaborative learning processes and outcomes, but also with respect to methodology. Here, too, the traditional disciplinary borders must be crossed.

Moreover, with respect to the design of support for collaborative learning environments, thinking only in terms of computer science and system functionality is out of date. Illustrative is the vision of Van den Berg and Vollebregt (2002) who predict:

"that in future there will be a demand for designers that are able to defrost rigid traditional mental models in order to connect the dynamics of the new working, learning and living in a chaorderly society with the passion of people and organizations in integrated design; design of physical and virtual elements in which working, learning, and private life functionally and emotionally meld together" (Van den Berg & Vollebregt, 2002, p. 17).

The increasing demand for cross-domain research is a challenge for future research. In particular, in order to stay ahead and be innovative in today’s knowledge-intensive society, this challenge is key. In summary, much can be gained by supporting ad hoc distributed teams dealing with the complexity of today’s world. Nevertheless, there is still much work to be done in reducing the perceived distance in distributed teams. Interestingly, distance is also a crucial concept for tango couples. Tango partners keep their own distance and identity, resulting in maximal intimacy. Paradoxically, perceived distance turns into perceived intimacy.

Moreover, this combination of intimacy and distance is characteristic for a tango. Both tango dancers and distributed team members have something magical, and at the same time have their feet firmly on the ground.

In conclusion, just like tango couples, distributed team members have the potential to engage in the spirit of collaboration. When support is directed at triggering this spirit, barriers will be easily removed.
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Several publications by the author are (partly) included in this dissertation. These articles and conference contributions, that are re-used, are listed below.

Chapter 1, 2, and 3


**Chapter 4 and 6**


**Chapter 5**


**Chapter 7**

Mulder, I., Swaak, J., & Kessels, J., (2003, August). Understanding designers, designing for understanding - Two studies on collaborative learning and shared understanding in video-based communication. In P. A. Kirschner (Chair), Learning and understanding in virtual teams. Paper conducted in a symposium at the 10th Biennial Conference of the European Association for Research on Learning and Instruction (EARLI 2003), Padova, Italy.

Samenvatting

De Argentijnse Tango is een dans van improvisatie en interactie. De ‘leider’ geeft een intentie, impuls tot een beweging; de ‘volger’ antwoordt hierop door de beweging in te zetten; en de leider volgt deze beweging weer, enzovoort. Een goede leider in de tango weet wat hij wil, hoe hij dat overbrengt. Met andere woorden, een goede leider weet wat de volger nodig heeft. Een goede volger presenteert zichzelf duidelijk, luistert goed met haar lijf, en geeft een eigen creatief antwoord. Dit vraagt om zelfbewustzijn, contact met jezelf en je danspartner; contact met de muziek; de ruimte en andere dansers; om een duidelijke rolverdeling – die wel gelijkwaardig is; om duidelijke taal, communicatie en interactie; om een dialoog, om ruimte geven en nemen. Kortom: om maximale nabijheid, met behoud van distantie (Liesbeth Menken, Tango Abrazo).

Inleiding

Niet alleen in het onderwijs, maar ook in het bedrijfsleven, komt de combinatie van werken en leren in multidisciplinaire projecten steeds vaker voor. Binnen en tussen bedrijven worden ad hoc expertteams gevormd voor het oplossen van complexe vraagstukken, waarbij multidisciplinaire gezichtspunten nodig zijn. In de huidige maatschappij wordt professioneel werk steeds kennisintensiever en vindt steeds meer leren op de werkplek plaats. Anders gezegd, leren en werken zijn steeds vaker geïntegreerd.

Samenwerkend leren in projecten is niet eenvoudig, vooral niet als groepsleden niet op dezelfde locatie en hetzelfde tijdstip aanwezig zijn. Informatie- en communicatietechnologieën, zoals videoconferencing, maken het mogelijk afstand en tijd te overbruggen.
Hoewel de belangstelling voor videoconferencing sinds 11 september 2001 toegenomen is, is het gebruik van deze systemen nog niet echt doorgebroken. Veelal wordt de voorkeur gegeven aan echt contact (face-to-face communicatie). Men is dan ook nog steeds bereid in de file te staan of zelfs per vliegtuig te reizen met bijbehorende kosten en reistijd. Videoconferencing overbrugt dan wel tijd en plaats, maar de samenwerking wordt niet noodzakelijkerwijs gemakkelijker, beter of leuker. Met andere woorden, de technologie stelt de teams wel in staat om samen te werken, maar stimuleert dit niet; teamleden worden niet uitgenodigd om samen te werken, laat staan samen te leren.

