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ABSTRACT

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Abstract

Organizations continuously explore new ways of supporting group collaboration. Group dynamics changed the moment organizations started to operate globally. Groups started to collaborate from different locations, and this caused the emergence of virtual teams and agile work. Microsoft is one of the companies that promises to support this new way of group collaboration. Organizations need new systems that connect distributed teams around the world.

Groupware are computer-based systems that support groups of participants to achieve a common task in a shared environment. The focus of groupware is mainly on how the technology supports group collaboration. However, the technology alone is not interesting enough to be researched. The success of group collaboration is dependent on many more variables besides technology. Computer-supported cooperative work (CSCW) is a research area that discusses the intersection between collaborative group behavior and computer-based technologies. It focusses on group behavior, group interaction, the work environment, and how computer-based systems can support those aspects. Even though CSCW was developed in the 1980s, it is still relevant today.

The main research question of this paper is to find success factors of CSCW that support group collaboration. To answer the research question, literature is being reviewed, groupware is measured in use cases and interviews are conducted with Microsoft employees specialized in group collaboration systems.

Results show that to support group collaboration, organizations should focus on active and dynamic participation of group members. Distributed organizations pulled groups apart and Passive group meetings in conference rooms are outdated and discourage collaboration. In addition, organizations must provide proper groupware to support common ground, grounding and group interaction.

Key words	Groupware, CSCW, Common ground, Grounding, Group collaboration
Further information	

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THE IMPACT OF GROUPWARE AND CSCW ON GROUP COLLABORATION

An overview of success factors in CSCW

Master´s Thesis
in Information Management

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ABSTRACT

Organizations continuously explore new ways of supporting group collaboration. Group dynamics changed the moment organizations started to operate globally. Groups started to collaborate from different locations, and this caused the emergence of virtual teams and agile work. Microsoft is one of the companies that promises to support this new way of group collaboration. Organizations need new systems that connect distributed teams around the world.

Groupware are computer-based systems that support groups of participants to achieve a common task in a shared environment. The focus of groupware is mainly on how the technology supports group collaboration. However, the technology alone is not interesting enough to be researched. The success of group collaboration is dependent on many more variables besides technology. Computer-supported cooperative work (CSCW) is a research area that discusses the intersection between collaborative group behavior and computer-based technologies. It focusses on group behavior, group interaction, the work environment, and how computer-based systems can support those aspects. Even though CSCW was developed in the 1980s, it is still relevant today.

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Results show that to support group collaboration, organizations should focus on active and dynamic participation of group members. Group meetings in conference rooms are very passive and discourage collaboration. Furthermore, organizations must provide proper groupware to support common ground, grounding and group interaction.

1 INTRODUCTION

Traditional organizations used to have face-to-face meetings to discuss agendas, company news, key topics and the division of tasks, for example. Organizations did not face many challenges in the communication, coordination, and collaboration of their meetings. Currently, however, organizations are operating globally, and face-to-face meetings are difficult to organize. They take too much time, and it is too expensive to transport everyone to the same location for a meeting. This resulted in the creation of virtual teams. Virtual teams that are supported by computer networks to connect them. Computers started to support human interaction (Ellis & Wainer, 2004).

However, distributed group meetings faced many challenges in comparison to face-to-face meetings. At first, computer applications were developed specifically for computer-human interaction (Grudin, 1994). Most computer systems were built to support individuals in their work, there was almost no support for group collaboration. This lead to the emergence of groupware: computer-based systems to support groups engaged in a common task (Ellis, Gibbs, & Rein, 1991). Groupware focusses on how technology can support group collaboration. Besides the advantages of groupware, it also brought many challenges that organizations have to deal with (Grudin, 1995).

Factors other than groupware also influence the success of group collaboration. This caused the emergence of CSCW. Computer-supported cooperative work studies how people work together and how computer-related technologies affect group behavior (Greenberg, 1991). This field studies the technological factors and group behavior factors that influence group collaboration. Most technological factors can be found in groupware. The impact of groupware challenges and groupware taxonomies on group collaboration are further discussed in this research. In contrast, group behavior is influenced by many different factors and a few of them are investigated: common ground, grounding and group interaction. Controlling and understanding these factors supports group collaboration.

Common ground of two or more persons is the sum of their common, joint or mutual knowledge, beliefs, and suppositions (Clark, 1996). Common ground is used to act jointly and to prevent miscommunication. In addition, common ground is based on a shared basis between people. This research investigates how groupware can support finding common ground that improves group collaboration.

Grounding is another factor that influences the success of group collaboration. People try to “ground” whatever they are doing and sharing together. Grounding eventually leads to a shared basis and common ground (Clark, 1996). Distributed work makes grounding difficult and groupware should provide support for grounding. Groupware enables people to “ground” in many different ways (Thissen, Page, Bharathi, & Austin, 2007).

Finally, the influence of group interaction on the success of group collaboration. Distributed work completely changed how groups interact with each other. Groups communicate, coordinate and collaborate in new ways together. Groupware should new ways of group interaction at all levels to improve group collaboration.

To examine the success on group collaboration, the following research questions are conducted:

- *RQ1: How to tackle groupware challenges?*
- *RQ2: Which groupware taxonomy supports group collaboration?*
- *RQ3: Which groupware factors support finding common ground?*
- *RQ4: Which groupware factors support grounding?*
- *RQ5: Which groupware factors support group interaction?*

These sub questions provide answers to discuss the main research question:

Which factors of CSCW support group collaboration?

An overview of CSCW factors that influence group collaboration is illustrated in figure 1.

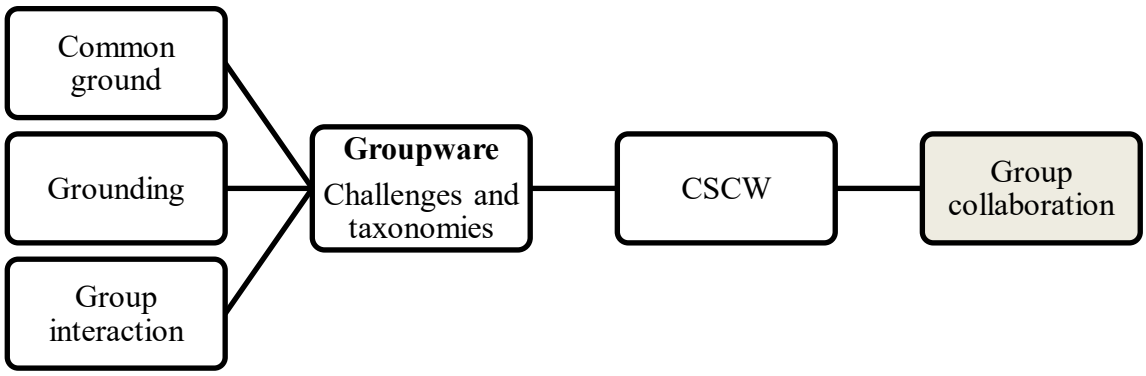

Figure 1 Factors of CSCW that support group collaboration.

An introduction of the problem is presented in Chapter 1 and the relevant literature is discussed in Chapter 2. The methods used in this study are defined in Chapter 3, after which the results are presented in Chapter 4. Finally, Chapter 5 discusses the findings and outlines the main conclusions of the research. In addition, it provides both the limitations and recommendations for further research.

2 LITERATURE REVIEW

2.1 Defining groupware and CSCW

Chapter 2.1 discusses the history and definitions of both groupware and CSCW. Both terms are very broad, and the literature presents many different definitions. This paper provides a clear and scoped definition of both terms. A brief history of groupware and CSCW is given to get a better understanding of the evolution of both terms. This reveals different factors that influence the success of both technologies. Chapter 2.2 discusses groupware characteristics, classification models and challenges. Literature contains different models, and this chapter's clear overview helps to compare and evaluate them. These findings are then tested in this research. Chapter 2.3 discusses success factors for collaboration and are tested further in this research.

2.1.1 A brief history and definition of groupware

Groupware has been defined as a technology to assist groups (Ellis & Wainer, 2004). Another definition of groupware is as any computer application, which could be software or hardware, that supports group activities in some way (Fouss & Chang, 2000). Yet another definition of groupware is as a computer-mediated collaboration that increases the functionality or productivity of the person-to-person process (Coleman, 1997). Dozens of other definitions can be found in the literature. To this day, researchers have not agreed on one simple definition of groupware.

Two major reasons can explain the variety in definitions of groupware. First of all, technologies and collaboration styles are continuously changing. New technologies create new ways of collaboration, and more is possible through technology. People continue to interact, communicate, collaborate, and coordinate in different ways (Ellis, Gibbs, & Rein, 1991). This results in new and reviewed definitions of groupware. Second, the history and the origin of the term "groupware" can explain the variety in definitions. The concept of groupware emerged in the 1980s and replaced the old concept of office automation. In addition, groupware gained interest among product developers and researchers from various fields (Grudin, 1994).

Other researchers have extended the definition of groupware. Groupware can be divided into four different groups: single display groupware, multi-display groupware, single device groupware, and multi-device groupware (Kim, Ko, & Lee, 2017). These different groups can be found in table 1. Kim, Ko, & Lee (2017) claim that single display groupware is immobile. However, this claim does not against the Surface Hub 2

(Microsoft Coorporation, 2019), which is a single display groupware device that can be moved. Chagas, Fuks, & Souza (2015) divided groupware into micro-groupware and meta-groupware. In micro-groupware, the main user is at the center of the group. In meta-groupware, the collaboration process takes place around the technology (Chagas, Fuks, & Souza, 2015). The literature is full of extended definitions of groupware. However, these definitions are mainly conducted to support and scope down specific research questions of groupware. Therefore, most extended definitions of groupware are not relevant for this paper and not included.

It is necessary to discuss groupware and other relevant keywords to get a better understanding of key factors. Groupware consists of two main parts: technology and groups. Groupware technology can be divided into two parts: software and hardware technologies (Ellis & Wainer, 2004). Groups can be small, such as two workers collaborating through an electronic whiteboard, or large, such as citizens voting for a president. Groups can be close, where members know each other, or loose, where members do not know each other (Ellis & Wainer, 2004). Besides, a group can vary in terms of size (small or large), degree of interaction (tight or loose), motivation and orientation (common goal or shared interest), objectives of work (defined and shared or occasional information exchange), and personal relationship (individuals know each other or individuals do not know each other) (Lausen, 2004). Communities, teams, society, units, organizations, and associations are all terms that this paper defines under the category of groups.

Table 1 Four different groups of groupware (Kim, Ko, & Lee, 2017)

	Single device	**Multi-device**
Single display	Traditional single display groupware	Target space
Multi display	Multi-view display	Multi-person display ecosystems

Different definitions with corresponding keywords of groupware are depicted in table 2 to find and construct a new definition of groupware. Keywords are important to emphasize certain elements of groupware.