Om zowel samen te werken als ook samen te leren, is een gemeenschappelijk begrippenkader binnen dergelijke teams van het grootste belang. Elkaar begrijpen is in gewone situaties al niet altijd even gemakkelijk, maar in virtuele teams is het nog lastiger. Daarom is een gemeenschappelijk begrippenkader wenselijk om in virtuele teams te werken en te leren. Over dit belang van een gemeenschappelijk begrippenkader is veel gezegd, maar hoe weet je nu of het aanwezig is? En hoe kun je technologie ontwerpen die uitlokt tot samenwerking en die het leerproces stimuleert?

**Gezamenlijk leren en videoconferencing**

Het uiteindelijke doel van dit onderzoek is meer grip te krijgen op het complexe proces van het bereiken van een gemeenschappelijk begrippenkader. Hiervoor zijn allereerst de concepten *gezamenlijk leren* en *gemeenschappelijk begrippenkader* uitgediept. Daarnaast is verwant onderzoek bestudeerd; empirische studies waarin teams samenwerken met behulp van videoconferencing zijn vergeleken. Hierbij was de aandacht gericht op hoe de concepten gezamenlijk leren en gemeenschappelijk begrippenkader geoperationaliseerd waren.

Het bleek dat studies op het gebied van videoconferencing zich met name richten op de vergelijking met face-to-face situaties, het gebruik van videoconferencing systemen, en het ontwerpen van zulke systemen. Slechts enkele studies besteden aandacht aan concepten die gerelateerd zijn aan leerprocessen en leerresultaten.

Om gezamenlijk leren en gemeenschappelijk begrip in videocommunicatie te doorgronden, is een conceptueel raamwerk uitgewerkt. Op basis van dit conceptueel raamwerk zijn meetinstrumenten voor het verkrijgen van inzicht in het gezamenlijke leerproces en het gemeenschappelijke begrippenkader ontwikkeld. Juist voor het doorgronden van moeilijk
meetbare concepten is een conceptueel raamwerk erg behulpzaam om conceptueel accurate resultaten te verkrijgen.

Dit raamwerk met betrekking tot gezamenlijk leren omvat zowel sociale als cognitieve aspecten. De centrale concepten die gebruikt zijn om gezamenlijk leren en gemeenschappelijk begrippenkader te bestuderen zijn: vraaggedrag, conceptueel leren, feedback en het uiten van affectie. In onderstaande figuur wordt het gehanteerde raamwerk weergegeven.

Verder is een combinatie van verschillende – zowel kwantitatieve als kwalitatieve en zowel objectieve als subjectieve – methoden en instrumenten gebruikt om een adequaat beeld van het gezamenlijke leerproces te verkrijgen. Een nevendoel is bij te dragen aan methoden voor computer-ondersteund samenwerkend leren. Huidige methoden en instrumenten lijken niet toereikend te zijn om innovatieve werkvormen te bestuderen.

**Eerste studie: inzicht in een gedistribueerd team**

Hoe leren ontwerpers in een gedistribueerd ad hoc team nu eigenlijk tijdens videobijeenkomsten, en hoe verkrijgen zij een gemeenschappelijk begrip? Om inzicht in het groepsleerproces van een multidisciplinair ontwerpteam te verkrijgen en om moeilijk meetbare concepten als gemeenschappelijk begrip en gezamenlijk leren meetbaar te maken is een exploratieve studie gedaan.