Table 2 Groupware definitions with corresponding keywords

Author, year	**Definition**	**Keywords**
(Valacich & Schneider, 2014)	"A software that enables people to work together more effectively."	Software, people, effectively

(Grudin, CSCW and Groupware: Their History and Trajectory, 1999)	"A software focus and often a commercial focus. When discussing groupware, the focus is on smaller groups, not organizations."	Software, small groups
(Ellis, Gibbs, & Rein, 1991)	"Computer-based systems that give support to groups of people engaged in a common task and that provide an interface to a shared environment."	Computer-based, support, groups, common task, shared environment
(Grudin, Groupware and social dynamics: eight challanges for developers, 1995)	"Software designed to support groups. Some examples: videoconferencing, voice applications, group calendars."	Software, support, groups
(Ellis & Wainer, 2004)	"Groupware, or in other words a collaboration technology, is a computing and communications technology-based system that assist groups and helps to support a shared environment."	Collaboration technology, assist, groups, shared environment
(Grudin & Poltrock, Computer Supported Cooperative Work , 2013)	"Groupware is focused on the technology, software designed with groups in mind."	Technology, software, groups
(Greenberg, 1991)	"Groupware is software that supports augments of group work."	Software, support, group work
(Lausen, 2004)	"Groupware is one aspect of a broader research field called: CSCW. It combines the understanding of the way how people work in groups with the enabling technologies of computer networking, and associated hardware, software techniques and services."	Groups, hardware, software, techniques, services
(Mohammed & Dahiru, 2015)	"Collaboration software' (groupware) is a term to describe computer applications that were explicitly designed to support group/teamwork."	Collaboration software, support, group, team

As depicted in Table 2, the literature does not agree on one simple definition of groupware. However, this paper does not use the term "collaboration software" as a synonym for groupware. Collaboration software only emphasizes software technologies.

Groupware is about collaboration technologies, which includes software and hardware. Both are needed for successful collaboration, especially in the broader research field of CSCW. Successful CSCW is dependent on groupware and group behavioral factors.

A new definition is constructed from the various definitions of groupware depicted in table 2. This new definition is used in this paper.

Groupware (or collaboration technology) are computer-based systems that support groups of participants to achieve a common task in a shared environment.

To clarify the definition, a computer-based system consists of software and hardware factors with the aim of supporting groups. Participants work in a shared environment. This can be in the same place or at the same time, or in a different place and different time. Finally, participants work together to achieve a common goal. Without a common goal, computer-based systems most likely only support the individual level of a user (Grudin, 1994). An overview is depicted in figure 2.

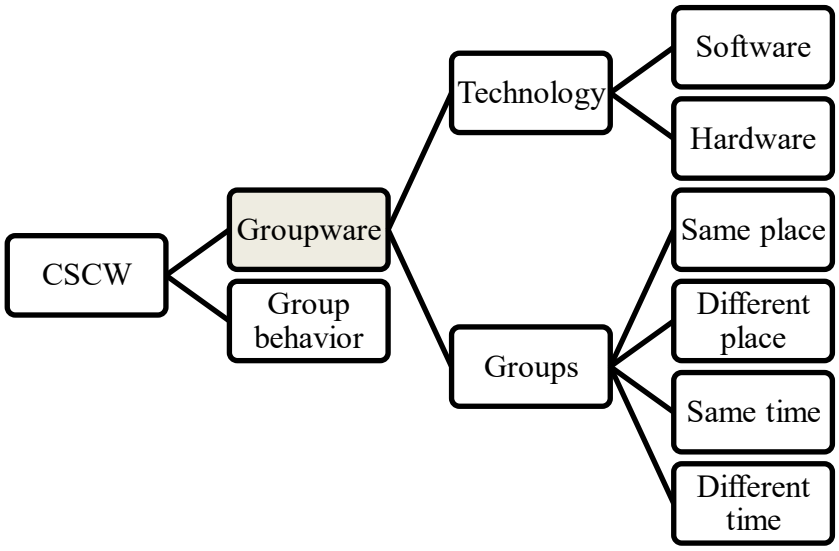

Figure 2 An overview of aspect of groupware

2.1.2 Computer-supported cooperative work

Groupware is one aspect of a broader research field called CSCW (Chagas, Fuks, & Souza, 2015). Computer-supported cooperative work is the research area that studies the use of communication and computing technologies to support group activities. The focus of CSCW is on how people collaborate and how technology can facilitate and enhance that collaboration (Ellis & Wainer, 2004). Computer-supported cooperative work

focusses on groupwork and is more than just a technology. Social scientists, technology developers, users, and other individuals are included (Grudin, 1994). While groupware has a more technical focus, CSCW examines collaboration and coordination within a group with the support of technology. Researchers have not agreed on one simple definition for CSCW, similarly to groupware.

The term "CSCW" has survived since 1984. However, the literature presents various definitions and focus areas of CSCW. Some have argued that CSCW has too many words. A different term has been mentioned: computer-supported collaboration (CSC) (Grudin, 1994). However, with CSC the term shifts the focus towards computer support and overlooks the importance of work.

Each word is further discussed in detail to provide more clarity in the definition of CSCW (Fouss & Chang, 2000):

- *Computer:* This term is used to define all technologies beyond simply computers. For example, a video is considered also considered to be within the research field of CSCW (Greenberg, 1991). Future computer technologies, hardware, and software are all included in the term "computer." However, the emphasis is on computer technologies.

- *Supported:* This term is used to define any computer technology that specifically supports or assists a group of individuals.

- *Cooperative:* This term refers to all group interactions. This includes cooperation, competition, and collaboration.

- *Work:* This term refers to the task or goal of a group. Social interaction and communication are needed to achieve work.

The literature on CSCW has many different definitions and focuses. There are a few explanations for this. First, the research area of CSCW is affected by a number of different disciplines. Sociology, psychology, management science, and computer science are just a few examples of disciplines that research the effects of CSCW (Fouss & Chang, 2000). All these disciplines should be taken into consideration while examining factors that influence CSCW. Second, new technologies create new ways of collaboration. For example, agile software development completely changed the way individuals collaborate (Abrahamsson, Salo, Jussi, & Warsta, 2017). Finally, the history and emergence of the term CSCW can explain the disagreement in definition and focus. The emergence of CSCW is derived from various computer system developments. Early computer system

developments focused on the individual user, later computers systems developments focuses on groups (Grudin & Poltrock, 2013).

Different definitions of CSCW with corresponding keywords are depicted in table X to find common ground and develop a new definition for CSCW. The focus is on the keywords to find important elements to construct a new definition.

Table 3 Different CSCW definitions with corresponding keywords

Author, year	**Definition**	**Keywords**
(Grudin & Poltrock, Computer Supported Cooperative Work , 2013)	"CSCW is a community of behavioral researchers and system builders at the intersection of collaborative behaviors and technology."	Collaborative behavior, technology
(Teruel M. , Navarro, Lopez-Jaquero, Montero, & Gonzalez, 2017)	"CSCW is about supporting multiple individuals working together with computer systems."	Multiple individuals, working together, computer systems
(Ellis, Gibbs, & Rein, 1991)	"CSCW looks at how groups work and seeks how technology (especially computers) can help them work."	Groups, technology
(Ellis & Wainer, 2004)	"The use of computing and communication technologies to support group activities."	Computing and communication technologies, support, group
(Poltrock & Grudin, Computer-Supported Cooperative Work and Groupware, 1994)	"CSCW focuses on work: the tasks people carry out, their workplaces and technology that could provide support."	Work, tasks, workplaces, technology
(Greenberg, 1991)	"CSCW is the scientific discipline that motivates and validates groupware design. It studies how people work together and how computer related technologies affect group behavior."	Computer related technology, group behavior
(Schmidt, 2016)	"CSCW in the research field in understanding cooperative work practices with the aim of contributing. Computing technologies that facilitate, mediate or regulate individual workers interdependent activities."	Cooperative work, computing, facilitate individuals

(Wulf, Rohde, Pipek, & Stevens, 2011)	"CSCW tries to apply computer science to deal with the challenges of an interrelation between social practices and ICT."	Social practices, ICT (information and communications technology)

As demonstrate in table 3, the literature does not agree on one simple definition of CSCW. Many researchers have emphasized specific factors of CSCW. In addition, some researchers have argued that groupware and CSCW are synonyms (Bannon, 1994). This is not supported in this paper. The focus of groupware is on computer-based systems to support a group. Besides computer-based technologies, CSCW also focusses on how groups work together and how technology affects that group behavior. Computer-supported cooperative work also shifted from research of small groups to groups in general, no matter the size (Wallace, Oji, & Anslow, 2017). Based on all the definitions, a new definition is developed for this paper as follows:

Computer-supported cooperative work is the research area that discusses the intersection between collaborative group behavior and computer-based technologies. It focusses on the work environment, group behavior, and on how computer-based systems affect those aspects.

2.2 Groupware characteristics, challenges, and classification models

2.2.1 Groupware characteristics

A deeper knowledge of groupware characteristics is needed before groupware challenges can be discussed. Each characteristic forms a challenge for groupware. In addition, the combination or interaction between different characteristics form a groupware challenge as well. In general, groupware can be separated into five major characteristic areas (Achmatowicz, 1994):

- *Distributed*
  Participants of a groupware session are normally not connected to the same psychical computer. Most participants use their own computer, which is connected to other computers through a network. Each participant may be in a different physical location. A distributed network of computers and participants form a challenge.

- *Shared environment*
  The goal of groupware is to use and create a shared working environment. Each participant should be able to join this shared environment. This environment could be a document, editor, virtual world, or any other application. A shared environment brings challenges to groupware. Accessibility, user rights, sharing and information storage for example.

- *Highly interactive*
  In the case of real-time groupware, there is significant interaction with other participants. Each participant would like to have the same response time as in an individual application. The aim of groupware is to be as close to the real world as possible. The feeling participants have in the real world must be comparable to those in the virtual world.

- *Closely coupled with other participants*
  Successful groupware requires information about other participants to be easily shared and communicated to each other. Without information sharing, groupwork is almost impossible. Since participants in groups are working closely together, information should be openly shared and not isolated.

- *Real-time notifications of events*
  This is a critical characteristic in groupware that is closely connected to the concept of close coupling. Since participants are working closely together with information sharing, groupware should work in real time. Participants need to know if someone enters or leaves the virtual world. Furthermore, when a participant edits a file, other participants need to be notified to avoid clashing simultaneous edits.

2.2.2 Groupware challenges

Groupware is the first and probably most important factor that influences CSCW. Overcoming technical obstacles does not always lead to guaranteed success. More obstacles need to be observed and overcome to achieve success; for example, the behavioral, social, and organizational factors that influence CSCW (Grudin & Poltrock, 2013). Different factors influencing CSCW overlap. All factors that influence CSCW must be covered to achieve success in implementing CSCW systems. Being successful in one area does lead to automatic success in all the other areas.

Challenges in groupware emerged the moment individual computers became connected through networks. PC applications were designed for the individual user based on

human factors (HF) and computer human interaction (CHI). Besides, systems were designed for an entire organization and not for specific groups. The first major challenges were identified by Grudin 1995: disparity between work and benefit, critical mass, social, political and motivational factors, exception handling, infrequently used features, difficulty of evaluation, intuitive decision-making and managing acceptance. Even though the challenges were identified more than 20 years ago, recent research has continued to cite and emphasize these groupware challenges (Lazarin & Almeida, 2016) (Olson & Olson, 2010). Grudin's (1995) eight challenges are discussed in more detail below:

- *Disparity between work and benefit*
  Groupware does never provide the same benefit for each individual group member. How much a member will benefit depends on their preferences, prior roles, assignments, and experience. The purpose of groupware is to obtain a collective benefit. In addition, some members must adjust more than others. Take the electronic calendar system, for example. The organizer of a meeting must check all the available times of the participating group members. In contrast, the individual group members only have to accept or decline the meeting invitation. In an ideal situation, everyone benefits equal from groupware. Finally, the design of groupware is also important; if it is designed for top management, other departments are likely to benefit less from the system.

- *Critical mass*
  Almost all groupware requires a high percentage of individuals to use the application. Without a critical mass, the application is most likely to fail. The application may fail even if it lacks only one or two users. Take the electronic calendar system as an example again. If one user does not use this system, a group organizer can never organize a meeting. Other individual applications should also be taken into consideration: users should all use the same application and should not have the possibility to choose between multiple applications.

- *Social, political, and motivational factors*
  Resistance to groupware may occur when it interferes with the complex social dynamics of groups. Groupware works at its best if all information is concrete and explicit. However, social, political, and motivational factors within groups are seldom stable or explicit, which makes them hard to control. For example, managers' free time is seldom free time. Group members know this, but the groupware does not. When a group member uses the automatic schedule assist to schedule a meeting with the manager, the meeting may be cancelled by the manger. Even this

happens too often, group members may resist the groupware. This inequality of information between group members and groupware puts the groupware at a disadvantage.

- *Exception handling*
  Groupware works at its best by a "working to rule" or "doing things by the book" approach. Group members, by contrast, can work in error handling situations, exception handling situations, and improvise when needed. Group members can adapt to fluctuations in work or find shortcuts in standard procedures, while groupware cannot.

- *Infrequently used features*
  Two issues arise with infrequently used features in groupware. First, they must not obstruct any frequently used feature. Second, the features must be known and accessible by group members. The discussion board on Microsoft Teams for example, it does not work when people only look at the conversations.

- *Difficulty of evaluation*
  Task analysis, design, and evaluation for single-user applications are much easier than for multi-user applications. For individual applications, the success is measured by only one member. For groupware, success is measured by multiple group members, all of whom have a different role and background. Evaluation in groupware takes longer. Lab experiments can be used for individual applications because they can capture important human-computer interaction factors. However, the same issue is more complex for groupware lab experiments. It is difficult to capture the complex social, motivational, political, and economic factors within groups. In addition Yasrab, Ferzund & Razzaq (2019 argue that groupware is more difficult to evaluate than individual applications because groupware is influenced by backgrounds and personalities from multiple group members. Besides, lab experiments cannot capture the complex social, economic, and political dynamics of groups. Each group is different and generalizing from groups for groupware is dangerous.

- *Intuitive decision-making*
  Decision making for groupware requires more knowledge and time in contrast to individual applications. Every application will most likely benefit one group more than another. Video conferencing is used more often by groups that commune a lot. Many decisions for individual applications draw on the intuition of the

manager. A manager with accurate intuition can quickly evaluate an individual application but most likely will fail when evaluating groupware. Given the disparity in benefit, managers often fail to recognize the downsides of groupware. Groupware may also require extra work for other group members, resulting in resistance. If a manager fails to properly evaluate groupware, it will most likely affect the acceptance of the application at a later phase.

- *Managing acceptance*
  The introduction of groupware must be done very carefully because the adaptation process plays a major role in the acceptance of a new groupware tool. Successful groupware must be accepted by all or at least the majority of the users. Individual applications may be successful if one out of five members use it. Groupware may be unsuccessful if only four out of five members use it.

Table 4 summarizes the first eight challenges. None of the challenges and solutions are isolated. Categories may overlap, interfere with, or contribute to another. For example, reducing the extra work required by non-beneficiaries will address the challenges of the disparity of work and the critical mass. Furthermore, not addressing the challenge of intuitive decision making will result in a more significant challenge of managing acceptance.

Table 4 Groupware challenges and solutions

Challenge	**Solution**
Disparity of work and benefit	Design groupware that will benefit each individual group member. Reduce extra work required by non-beneficiaries. Express the collective and indirect effect that each group member can participate in.
Critical mass	Reduce extra work required for all members of the group. Remove alternative individual applications that may interfere with the groupware.
Social, political, and motivation factors	Recognize the issue of social dynamics within a group and that information is not explicit and concrete. Work together with group members to discover hidden social, political, and motivational factors.
Exception handling	Learn how work is actually done and how people use the groupware to support that work.

Infrequent used features	Build on existing groupware instead of building new groupware. Create awareness for infrequently used features and use AI to find alternative procedures.
Difficulty of evaluation	Train managers and provide the resources to evaluate groupware.
Intuitive decision making	Recognize the issue of benefits in contrast to the extra work required by some group members.
Managing acceptance	Build on existing groupware to solve the problem. For new groupware, understand the environment for group members.

Recent work has demonstrated recent challenges in groupware: difficulty of evaluation, security issues, privacy, information access and updated notification (Yasrab, Ferzund, & Razzaq, 2019). Most challenges focus on new security threats in groupware. Challenges not discussed by Grudin (1995) are discussed.

- *Security issues*
  These issues pertain to the danger of attackers hacking personal or sensitive information from group members. Security of groupware is different from individual applications because multiple group members can access a new shared environment. External threats aside, internal threats can also form a new danger to the group.

- *Privacy*
  This issue pertains to the threat of an attacker hacking someone's identity and using it for wrong means. Developers must be aware of new possible privacy threats when they design groupware. Each group member shares personal information with other group members in a shared environment.

- *Information access*
  Information access and sharing are crucial in groupware. Even if data management and access are controlled by the owner, illegal access may still arise due to group members who are new to groupware and are still learning about the rules and policies.

- *Updated notification*
  Most groupware uses real-time notification systems. The threat arises if these notifications are used in a negative way.

Research from Yasrab, Ferzund & Razzaq (2019) has introduced security threats to groupware. Most importantly, designers and developers should take threats from group behavior into consideration when they develop groupware. Internal group threats also form another security risk. New emerging threats in groupware explains the ongoing relevance in CSCW.

2.2.3 Groupware and CSCW taxonomies

Taxonomies and classification models are applied to the variety of groupware. The taxonomies characterize and classify different areas within groupware to identify technologies that support different types of work. Taxonomies within groupware are important because some technologies are explicitly used to support a certain type of work (Grudin & Poltrock, 2013). Since groupware is part of the broader area of CSCW, all groupware taxonomies fall under the CSCW taxonomies as well. The literature contains various groupware taxonomies, and the most used and relevant ones are discussed below.

Time and space taxonomy: four-square model

The four-square model of time and space (Johansen, et al., 1991) is the most cited and used form of taxonomy. This groupware taxonomy has two major areas: time and space. Groups can work together in a real-time and synchronous interaction or work in a non-real-time and asynchronous interaction. Groups can work face-to-face in the same place, or groups can be distributed and work together over different locations. It is important to emphasize that the same place stands for the same physical place and not a virtual online place. The matrix that arises from these two areas is depicted in table 5 and table 6. The matrix consists of four quadrants, which are discussed below:

- *Same time, same place:* these are traditional face-to-face meetings in conference rooms. Unscheduled meetings anywhere within the office are also included in this quadrant.

- *Same time, different place:* group members who are dispersed but still communicate at the same time. Video calls, conference calls, instant messaging, and real-time document editors are included in this category.

- *Different time, same place:* group members who are collaborating in the office but at different times.

- *Different time, different place:* e-mail, voice mail and shared calendar systems are well known examples.

However, many organizations offer a 24/7 service for staff and customers. Therefore, some taxonomy matrices include a fifth cell: any time, any place. This fifth option integrates all four quadrants (Johansen B. , 2010). Each quadrant also does not operate in isolation; current groupware can have multiple functionalities within different quadrants. Take Microsoft Teams, for example. Videoconferencing, real-time file editing, and instant messaging are all within the "same time and different place" quadrant. Teams within Microsoft Teams are within the "different time and different place" quadrant.

Table 5 Four square model (Johansen, et al., 1991)

	Same place	**Different place**
Same time	Face-to-face interaction	Synchronous distributed interaction
Different time	Asynchronous interaction	Asynchronous distributed interaction

Table 6 builds on Johansen et al. (Johansen, et al., 1991) with recent well-known examples that are relevant for this research.

Table 6 Four square model examples (Johansen, et al., 1991)

	Same place	**Different place**
Same time	Electronic meeting room, conference room, hallway in the office, coffee area	Application sharing tools: Google Docs, Microsoft Office, Skype, Microsoft Teams messaging or calls
Different time	Shift work and team rooms	Emails, newsgroups, Microsoft Yammer, Microsoft Teams

Time and space taxonomy: nine-square model

Research from Grudin and Poltrock (1997) has built on Johansen et al. (1991) by extending the matrix with a new category. A different time or place can now be predictable or unpredictable. However, whether an event is predictable is very dynamic, and the squares do not have clear boundaries. Besides, the literature does not indicate much support for

the extended matrix of nine squares. Therefore, this matrix is not considered in this research.

Table 7 Nine square model (Grudin & Poltrock, 1997)

	Same place	**Different place but predictable**	**Different place and unpredictable**
Same time	Electronic meeting room	Desktop videoconferencing	Multicast events
Different time but predictable	Work shifts	Electronic mail	Newsgroups
Different time and unpredictable	Team rooms	Collaborative writing	Workflow

Functionality level taxonomy

Another approach to groupware taxonomies is categorizing on functionalities. Research by Ellis and Wainer (2004) has created a groupware functionality taxonomy. In short, the taxonomy consists of four categories (aspects) that are listed below:

- *Keepers* are the set of functionalities that fall within the manipulation, storage, access, and sharing of data. Data is the central point of the functionality.

- *Coordinators* are the functionalities that are related to the order and synchronization of all individual activities that make up the entire group process. The responsibility of the coordinator is to follow the predefined plan. Coordinators are responsible for enabling activities, notifying group members, inspecting current processes, and helping group members to manage their work.

- *Communicators* are the functionalities related to the communication among group members. This can be in the same time or in different times.

- *Team agents* are the functionalities related to the software components to perform functionalities to help dynamics within a group. Team agents are artificial participants. They provide performance or mediate group members for example.

However, the functionality taxonomy is neither complete nor categorial. Some functionalities fall within multiple aspects of the groupware taxonomy. Besides, some functionalities cannot be placed in an aspect at all. Furthermore, most groupware system

functionalities fall within the first three categories of the functionality taxonomy model (Ellis & Wainer, 2004).

Application level taxonomy

Another approach is to categorize groupware by the type of application. Research (Ellis, Gibbs, & Rein, 1991) has categorized groupware under message systems, multiuser editors, group decision support systems and electronic meeting rooms, computer conferencing, intelligent agents, and coordination systems. Many more groupware taxonomies can be found in the literature but are not relevant for this research paper.

2.3 Success factors in collaboration

The main goal of this research is to investigate which factors of CSCW support group collaboration. In addition to technological factors, group behavioral factors impact the success of group collaboration as well. CSCW supports groups in the communication, collaboration, and coordination of tasks (Grudin & Poltrock, 2012). Collaboration is defined as working with others on a task to achieve a common goal (Teruel M. , Navarro, López-Jaquero, Montero, & González, 2017). “Working with others” and a “common goal” are key in the definition.

To achieve successful collaboration, the following factors are considered: common ground, grounding and group interaction. All factors contain many variables and are discussed in this chapter. Because teams are distributed, groupware is needed to support these factors. The goal of this chapter is to develop and search for possible factors that influence the success of group collaboration. These factors are then tested in Chapter 4 against different groupware to determine success factors in CSCW. An overview of aspects in CSCW is illustrated in figure 3.