Drie Nederlandse studenten werkten samen met vier Amerikaanse collega’s aan het ontwerp van een wielkastconstructie voor de auto-industrie. Gedurende vier maanden is het gedistribueerde ontwerpteam bestudeerd. De wekelijkse videobijeenkomsten zijn geobserveerd met behulp van semi-
gestructureerde observatieschema’s. De communicatie die tijdens deze
synchrone bijeenkomsten plaatsvond is volledig uitgeschreven en
gecodeerd. Inzicht in het gemeenschappelijk begrippenkader is verkregen
door de deelnemers aan het eind van iedere bijeenkomst een aantal
zelfscoringsvragen voor te leggen. Op deze meetschalen konden de
deelnemers aangeven in hoeverre zij het gevoel hadden dat hun ideeën met
die van de andere teamleden overeenkwamen, bijvoorbeeld hun ideeën met
betrokking tot de inhoud van de taak, de onderlinge relaties in het team en
de werkprocedure. Verder zijn aan het begin, halverwege en aan het eind
van het ontwerpproject interviews gehouden en hebben de studenten een
web-gebaseerde vragenlijst ingevuld. In de interviews en vragenlijsten is
onder andere gevraagd naar projectervaring, interesses en vaardigheden.

Resultaten
Wat opviel in de groepscommunicatie was dat er wel vragen werden gesteld
maar dat er nauwelijks werd doorgevraagd. Ook werd er weinig feedback
gegeven en nauwelijks gereflecteerd. Bovendien werden veel vragen niet
beantwoord. Het resultaat was dan ook dat het gemeenschappelijk
begrippenkader niet groot was. Uit de zelfscoringsvragen bleek dat de
perceptie van het gemeenschappelijk begrippenkader wel was toegenomen
in de loop van het project.

De resultaten van dit team zijn vergeleken met andere gedistribueerde
ontwerpteams; ook in deze teams vond weinig reflectie plaats.

Gemeenschappelijk begrip en vraagbehandeling

In het licht van deze resultaten is het conceptuele raamwerk herzien.
Omdat het lijkt dat veel vragen niet worden beantwoord, worden de
concepten vraaggedrag en feedback nader bestudeerd. Het stellen van vragen is
een belangrijke voorwaarde voor leren en begrip, niet alleen voor degene
die de vraag stelt maar ook voor de groep als geheel. Vragen houden de
groep gefocust en voorkomen dat men in een impasse terechtkomt.
Bovendien worden de teamleden erdoor gedwongen hun informatie en
concepten duidelijker te presenteren.

In face-to-face communicatie kunnen mensen eenvoudig bijdragen aan
elkaars spraakuitingen, door middel van het stellen van vragen, door te
parafraseren, of door te vragen om verduidelijking. In videocommunicatie
ligt het wat minder duidelijk.
Opmerkelijk is dat expliciete signalen die in face-to-face communicatie algemeen geaccepteerd zijn, in videobijeenkomsten niet of nauwelijks worden gebruikt. Een voorbeeld is het time-out gebaar, dat in gewone vergaderingen of tijdens sportactiviteiten wordt gebruikt om aandacht voor vragen te krijgen.

Met andere woorden, het lijkt zo te zijn dat er in videoconferencing nog geen cultuur is voor vraagstellend gedrag en dat het stimuleren en expliciteren van vraaggedrag ondersteuning nodig heeft. Hiervoor kunnen zowel technologische als niet-technologische middelen worden ingezet. Dit onderzoek richtte zich op ondersteuning die natuurlijk, intuitief en laagdrempelig is en de samenwerking beter, gemakkelijker en leuker maakt. Voor ad hoc teams is dit nog belangrijker, omdat deze doorgaans snel worden gevormd en er dus weinig tijd is voor training en het vormen van sociale contacten.

Vervolgens is verwant onderzoek onder de loep genomen met het oog op zowel de rol van de technologische ondersteuning als de rol van een facilitator. Hoewel in de drie bestudeerde studies vergelijkbare problemen voorkwamen met betrekking tot het vraaggedrag tijdens videocommunicatie, bleken de gehanteerde interventies gezamenlijk leren in gedistribueerde teams niet op een natuurlijke en eenvoudige manier te stimuleren.

**Ontwerpen voor beter begrip**

Een veel gesuggereerde oplossing is het verbeteren van de technologische ondersteuning. Dat is makkelijker gezegd dan gedaan. Want: hoe ontwerp je technologie die samenwerkend leren ondersteunt of zelfs stimuleert?