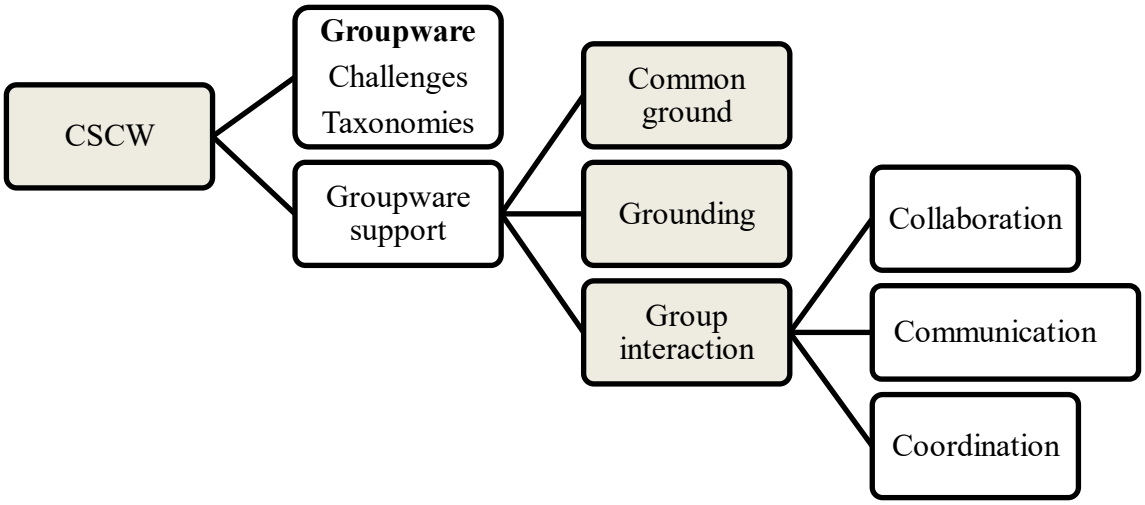

Figure 3 An overview of aspects in CSCW

2.3.1 Common ground

The concept of common ground needs further explanation before the concept of grounding can be discussed. For a group to act jointly, group members must coordinate what they do and when they do it. Group members must appeal to their common ground if they want to coordinate. Common ground is needed for each joint activity with others; these activities can be small or large. Besides, each new joint activity builds on existing common ground (Clark, 1996). Other notions of common ground are joint knowledge (McCarthy, 1990), mutual knowledge or belief (Schiffer, 1972), and common knowledge (Lewis, 1969). The common ground of groups is the sum of their common, joint, or mutual knowledge, beliefs, and suppositions. Self-awareness and awareness of the surroundings are crucial for common ground (Clark, 1996).

The following example explains common ground:

- *Situation:* Arthur, Bob, and Charles are standing in the same room. A table with an object on it is in the middle of the room. The object is a piece of paper.
- *Arthur* is aware of the situation and the object.
    - *Arthur* is also aware that Bob and Charles are aware of the situation and the object.
- *Bob* is aware of the situation and the object.
    - *Bob* is also aware that Arthur and Charles are aware of the situation and the object.
- *Charles* is aware of the situation and the object.

- *Charles* is also aware that Arthur and Bob are aware of the situation and the object.

In this situation, Arthur, Bob, and Charles form a group. The group has common ground that there is an object on the top of a table that is in the middle of the room. The group also has common ground that this object is a piece of paper. Each group member is aware of the situation and the object, but each group member is also aware that the other group members are aware of the situation and the object. Therefore, not a single group member can deny the existence of the object and miscommunication is prevented.

The group found common ground due to a shared basis. Finding a shared basis is crucial for common ground. A shared basis is needed for the coordination within the group (Clark, 1996). The group is now able to act together based on their common ground. The process of common ground is depicted in figure 4.

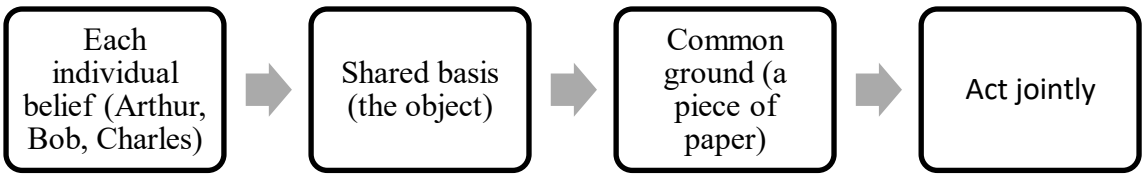

Figure 4 Process of common ground

Two more situations of common ground in a business setting are discussed. The following situations express the importance of finding common ground for groups to collaborate. Situation 1 succeeds in group collaboration, situation 2 fails. One situation is a face-to-face meeting, and the other is supported through groupware (Skype).

The situation

Arthur (from the Netherlands) and Bob (from the United States) are having a meeting to plan the expenses for the next year. Arthur has information about the expense budget on a piece of paper: the expense budget is € 15,000. Bob would like to know this information to make a joint decision. Amounts are written in US English, thousand separators are done by commas instead of periods.

Situation 1: A face-to-face meeting

Arthur and Bob are having discussion in the meeting room:

1. Bob: *Arthur, could you please provide me the expense budget for next year?*
2. Arthur: *Sure, it is 15,000.* Arthur shows Bob the paper with the € 15,000 value.
3. Bob: *Thanks, I see it is € 15,000, good to know. Let's invest € 5,000 in maintenance.*

4. Arthur: *Sure.*

In this situation, common ground is reached on a shared basis: a piece of paper with the € 15,000 value written on it. As common ground is achieved, Arthur and Bob can coordinate and act jointly to secure an investment of € 5,000 in maintenance. The process of successful collaboration of situation 1 is depicted in figure 5.

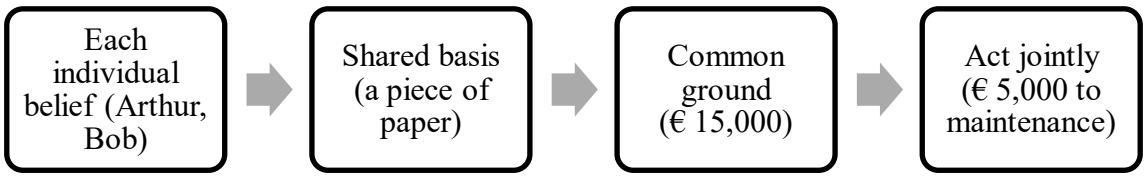

Figure 5 Finding successful common ground leads to successful group collaboration

Situation 2: A Skype meeting

Arthur and Bob are having a Skype discussion. Only audio conferencing is enabled, and both webcams are turned off.

1. Bob: *Arthur, could you please provide me the expense budget for next year?*
2. Arthur: *Sure, it is 15,000.* Arthur does not mention the amount in euro.
3. Bob: *Thanks, let's invest 5,000 in maintenance.* Bob thinks that the 5,000 is in U.S. dollars.
4. Arthur: *Sure.*

In situation 2, common ground is not properly reached because Arthur was thinking in Euro and Bob was thinking in American dollars. This is an example of finding common ground without a shared basis. Therefore, this will result in poor coordination and an incorrect joint activity. It is crucial for group members to work hard to find a shared basis for their common ground (Clark, 1996). Decisions based on different bases are depicted in figure 6. The result of two different bases is caused by miscommunication. A repair of their decision is needed to solve the issue.

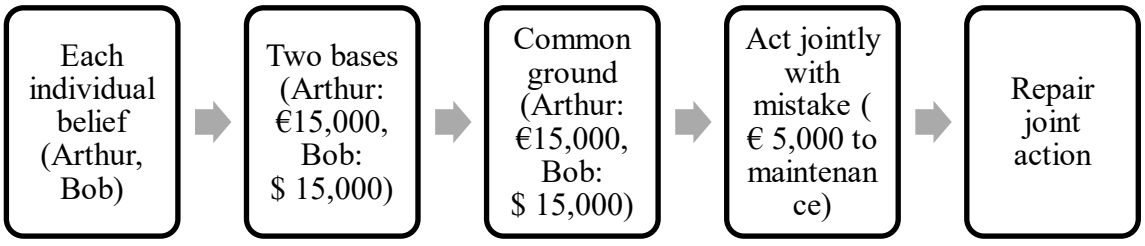

Figure 6 Different shared basis leads to a failure in group collaboration

Finding the right amount of shared bases is crucial for common ground. A shared basis is evidence of information that leads to common ground. People make use of two types of shared bases. The first type is based on evidence about the cultural community that people belong to. A shared basis of this type leads to communal common ground. The second type is based on the evidence from personal experiences with another person. A shared basis of this type leads to personal common ground. Groupware should support finding both types of shared bases. Communal common ground and personal common ground are discussed below (Clark, 1996):

1. *Communal common ground*
   Evidence that is based on the cultural community that people belong to leads to communal common ground. People categorize people by nationality, education, occupation, employment, hobbies, language, religion, or gender as a basis to infer their expertise about the community. In other words, people categorize one another by their communities. People can also be part of multiple communities at the same time. Each community has a basis of expertise about the community. People in the same community share the same basis, which improves finding communal common ground.

Figure 7 illustrates an example of Arthur and Charles. Arthur is Dutch and a university student in economics. In addition, Arthur speaks German as a second language. Charles is also Dutch and a university student in IT. Besides, Charles speaks French as a second language. Both persons share a basis in the Dutch language, culture, and university educational practices. This shared basis leads to communal common ground and is used in joint decision making. There is no shared basis in economic expertise, IT expertise, German and French language, which is why none are included in the communal common ground. However, knowing that Charles is an IT student still gives Arthur the awareness that Charles has some expertise in IT. To act jointly, Arthur and Charles must base their joint decision on their shared basis and avoid using their individual bases. Arthur and Charles can act jointly in Dutch, for example. Arthur and Charles cannot act jointly in German or French.

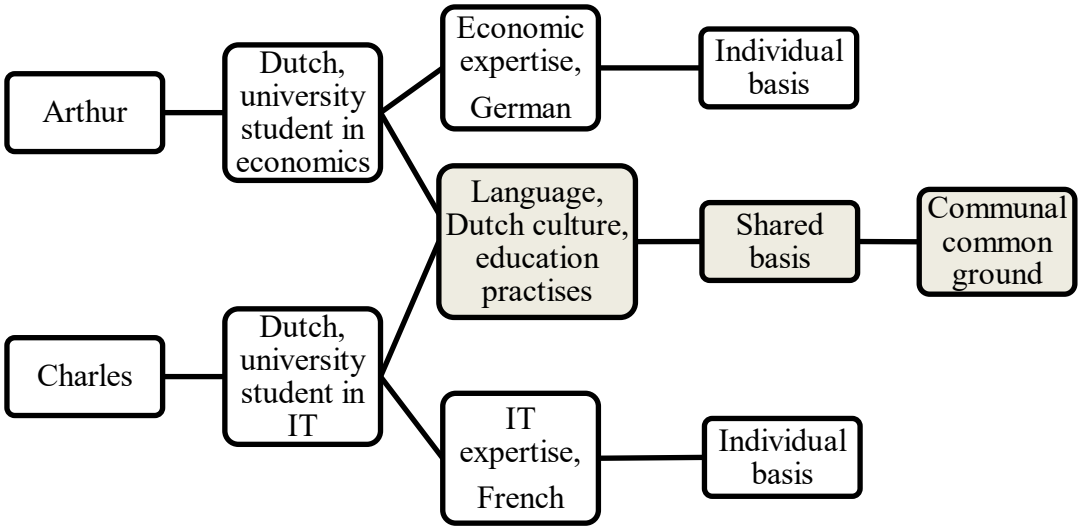

Figure 7 From left to right: name, community, area of expertise, type of basis, and communal common ground

Communal common ground and groupware

Groupware supports finding communal common ground, although it depends on which application is used. Microsoft Teams is used as an example of groupware that supports finding a shared basis. Within Teams, it is possible to see additional information about each person within the organization. An example is depicted in figure 8.