Binnen het domein van groupware design is het algemeen geaccepteerd dat een iteratieve ontwerpaanpak en het betrekken van gebruikers hierbij cruciaal zijn voor het ontwerpen van bruikbare systemen. Desondanks blijkt toch al te vaak dat groupware systemen vanuit een technisch perspectief ontstaan en slecht aansluiten bij de behoeften en de dynamiek van samenwerkende teams. Ondersteuning voor het samenwerken aan complexe taken moet dan ook niet alleen bruikbaar zijn, de geboden ondersteuning moet ook tegemoet komen aan de dynamiek van de teams, de complexiteit van de taak en open staan voor innovatie.

Bovendien gaat het hier om een bijzondere vorm van samenwerken, namelijk gezamenlijk leren en elkaar begrijpen. Dus de beoogde technologie moet niet alleen samenwerking stimuleren, maar ook gezamenlijk leren en
reflectief gedrag uitlokken. Anders gesteld, de beoogde technologie kan gezien worden als een deel van een leeromgeving. Daarom zijn behalve groupware design benaderingen ook benaderingen op het gebied van curriculum ontwerp vergeleken. Op basis van de inzichten uit beide ontwerpwerelden wordt geconcludeerd dat de beoogde technologie niet alleen aan de algemeen aanvaarde bruikbaarheidscriteria moet voldoen, deze ondersteuning moet ook intuïtief, natuurlijk en laagdrempelig zijn, en bovendien de virtuele samenwerking aantrekkelijker maken.

Om aan deze voorwaarden tegemoet te komen wordt een gezamenlijke ontwerpenadering voorgesteld, die uitgaat van de interactie tussen teamleden, ofwel van de functies van menselijk gedrag. Vanuit dit perspectief worden eisen aan de technologie afgeleid van de ‘natuurlijke’ functies van menselijke interactie. Technologie die hieraan voldoet, wordt natuurlijke technologie genoemd. Wanneer deze technologie gebruikt kan worden zonder gedetailleerde instructies of een handleiding kan deze technologie ook intuïtief genoemd worden.

De in dit onderzoek voorgestelde benadering heeft het label gezamenlijk omdat ze uitgaat van een team van ontwerpers. Het gaat om gezamenlijk ontwerpen met gebruikers in plaats van ontwerpen voor gebruikers. Zowel op het gebied van groupware design als curriculum ontwerp worden gebruikers, zoals managers, werknemers, studenten en docenten, steeds vaker bij het ontwerpproces betrokken.

In dit onderzoek is deze gezamenlijke ontwerpenadering gehanteerd om technologie te ontwerpen die het vraaggedrag stimuleert. Er is een workshop georganiseerd waaraan verschillende experts en toekomstige gebruikers deelnamen. Om het vraagstellend gedrag in virtuele teams beter te ondersteunen zijn de sociale en cognitieve functies van vraagstellend gedrag onderzocht. Met andere woorden: wat doen mensen als ze een vraag willen stellen? Voorbeelden van sociale en cognitieve functies van vraagstellend gedrag zijn: kunnen aangeven dat je een vraag hebt, aandacht voor je vraag krijgen en het kunnen adresseren van een vraag.

Allereerst hebben de workshopdeelnemers gezamenlijk geïdentificeerd welk vraaggedrag ondersteund moet worden. Daarna hebben ze in tweetallen ‘prototypes’ uitgewerkt die dit gedrag ondersteunen. Het grote verschil met traditionele softwareontwikkeling is dat deze creatieve prototypes (bijvoorbeeld schetsen of uitbeeldingen) de nadruk leggen op interactie in plaats van hoe het technisch te ontwikkelen is. Aan het einde van de dag zijn alle ideeën gepresenteerd en werd er besproken welke ideeën de voorkeur genieten.
De gekozen ideeën zijn met technische experts en softwareontwikkelaars besproken. Drie ideeën zijn uitgewerkt, zodat er een werkbaar prototype van gemaakt kon worden. Daarna zijn deze prototypes geëvalueerd in een gebruikersstudie. Dit heeft geresulteerd in de ontwikkeling van een hulpmiddel ter ondersteuning van vraaggeraad, de Q-tool. De Q-tool helpt de gedistribueerde teamleden om aandacht voor hun vraag te krijgen van het andere subteam.