Figure 8 Microsoft Teams profile of Bastiaan Nabben

Before a user wishes to start a meeting with Bastiaan, they can find evidence for areas of expertise. This evidence can be used to form communal common ground with Bastiaan. Figure 8 indicates that Bastiaan is part of the following communities: men (gender), white (ethnicity), 20-30 years old (age), Dutch (culture and language), intern (employment), and product marketing (occupation). With this evidence, the user can assume Bastiaan has expertise within the following areas: the Dutch language, culture, economics and politics. Bastiaan also has expertise in product marketing and works as an intern. Compare

this information to a Microsoft Outlook profile, where only three communities can be found, men (gender), white (ethnicity) and 20-30 years old (age). Figure 9 illustrates an example of a Microsoft Outlook profile. Be aware, figure 9 illustrates a quick profile of Bastiaan. An extended profile is available but extra steps must be taken to get there. In addition, the main purpose of these examples is to explain the difference in finding a shared basis for communal common ground. Finally, Microsoft Outlook integrates the extended profile from Microsoft Teams. Without Microsoft Teams, the Microsoft Outlook profile may only contain name and e-mail address and therefore barely depict any evidence of communal common ground.

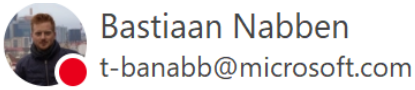

Figure 9 Microsoft Outlook profile of Bastiaan Nabben

The Skype meeting

Recall "Situation 2: a Skype meeting", a meeting that resulted in poor decision making for two reasons. First, Arthur and Bob did not find a shared basis, and common ground was not reached. Second, Arthur and Bob acted on their individual bases. Arthur is expecting to spend € 5,000 on maintenance. In contrast, Bob is expecting to spend $ 5,000 on maintenance. Both acted based on another currency. Arthur and Bob should have worked towards the shared basis of €15,000 in expenses for the next year.

Arthur and Bob should search for a shared basis that leads to communal common ground. Microsoft Teams may offer a solution by showing evidence of communities. Arthur can see that Bob works in the United States. At the same time, Bob notices that Arthur works in the Netherlands. Given this shared basis. Arthur may mention the 15,000 in euro to prevent miscommunication. In contrast, Bob can ask flor clarification of which currency is used. Bob is aware that Arthur may use the euro instead of the dollar.

Microsoft Outlook may also provide a solution. Since Arthur types the amount, a euro sign may be placed in the message. However, if this is not the case, the amount is depicted without currency. If Bob assumes that Arthur is also from the United States, no questions arise regarding the type of currency is used. Bob assumes the dollar is used. Table 8 depicts the results of using Microsoft Outlook compared to Microsoft Teams.

Table 8 Microsoft Outlook and Microsoft Teams (groupware) to support finding a shared basis that lead to common ground

	Outlook	**Outlook**	**Teams**	**Teams**
Evidence for communal common ground	Gender, ethnicity, age	Gender, ethnicity, age	Gender, ethnicity, age, nationality, occupation, employment	Gender, ethnicity, age, nationality, occupation, employment
Arthur	It is 15,000	It is € 15,000	It is € 15,000	It is 15,000
Bob	OK, thanks	OK, thanks	OK, thanks	Is it 15,000 euro or 15,000 dollars?
Result	€ 15,000 and $ 15,000	€ 15,000	€ 15,000	€ 15,000
Shared basis?	No	Yes	Yes	Yes

2. *Personal common ground*

   Joint or mutual personal experiences leads to personal common ground. A joint personal experience is a shared basis that can be used later for joint decisions. A discussion between Arthur and Bob leads to personal common ground, which later can be used again. Most of the joint personal experiences fall into two categories: joint perceptual experiences and joint actions. These two categories are briefly discussed below (Clark, 1996). A joint perceptual experience is based on perceptual bases. Joint actions are based on actional bases. Together, they form personal common ground.

   a. *Perceptual bases*

      A basis between two people arises when they share a perceptual experience. People can share a perceptual basis when they see, feel, hear, taste or smell things. Everyone has perceptual access to things in their perceptual shell. The moment two perceptual shells overlap, the creation of a perceptual basis is possible. However, for people to jointly experience the same event, they must be aware of the same things within this event. Jointly events are mainly established in three ways: by gestural activities, partner's activities or salient perceptual events.

- *Gestural indications:* gestures of a person. A person can use gestures to locate objects, events, and places. Arthur can point at a table in the middle of the room. Once Bob looks at the table, the table becomes part of Bob and Arthur's perceptual common ground.

- *Partner's activities:* activities by a person without the intention to communicate this activity to another. An activity could involve looking at people, picking up objects, or attending to things. If Arthur is looking at a piece of paper on the table, and Bob notices, Bob could say to Arthur: "Is this the expense report for next year?" By asking a question, Arthur is aware that Bob is also looking at the expense report. From this moment, they share the same basis of the expense report, which leads to personal common ground.

- *Salient perceptual events:* A salient event is an event that suddenly happens and catches the attention of multiple people. If Arthur hears a loud sound, and Bob is in the same room as Arthur, Arthur can assume that Bob heard the sound as well and may ask him: "What was that?" A shared basis is created, a loud sound, which leads to personal common ground. People can see, hear, smell, or feel salient events.

b. *Actional bases*

An actional basis of personal common ground is achieved by speech. Arthur can say to Bob: "Charles will arrive in 15 minutes." From this moment on, it is personal common ground that that Charles is arriving in 15 minutes. However, a few conditions must be met before common ground is reached. First, Bob must understand the English language. Second, Bob must understand the linguistics of all the words. Each word can have a different meaning for Arthur and Bob. The speakers must understand if they are talking about the same Charles and whether Charles is arriving in the office or in the meeting room, for example.

Communities have an impact on communal common ground. In contrast, friends and strangers have an impact on personal common ground. The closer people are, the more personal common ground they share. Strangers share no personal common ground; close friends share extensive personal common ground. If two people are close friends, they even share private information. This deepens mutual liking and trust (Clark, 1996). It can

be concluded that friends have a larger shared basis of personal common ground than strangers. Based on this, joint actions made by friends are more likely to succeed than those made by strangers.

Communities, friends, and families develop communal lexicons (Clark, 1996). Both lexicons make it difficult for outsiders to develop a shared basis. Outsiders do not know the meaning of personal lexicons used within a group.

Finally, common ground is the collection of everyone's shared bases. Communal common ground is based on the belief that a person is member of a community. Personal common ground is the collection of joint perceptual experiences and joint actions (Clark, 1996). The memory of individuals is important to recall a mutual shared basis. If memory cannot recall the shared basis, groupware can support this.

Personal common ground and groupware

Groupware supports finding a shared basis for personal common ground, especially when people are distributed globally. Video conferencing tools lead to perceptual bases, and audio-conferencing lead to actional bases. Without video and audio conferencing, it is almost impossible for distributed groups to create personal common ground.

Microsoft Teams is an example that supports lexicons and the sum of shared bases that lead to personal common ground, which is more difficult to achieve in face-to-face meetings. Lexicons that are used in a group can be written down under the *Files* or *Wiki* tab of a group, this is illustrated in figure 10. This is a significant advantage for strangers who have just joined the group because it has become possible for strangers to integrate in a new group much faster. However, the lexicons must be written down in the group, or nobody will be able to see them. Organizations should emphasize the importance of sharing lexicons in Microsoft Teams or any other groupware.

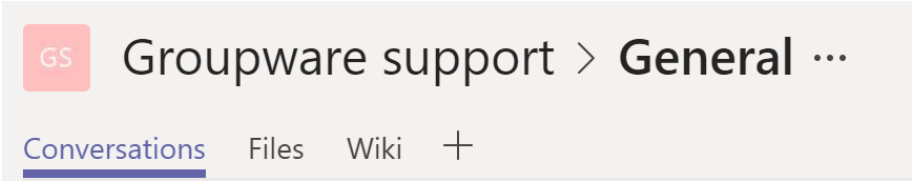

Figure 10 Lexicons can be saved under Files or Wiki to support personal common ground

The shared bases of group members can also be saved in Teams. All the shared information can be found within the Teams call before, during, or after the meeting. In addition, conversation, files, meeting notes, and whiteboard can always be found in Microsoft Teams. This supports the sum of personal shared bases. If someone cannot recall what was discussed in the last meeting, that information can be found in Microsoft Teams. Besides, people joining late for a meeting can catch up with the information provided

within Microsoft Teams. Figure 11 depicts an overview of a Teams call with all the relevant information.

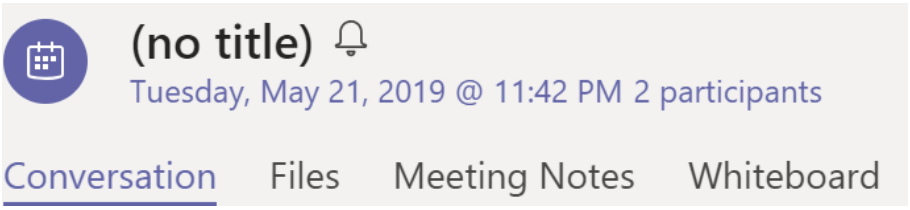

Figure 11 Teams meeting overview to support personal common ground

Shared bases that lead to personal common ground can be divided in four main categories: perceptual bases, actional bases, lexicon bases, and the sum of shared bases. All these categories are depicted in table 9 and are measures against relevant groupware. Microsoft Office 365 and G Suite applications are selected because they have the largest market share in business (Soni, 2018) (Statista, 2019). Table 9 depicts the extent to which each groupware supports finding a shared basis.

A checkmark is given when the application supports finding a clear shared basis for personal common ground. A cross is given when the application does not support a finding a clear shared basis. For example, it is possible in Microsoft Outlook to find the sum of shared personal bases. However, Microsoft Outlook does not provide a clear overview for entire groups. Group members can e-mail each other without mentioning the entire team for example. This leads to shared bases for specific members within the group and is therefore not sufficient for the sum of shared personal bases. Within Microsoft Teams in contrast, it is possible to keep the discussion within one group so that everyone is always updated. This results in a clear shared basis for personal common ground.

Table 9 Microsoft Office 365 and G Suite groupware supporting shared bases of personal common ground

	Perceptual bases	**Actional bases**	**Lexicon bases**	**Sum of shared personal bases**
Microsoft Outlook	×	×	×	×
Microsoft Office 365 online	×	×	✓	×
Microsoft Teams	✓	✓	✓	✓
Gmail	×	×	×	×
Google Groups	×	×	✓	×
Google Docs online	×	×	✓	×
Google Meet	✓	✓	×	×

Table 9 illustrates that Microsoft Teams has the most potential in finding a shared basis that leads to personal common ground. More common ground leads to more joint actions, a state of affairs that is better for group collaboration (Clark, 1996).

The following paragraphs explain the sum of shared personal bases in greater detail. The sum of shared personal bases includes personal bases, actional bases and lexicons bases. Groupware must contain all the shared information of a group to satisfy the criterion of the sum of shared personal common ground bases. This information includes messages, files, team meetings, team updates, and so on. Teams is the only application that can support this, and it is depicted in figure 12.

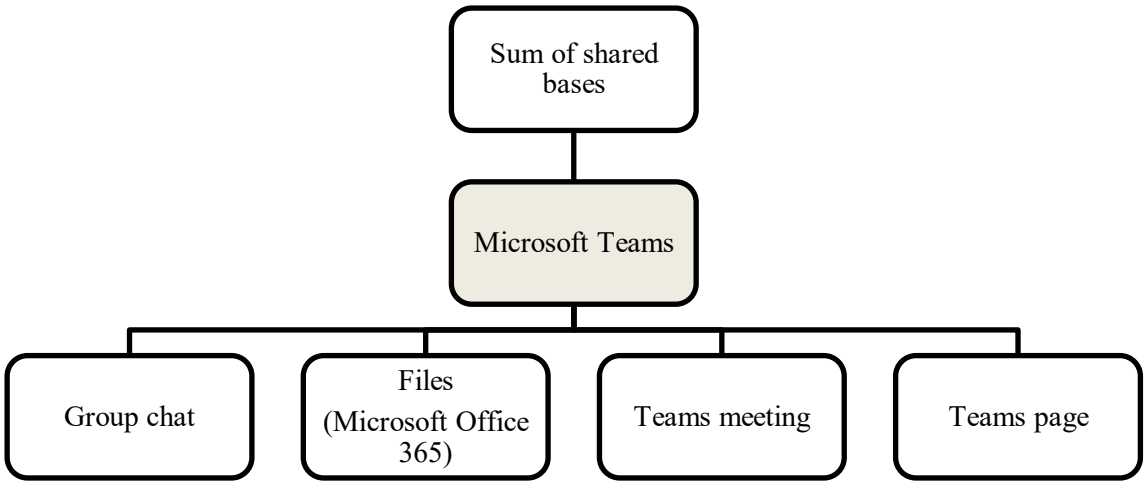

Figure 12 Microsoft Teams integrate all personal bases in one application

Figure 12 depicts the importance of the integration of various functionalities in Microsoft Teams. Groups can share all the information in one application. This leads to greater personal common, better joint decision making and less miscommunication.

The following example illustrates the importance of this integration. Arthur, Bob and Charles are working together on a project. In the first meeting, they all worked together in Excel online. They concluded that the maintenance expenses for next year will be € 5,000. After the meeting, Arthur sent Bob an e-mail with new tax regulations. Arthur forgot ton include Charles. Based on these new regulations, Arthur and Bob decided to decrease the maintenance expenses by € 1,000. However, these changes were not made in Excel or communicated to Charles. At the same time, Charles sent an email to the finance department with a request for € 5,000 in maintenance expenses for next year. The group failed because different bases of information were used to make a decision. This was due to the use of two different applications. The example is depicted in figure 13. Microsoft Teams may have solved the issue. First, the Excel meeting should have taken place within Microsoft Teams shared files section. Secondly, Arthur could simply update the group within Microsoft Teams about the change in expenses. Joint decision making failed because two applications were used instead of one. To conclude, integrate as many features as possible in groupware to prevent a disparity of information. A disparity of information that leads to different shared bases and bad decision making.

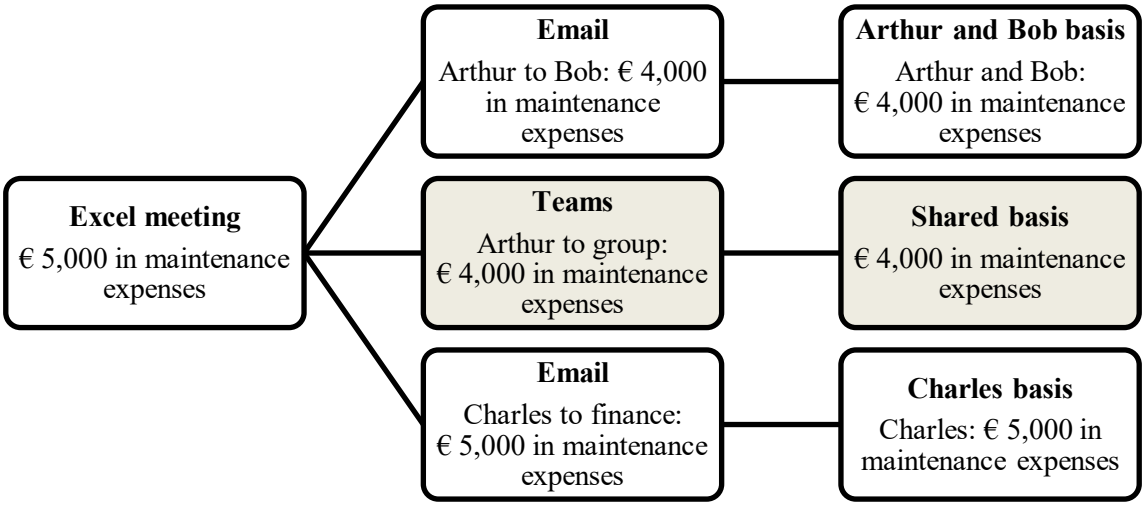

Figure 13 Achieving personal common ground with groupware

2.3.2 Grounding

Shared bases of information lead to common ground. Common ground is needed for groups to coordinate joint activities, which eventually leads to better collaboration. Grounding is about establishing this common ground. People try to ground all their actions and what they are doing together. Grounding should be done in all levels of communication. For example, Arthur, Bob, and Charles need to successfully understand each other to create a shared basis. To achieve this goal, they try to ground what they are doing together. There are a few principles that people use to ground their actions. Understanding these principles helps to find the criteria needed for groupware to support grounding, and finally better group collaboration. There are four major principles in grounding: closure of actions, joint closures and contributions (Clark, 1996). This research builds on Clark's research Clark (1996) with new and more business-related examples of grounding. Figure 14 depicts an overview of the grounding process.

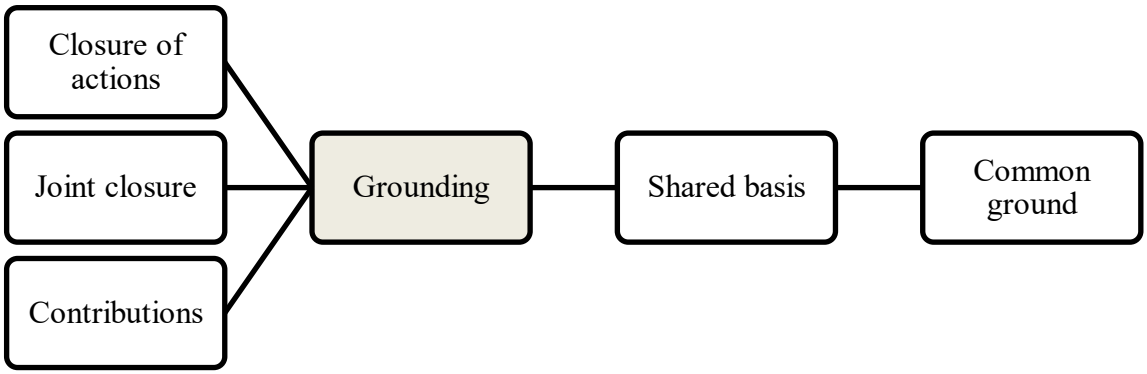

Figure 14 Principles that lead to grounding

Closure of actions

People always look for evidence in the results of their actions. People search for evidence about what they have done in contrast to what they intended to do. Without evidence, people may try their action again until they succeed. Calling an elevator by pressing the up button is a typical example of a closure of action. The moment a person presses the "up" button, that person expects evidence for their action. People want to feel the button depress under their finger and see the up light turn on. If people do not have this feeling, or the light does not turn on, people will try their action again.

Another example is found in Dutch traffic lights. Bikers must press a button to indicate that they want to cross. However, old bike light buttons did not indicate any form of feedback, which caused people to smash the button multiple times before the light turned green. To solve the problem, the new bike light buttons have created two forms of feedback: light and the button depressing. Besides looking for evidence, people like to be in control. Many traffic light buttons do not even work. The function of the button is to put people in control, which tends to calm people down (RTL Nieuws, 2016) (Jong & Penris, 2016).

Figure 15 New traffic light with feedback in light

In a business setting, people always look for evidence of their actions. A typical example is found in video conferencing: *"Can you hear me?"* is one of the most used actions of closure. Without any feedback, people will repeat this phrase multiple times. Therefore, it is critical for groupware to include as much feedback evidence as possible.

Evidence of closure should be sufficient for current purposes. This means that evidence should not exaggerate, or people may become frustrated. An elevator that makes a sound every three seconds to indicate that it is coming is very exaggerated.

Sufficient evidence is based on three criteria: validity, economy of effort and timeliness:

- *Validity:* evidence must be valid, reliable, and interpretable for it to be useful. An up light for an elevator would not be reliable if the elevator goes down.

- *Economy of effort:* evidence must be easy to acquire. The benefit of the evidence must surpass the effort taken to achieve it. Holding the up button for 30 seconds before the light turns on may be too much effort.

- *Timeliness:* evidence must be on time. People work in sequences. If one action is closed, people move on to the next one. Furthermore, not finding evidence on time may result in repeatedly performing the same action. If the up light of an elevator takes 10 seconds to turn on, that may be too late.

Most importantly, evidence must be sufficient for current purposes, and validity, economy of effort, and timeliness help to achieve this.

Joint closures

Besides individual closure, groups also need evidence that their joint actions result in closure. Groups search for evidence, and if they cannot find it, they will try the action again, repair the action, or stop before taking the next action. The principle of joint closure is as follows: people try to establish a joint belief that they have sufficiently succeeded for their current purposes. All group members need evidence for their own actions and the actions of another. If people cannot show their action to another, grounding is not possible. People need evidence for another's actions.

Imagine Arthur and Bob are working together in a shared Excel file. The moment Arthur inserts € 5,000 in maintenance costs, he can immediately see his input in Excel as evidence for his action. However, due to a poor connection, Bob does not see Arthur's input in Excel. Both Arthur and Bob cannot close their joint activity. In addition, both Arthur and Bob try to succeed with the least joint effort. Everyone tries to close their own action with the least amount of effort. In the example given, Arthur is done and waits for Bob to reply. Bob sees nothing and is waiting for an input from Arthur. This finding is very interesting for groupware. Many groupware techniques focus on evidence for success. It may be a useful alternative to display evidence for failure as well. Notifying a failure helps both group members to realize that a solution is needed to continue.

Contributions

People contribute in conversations to put effort into reaching joint closures. People contribute to discourse to signal their understanding. Without discourse, joint closures are very difficult to establish. Demonstrating a signal of understanding could be positive or negative. Positive evidence must be found to reach joint closure. Assume Arthur is communicating to Bob. Arthur should search for positive evidence in Bob, and Bob should signal positive evidence back to Arthur and vice versa. There are four classes of signaling, and the following paragraph explains them through a conversation between Arthur and Bob.

- *Assertions of understanding:* both can smile, nod, or respond with "okay," "uhum," and "right" to signal understanding.

- *Presuppositions of understanding:* if Arthur continues talking or moves on to the next phase of the story, he presupposes that Bob understood the first part. Otherwise, Bob should have interfered in the story.

- *Displays of understanding:* if Arthur is asking Bob a question and Bob replies, this is a display of understanding from Bob.

- *Exemplifications of understanding:* both can exemplify their understanding by repeating what the other person said or using non-verbal communication to express their feelings about the situation. When one is exemplifying their understanding, the other can check for the signal.

It is critical for groupware to include signaling. Signaling supports grounding, and grounding supports finding a common ground. Besides, contributions can either be concluded or continued. In concluded contributions, group members signal understanding by proceeding to the next contribution. Group members both talk at the same level of communication. An example of concluded contributions is indicated below:

Arthur: *Bob, what are you?*
Bob: *I am an IT professional.*
Arthur: *That's nice.*

There is evidence on three levels.