**Tweede studie: het effect van de Q-tool**

Een tweede empirische studie gaat in op de rol van vraagstellend gedrag in het gezamenlijke leerproces. Anders dan de eerste studie die een exploratief karakter heeft, is deze studie toetsend van aard. In het experiment is zowel de rol van de Q-tool als die van de facilitator in het ondersteunen van de vraagbehandeling onderzocht.

De hypothese is dat de teams die samenwerken met de Q-tool of een facilitator, hun vragen beter stellen, wat leidt tot een toename van reflectief gedrag; er wordt meer doorgevraagd en meer en beter antwoord op vragen gegeven. Deze groepen zullen een beter gemeenschappelijk begrippenkader ontwikkelen, wat leidt tot een beter ontwerp. Om deze hypothese te toetsen zijn 20 multidisciplinaire studententeams bestudeerd, die in twee subgroepen samenwerken aan een complexe ontwerptaak, namelijk het ontwerpen van een ‘nieuwe dienst voor een universiteitsportal’.

Alle teams konden via videoconferencing met elkaar communiceren; 10 van de 20 teams beschikten hiernaast ook over de Q-tool. De experimentele condities waren een conditie met en zonder een Q-tool. Behalve naar het effect van de Q-tool is naar de rol van een facilitator gekeken. Omdat spontaan faciliterend gedrag is geobserveerd, zijn de teams achteraf ingedeeld in teams met en zonder een facilitator. Verder waren alle teams voorzien van visuele hulpmiddelen, zoals papier, potloden, een flap-over en een tekenbord.

Om inzicht te verkrijgen in het bereiken van begrip en het gezamenlijke leerproces zijn diverse instrumenten gebruikt om de volgende concepten te meten, te weten:

- Kennis en ervaring (vragenlijst);
- Perceptie van gemeenschappelijk begrip (meetschaal);
- Perceptie van gemeenschappelijk begrip van eindontwerp (meetschaal);
- Kwaliteit van eindontwerp (expertbeoordeling);
- De rol van de facilitator in het team (observatie);
– Gebruik van de Q-tool (logbestanden);
– Teamcommunicatieproces (video-opname);
– Ervaringen van deelnemers (rapport).

Om meer inzicht in de teamcommunicatie te verkrijgen is een codeerschema ontwikkeld. Het gehanteerde codeerschema is gebaseerd op het schema dat in de exploratieve studie is gebruikt. Het schema is aangepast omdat de doelstelling in het experiment behalve op leren en begrip, vooral gericht is op vraaggedrag. Een ander verschil met de eerste studie is dat het codeerproces vereenvoudigd is. Waar het in de exploratieve studie nodig was de communicatie tussen de teamleden volledig uit te schrijven, is voor het experiment een codeertool ontwikkeld die het mogelijk maakt video’s te coderen terwijl je kijkt. Hiermee was bovendien gezamenlijk coderen op afstand mogelijk, daar de codeertool gebruikt maakt van ‘video over IP’ (Internet Protocol).

Resultaten
In alle teams – dus zowel met als zonder de Q-tool – nam de perceptie van gezamenlijk begrip significant toe tijdens het ontwerpproces. Hoewel de perceptie van gezamenlijk begrip groter was in teams met de Q-tool dan in teams zonder de Q-tool, was dit verschil niet significant. Teams met de Q-tool hadden niet een significant betere vraagbehandeling en reflecteerden niet meer dan teams zonder de ondersteuning. Verder bleek het moeilijk een verbetering in het groepsleerproces te relateren aan een kwalitatief beter eindontwerp.

Reflectie
Een interessante vraag is waarom de interventie van de Q-tool niet sterk genoeg blijkt om het vraagstellend gedrag te beïnvloeden en zodoende ook niet leidt tot meer reflectie en meer gezamenlijk begrip in de gedistribueerde teams.

Onderzoeksoptzet
Een belangrijk verschil tussen de twee empirische studies is dat de eerste studie exploratief was en vier maanden duurde; de tweede studie betrof een experiment van anderhalf uur. Een relevante vraag is dan ook of een experimentele opzet wel de juiste opzet is om reflectief gedrag te doorgenooten. In het algemeen wordt een experiment ingezet om zoveel mogelijk variabelen te controleren. Daardoor laat een experimentele opzet weinig ruimte over voor lange-termijn effecten zoals groepsontwikkeling. Zelfs als de tijdsduur verlengd wordt, is het nog maar de vraag of de
kunstmatige opzet van een experiment de spontane dynamiek van een groep niet (negatief) beïnvloedt. De dwingende condities van een experimentele opzet in combinatie met de tijdsdruk lijken reflectief gedrag te belemmeren. Waarschijnlijk creëert een meer etnografische opzet, die recht doet aan de ontwikkeling van een team, een gunstiger situatie om inzicht te verkrijgen in de effecten van de Q-tool.

Ontwerpenadering
De gezamenlijke ontwerpenadering lijkt voordeel op te leveren. Behalve de positieve ervaring van de workshopdeelnemers en de grote hoeveelheid ideeën, waren de ontwikkelkosten erg laag. De totale tijd om de ondersteuning voor het proces van vraagbehandeling te ontwikkelen was relatief kort. Het eindresultaat was verrassend eenvoudig te ontwikkelen en eenvoudig te gebruiken. Dit lijkt een direct gevolg te zijn van het ontwerpen vanuit de menselijke interactie. Samengevat: de voorgestelde ontwerpenadering lijkt zijn vruchten af te werpen voor het ontwerpen van technologische ondersteuning voor teams. Te meer daar geen negatieve feedback is ontvangen over de bruikbaarheid van de prototypes en de Q-tool. Dit resultaat is zeker niet triviaal. Vooral als in acht wordt genomen dat huidige ontwerpenaderingen zich grotendeels concentreren op het ontwikkelen van bruikbare systemen.

Hoewel deze ontwerpenadering succesvol lijkt, is het effect van de Q-tool niet statistisch aangetoond. De ontwikkelde Q-tool is niet sterk genoeg om effecten in het vraaggedrag te sorteren, zodat teamleden meer reflecteren, gezamenlijk leren en uiteindelijk meer gemeenschappelijk begrip hebben. De vraag blijft tot op welke hoogte technologie drempels kan wegnemen en in welke mate technologie überhaupt gedrag kan beïnvloeden. Een mogelijke verklaring kan zijn dat de rol van technologie overschat is.

Conceptueel raamwerk
In het initiële conceptuele raamwerk spelen zowel sociale als cognitieve aspecten een rol. Naar aanleiding van de resultaten van de eerste empirische studie is het raamwerk aangepast en ligt de nadruk enerzijds op het vraaggedrag en anderzijds op reflectief gedrag. Hoewel vraaggedrag en reflectief gedrag in brede zin zijn bestudeerd, is het gebleken dat het stellen van vragen niet altijd leidt tot reflectie. Een vraag voor vervolgonderzoek is welk soort vragen tot reflectie leidt.

Zoals gezegd is er in het conceptuele raamwerk aandacht besteed aan zowel sociale als cognitieve aspecten. Desondanks lijkt door de focus op het ondersteunen van de vraagbehandeling de cognitieve interactie benadrukt. Een interessante vraag is of het formuleren van vragen en het beantwoorden
ervan voldoende is om een gemeenschappelijk begrippenkader te verwerven en om reflectief te zijn. Met name in *gezamenlijk* leren en *gezamenlijk* reflecteren spelen sociale en affectieve aspecten een rol. Ander onderzoek, bijvoorbeeld meer sociaal-psychologisch onderzoek, geeft aan dat concepten als vertrouwen, betrokkenheid, motivatie, humor en wederzijdse aantrekkelijkheid het teamproces beïnvloeden.

Wat de precieze rol van deze aspecten in ad hoc teams die communiceren via videoconferencing is, is nog niet in deze context bestudeerd. Het is dan ook aan te bevelen naast het onderscheid tussen sociale en cognitieve aspecten, affectieve aspecten expliciet te onderscheiden. Zo kunnen sociale, cognitieve en affectieve aspecten in hun onderlinge samenhang nader bestudeerd worden.

### Bruggen bouwen

De doelstelling van dit onderzoek was tweeledig. Enerzijds was het doel om beter inzicht en begrip te verkrijgen in de concepten gezamenlijk leren en het bereiken van een gemeenschappelijk begrip. Anderzijds was er een methodologisch doel, namelijk een bijdrage te leveren aan de ontwikkeling van methoden en meetinstrumenten om zowel het leerproces als de leerresultaten te doorgroden. Concluderend: er is inderdaad meer inzicht verkregen in het meetbaar maken, ontwerpen en ondersteunen van deze leerprocessen in gedistribueerde ad hoc teams die samenwerken aan complexe ontwerptaken via videoconferencing.