1. Bob does not ask for clarification and believes he understands what Arthur meant.
2. Bob gives an answer as the next contribution. Bob is displaying that Arthur asked a question.
3. Bob gives an appropriate answer. Bob displays that he understood the question.

It is important to point out that Arthur had the possibility to interfere in Bob's reply. By not doing so, Arthur signals his understanding of the question to Bob.

In continuing contributions, understanding is in the background of the conversation. A major advantage of continuing contributions is that the conversation can go on while grounding is happening. While Arthur is telling his story, Bob can signal assertions of understanding. Both types of contributions help in grounding joint actions.

Based on the different principles of establishing grounding, a new overview is provided in figure 16. Groupware should include these principles to support groups in the grounding of their joint activities. These principles are tested in chapter 4.

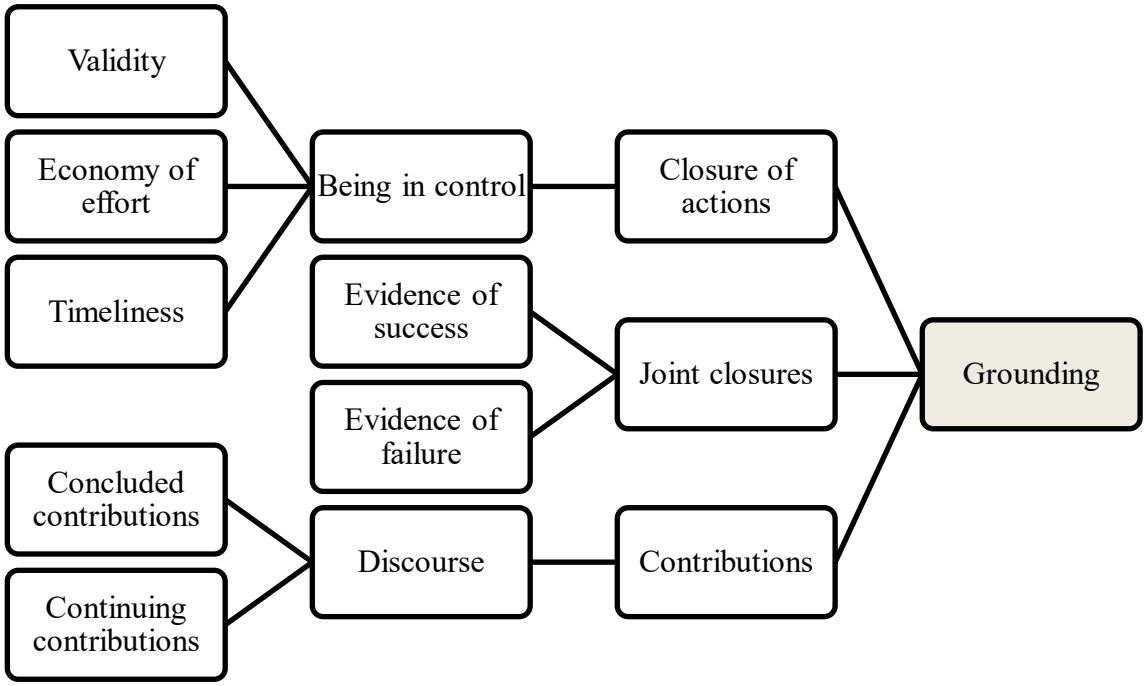

Figure 16 Principles to establish grounding

2.3.3 The 3C model

Most computer-based systems were designed to support the interaction between user and computer. Groupware systems should be designed for user-to-user interaction, otherwise known as group interactions. Understanding of group interaction is needed to support group collaboration. Group interaction consists of three major areas: communication, coordination, and collaboration (Ellis, Gibbs, & Rein, 1991). This is known as the 3C model and is discussed below. Research from Grudin and Poltrock (2013) has suggested to focus on three different areas of group interaction: communication, coordination, and information sharing. However, information sharing is included within the concept of communication in this paper, and therefore Grudin and Poltrock's (2013) approach is not used.

Communication

Communication is the process whereby messages or information are sent from one person or place to another (Valacich & Schneider, 2014). People share information and try to create a shared reality. Virtual teams changed the way people communicated. Communication can either be synchronous, which means at the same time, or asynchronous, which means at different times (Johansen, et al., 1991). Virtual teams are a group of members that are in different physical locations. Computer-mediated communication is needed to enable group members to send and share information (Peters & Manz, 2007). Groupware

can support synchronous communication, asynchronous communication, or both. In general, virtual teams can communicate in four different ways: written, visual, verbal, and non-verbal (Thissen, Page, Bharathi, & Austin, 2007).

- *Written (text):* messages and information in the form of written text.

- *Visual (graphics and animations):* messages and information in the form of visuals. Especially useful when technology is facilitating visual information.

- *Verbal (audio):* messages and information in the form of speech.

- *Non-verbal (video):* messages and information without speech in the form of body language.

Physical teams have one major advantage over virtual teams: physical interaction (Ebrahim, Ahmed, & Taha, 2009). Group members can shake hands and exchange physical objects, for example. Technology can never replace physical interaction, but it is critical to understand the advantages of physical collaboration over virtual collaboration.

Groupware that facilitates written, visual, verbal, and non-verbal communication increases the success in group interaction and group collaboration. Additionally, groupware that supports synchronous and asynchronous communication also improves group interaction.

Coordination

Successful coordination involves all group members working together towards a shared objective. All tasks and activities need to be specified for each group member. Each group member must know their personal task, role, and place in the group. A coordination problem arises when a shared objective is dependent on multiple group members. The success of a person's action is dependent on the success of another person's action. Group members are mutually dependent. (Schelling, 1960). Coordination is needed because distributed activities are highly interdependent. Each group member performs their own actions. Therefore, coordination ensures that all individual actions are coordinated to achieve the desired result. Technology can support coordination in three major areas (Klein, 1996):

1. *Distribution across participants:* support for the flow of tasks and information among group members. Groupware must support scheduling, workflow, and process managing, for example.

2. *Distribution across perspectives:* support for conflict management. Group members have different perspectives and goals on the shared project. Resolving conflict usually starts with how the conflict occurred and why. The history of decisions needs to be accessed. Afterwards, multiple steps are taken to resolve the issue. In many cases, negotiations occur between the group members.

3. *Distribution across time:* information and decisions that are made at an earlier stage must be available at a later stage. Groupware must support information access at all times.

Collaboration

Collaboration enables group members to update their actions, decisions, and information with the group (Klein, 1996). In addition, group members collaborate and help each other to achieve a common goal. A collaboration is a mutually beneficial relationship between two or more people to achieve a common goal (Mattessich & Monsey, 1992). However, for any type of collaboration, some sort of trust needs to be in place. Groupware should support creating trust (Coleman & Levine, 2008).

Successful collaboration factors can be grouped into six categories: environment, membership, process, communication, purpose, and resources (Mattessich & Monsey, 1992). Groupware supports the membership, communication, and purpose factors. Each factor has multiple sub-factors:

- *Membership:* feeling of ownership, involved in decision making, flexibility, clear rules and guidelines, and adaptability of the group.

- *Communication:* open and frequent, formal, and informal.

- *Purpose:* concrete goals and objectives, shared vision, and unique purpose.

Figure 17 depicts the possible factors that influence group behavior. All factors are measured against different types of groupware in chapter 4.

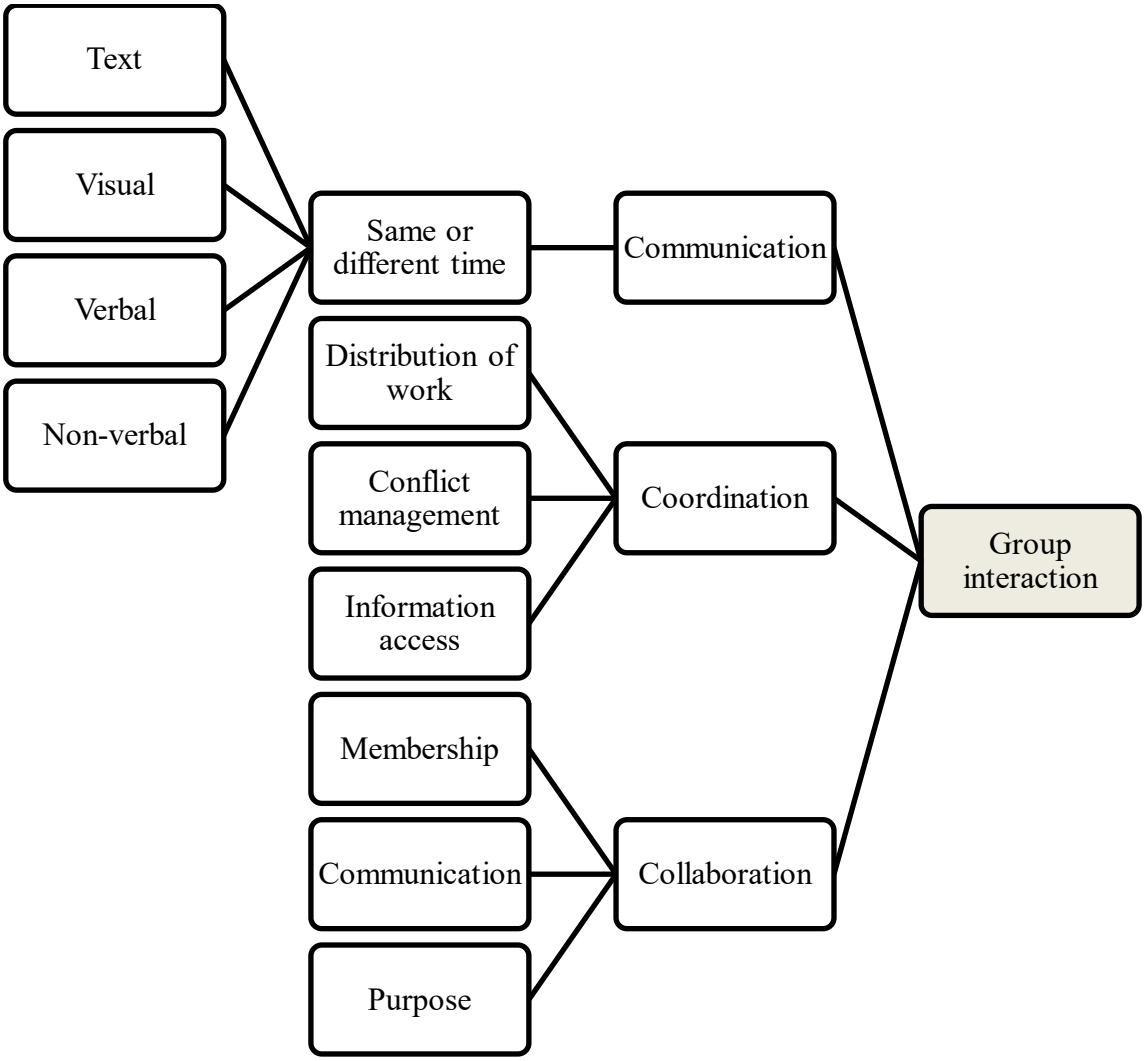

Figure 17 Factors influencing group interaction

3 METHODOLOGY

3.1 Methodology

Chapter 3.1 discusses the methodology used in this paper. Based on the literature, use cases and interviews are conducted to test the different factors in CSCW. Chapter 3.2 describes the use cases and the tested variables. The results are shown in chapter 4.

This research aims to find answers to the following research questions. In addition, each research questions are tested with different variables. The variables can be found in the indicated paragraph.