Hoewel in de praktijk leren en werken steeds vaker geïntegreerd zijn, is deze integratie niet zo duidelijk zichtbaar in huidige onderzoeksresultaten. Uit dit onderzoek komt naar voren dat huidige onderzoek naar gezamenlijk leren zich vooral richt op de onderwijswereld en dat veel minder onderzoek in het bedrijfsleven plaatsvindt. Het empirische onderzoek dat probeert grip te krijgen op complexe leerprocessen bestudeert met name tekstgebaseerde omgevingen. Weinig is bekend over gezamenlijk leren tijdens videoconferencing.

Met andere woorden, veel interessant onderzoek vindt nog steeds op zogenaamde ‘disciplinaire eilanden’ plaats. Bruggen zijn nodig om de inzichten van deze onderzoeken te verbinden en nieuwe inzichten te verkrijgen. Een uitdaging voor de toekomst is multidisciplinair onderzoek. Er is nog veel winst te behalen in het ondersteunen van gedistribueerde ad hoc teams in een toenemende complexe samenleving.
Een laatste kanttekening. Ondanks het voorafgaande lijkt het erop dat het succes van virtuele teams niet (alleen) afhankt van de technologie. De meest belemmerende factor kan wel eens het gevoel van afstand zijn.

Veel gedistribueerde teamleden ervaren de afstand in deze manier van samenwerking als een drempel en verkiezen daarom face-to-face communicatie. Interessant genoeg speelt afstand ook in de tango een cruciale rol. Tangopartners geven elkaar de ruimte met behoud van de eigen identiteit. Het gaat dus om maximale nabijheid met behoud van distantie.

Anders gezegd, de ervaren afstand moet worden omgezet in een ervaren intimiteit. Zowel tangodansers als virtuele teamleden hebben iets magisch en iets mystieks, en lijken de realiteit te ontvluchten. Desalniettemin staan ze met beide benen op de grond. Net als tussen tangopartners kan tussen gedistribueerde teamleden een bijzondere chemie ontstaan. Wanneer de ondersteuning in staat is om deze chemie aan teams te ontlokken, zullen barrières snel vervagen.
Understanding designers  
Designing for understanding

Ingrid Mulder

Like tango dancers who cannot start their dance without a certain amount of shared understanding, design teams cannot begin their work. The combination of distance and a strong reliance on technology makes understanding between dispersed team members less than obvious. This book reports on distributed teams that collaborate on complex design tasks and communicate by means of videoconferencing. The goal is to enhance the potential of distributed teams by providing proper support. For this, a collaborative design approach is advocated. The underlying assumption is that proper support invites team members to learn and work together – similar to the right tango music that evokes the right mood and right tempo for a certain moment. The research concentrated on the assessment of collaborative learning and shared understanding in video-based communication and how it can be supported. It is concluded that not technology is the most obtrusive factor for the success of virtual teams. The most interfering factor is the perceived distance that seems to hamper many distributed team members. However, just as tango couples, distributed team members have the potential to engage in the spirit of collaboration. When support is directed to trigger this spirit, barriers for collaborative learning and shared understanding can easily be removed.

About the author

Ingrid Mulder (1971) studied Management and Organisation (1995), she obtained her MA degree in Policy and Organization sciences, University of Tilburg (1998), and graduated in group dynamics and the use of group support systems. She has carried out research in international and national project management and the use of group support methods. Her passion for the design of art and innovative technology was given a theoretical basis at the Interaction Design Institute Ivrea (2001). She worked as a trainer of political education projects and as a teacher in communication and management skills. Since 1998 she has been a scientific researcher at the Telematica Instituut where she worked in several projects crossing borders of theory and practice as well as disciplinary borders. As reported in this book she specialised in collaborative learning and the design of innovative technologies from a user-centered perspective. Currently, she elaborates on this and concentrates on developing methods and techniques for capturing innovation, experiences, and future user needs.

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