- *RQ1: how to tackle groupware challenges (3.2.2)?*
- *RQ2: which groupware taxonomy supports group collaboration (3.2.3.)?*
- *RQ3: which groupware factors support finding common ground (3.2.4.)?*
- *RQ4: which groupware factors support grounding (3.2.5.)?*
- *RQ5: which groupware factors support group interaction (3.2.6)?*

Eventually, these research questions find evidence to answer the main research question:

Which factors of CSCW support group collaboration?

Different use cases are constructed to measure the effectiveness of different variables on group collaboration success. Each use case consists of a different type of groupware that supports group collaboration. Each groupware is measured against the same variables to determine the success of group collaboration. Eventually, all groupware techniques are compared. The type of groupware that succeeded in supporting group collaboration contains success factors for group collaboration. This research method is depicted in figure 18.

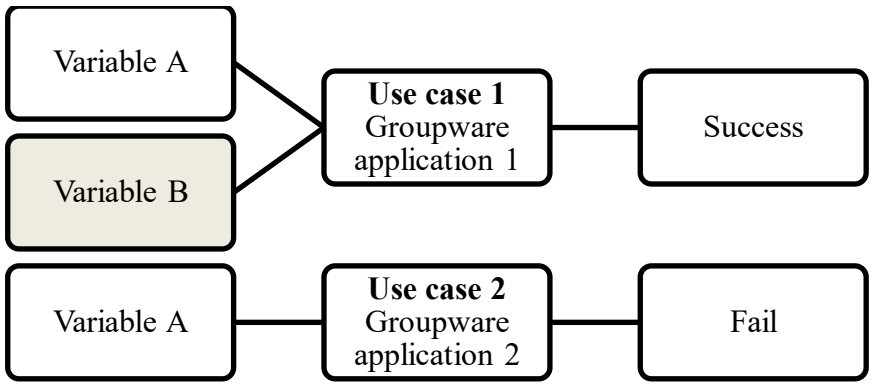

Figure 18 Comparing different use cases

Figure 18 illustrates that variable B is a success factor for group collaboration. If use case 2 is also a success, two conclusions can be drawn: either both variables are success factors, or a third unknown variable caused the success in group collaboration. To be scientific, more than 20 variables were measured in six use cases. Comparing all use cases with the variables provided scientific proof of the success of the variables regarding group collaboration.

In addition, three interviews were conducted to identify success factors in the Surface Hub 2 (Hub 2), which is one of the newest groupware collaboration tools. Besides, these interviews demonstrate different success factors that were missed in the literature. The interviews provided deeper insights about the Hub 2 and how this groupware collaboration device supports group collaboration. In addition, features of the Hub 2 and other groupware were discussed.

The interviews were conducted with Microsoft sales representatives, all of whom were part of the Surface Devices team and specialized in the Hub 2. All interviewees were selected for their coverage of a different Microsoft sales area to increase scientific relevance and reduce bias. One covered the Netherlands; one covered Europe, the Middle East, and Africa; and the last one covered the United States.

A list of success factors that positively supports group collaboration was constructed as the product of this research. Future groupware should include these success factors to be more successful in group collaboration.

3.2 Variables and use cases

This section presents a situation to measure and test the effectiveness of the different variables. Different groupware (use cases) are tested on the situation to measure effectiveness, these are described in 3.2.1. until 3.2.7.. Once the groupware positively contributes to the outcome of the situation, it can be concluded that the variables within the

groupware are success factors for group collaboration. The result is a list of success factors of groupware. An overview is depicted in figure 19.

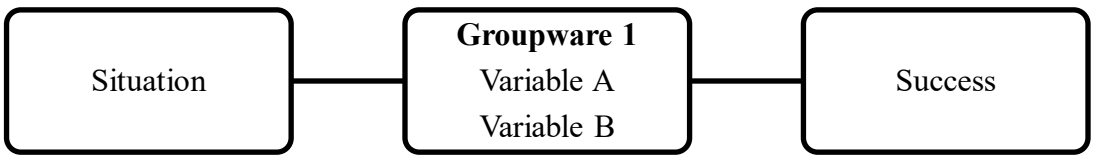

Figure 19 Variable A and B are success factors in groupware.

The second approach is to compare different types of groupware to determine the effect of each variable. If, for example, one groupware succeeds and another fails, the underlying variables may explain this difference. This is depicted in figure 20.

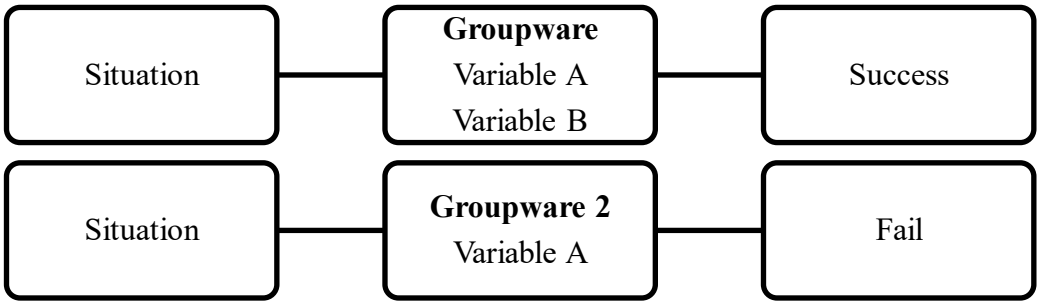

Figure 20 Variable A and B together are success factors; variable A alone is not sufficient.

Each piece of groupware (use case) consists of at least one extra variable over the previous one. This is needed to for compare the success of different variables. For example:

Use case 1 includes variable A.
Use case 2 includes variable A and B.
Use case 3 includes variables A, B, C, and D.

This approach makes it possible to measure the effect of each single variable and the combination of them.

The use cases use the following groupware:

A. E-mail (Microsoft Outlook)
B. Audio conferencing (Microsoft Skype)
C. Audio and video conferencing (Microsoft Skype)
D. Audio and video conferencing with file sharing (Google Meet and Google Docs)
E. Individually distributed group work (Microsoft Teams)

F. Collaboratively distributed group work (Microsoft Hub 2)

The Microsoft Office 365 and G Suite groupware technologies are selected because they cover the largest market share in business (Statista, 2019) (Soni, 2018). All use cases were tested based on the literature review, the interviews and the researcher's knowledge about the different groupware. Given the scope and time of the research, not all results are discussed, only the most interesting findings.

3.2.1 The situation

Arthur, Bob, Charles, David, and Emily are distributed globally and form a group. The group needs to collaborate to achieve a common goal: to formulate the goals, income, and expenses for 2020. Each group member has valuable information that contributes to the common goal, and everyone is needed for success. Arthur and Charles have worked together before. Nobody else knows anyone else. The group is globally disturbed, and groupware is needed to support group collaboration.

Table 10 An overview of group characteristics of the situation

	Arthur	**Bob**	**Charles**	**David**	**Emily**
Nationality	Dutch	Dutch	American	Chinese	Japanese
Location	Nether-lands	Netherlands	United States	China	Japan
Gender	Man	Man	Man	Man	Woman
Profession	IT	Finance	IT	Legal	Account-ancy
Information	Goals for 2020	Expense report of 2019	Income forecast of 2020	Tax regulations	Expense forecast for 2020

3.2.2 Eight groupware challenges (RQ1)

All use cases were tested against the eight groupware challenges. The main goal is to find out the following:

1. How to tackle groupware challenges?
2. Which groupware challenges are most common?

The symbols have the following meaning:

- ✓ Groupware can tackle the challenge
- × Groupware cannot tackle the challenge

Table 11 Use cases measured against groupware challenges

	Use cases					
Challenge	**A**	**B**	**C**	**D**	**E**	**F**
Disparity between work and benefit	✓	×	?	✓	×	?
Critical mass						
Social, political, and motivational factors						
Exception handling						
Infrequent used features						
Difficulty of evaluation						
Intuitive decision making						
Managing acceptance						
Total						

3.2.3 The four-square matrix (RQ2)

All use cases are measured in the four-square matrix. The main goal is to determine

1. Which square in the four-square matrix positively (or negatively) influences group collaboration?

Table 12 Use cases measured in the four-square matrix

	Same place	**Different place**
Same time	A, B	E
Different time	C, D	F

3.2.4 Common ground (RQ3)

All use cases were measured against common ground bases. The main goal is to find out

1. Which groupware factors support finding common ground?

The symbols have the following meaning (same for 3.2.5 and 3.2.6):

- ✓ Groupware supports finding a shared basis
- × Groupware does not support finding a shared basis

Table 13 Use cases measured against common ground variables

	Use cases					
Variables	**A**	**B**	**C**	**D**	**E**	**F**
Communal bases	✓	×	?	✓	×	?
Perceptual bases						
Actional bases						
Lexicon bases						
Sum of personal bases						
Total						

3.2.5 Grounding (RQ4)

All use cases were measured against common grounding variables. The main goal is to find out

1. Which groupware factors support finding grounding?

Table 14 Use cases measured against grounding variables

		Use cases					
Variables	**Sub variables**	**A**	**B**	**C**	**D**	**E**	**F**
Closure of actions	Validity	✓	×	?	✓	×	?
	Economy of effort						
	Timeliness						
Joint closure	Evidence of success						
	Evidence of failure						
Contributions	Discourse						
	Concluded						
	Continuous						
Total							

3.2.6 3C model (RQ5)

All use cases were measured against common grounding variables. The main goal is to find out

1. Which groupware factors support group interaction?

Table 15 Use cases measured against group interaction variables

		Use cases					
Variables	**Sub variables**	**A**	**B**	**C**	**D**	**E**	**F**
Communication	Text	✓	×	?	✓	×	?
	Visual						
	Verbal						
	Non-verbal						
Coordination	Distribution of work						
	Conflict management						
	Information access						
Collaboration	Membership						
	Communication						
	Purpose						
Total							

3.2.7 Interviews

The interviews provide more detail about how the Microsoft Hub 2 supports group collaboration. These interviews provide information to fill in the use cases but also explore different unseen factors that may influence group collaboration. The results demonstrate different groupware-related factors that influence group collaboration. In addition, the interviews provided more information regarding other groupware.

Two interviews were conducted in Dutch with the use of Microsoft Teams. Audio and video conferencing were used. The last interview was in English and executed by e-mail.

4 RESULTS

4.1 Use cases

The use cases in this study are abbreviated to A, B, C, D, E and F to easily depict them in the result tables. All use cases use another groupware to support the overall success of group collaboration.

A. *E-mail (Microsoft Outlook):* Microsoft Outlook is used for e-mail and scheduling.

B. *Audio conferencing (Skype):* group members can call each other for planned or unplanned meetings. Microsoft Outlook is integrated in Skype meetings.

C. *Audio and video conferencing (Skype):* group members can call each other for planned or unplanned meetings. Microsoft Outlook is integrated for Skype meetings.

D. *Audio and video conferencing with file sharing (Google Meet and Google Docs):* Group members can call each other for planned or unplanned meetings and work on shared files. Google Calendar is integrated in Google Meet.

E. *Individual distributed group collaboration (Microsoft Teams):* all activities within Microsoft Teams: video calls, instant messaging, team updates, and team scheduling. Microsoft Outlook is integrated in Microsoft Teams.

F. *Collaborative distributed group collaboration (Microsoft Hub 2):* group members use the Hub 2 (Hub 2) with the most commonly used applications: Microsoft Whiteboard, Microsoft Teams, and Microsoft PowerPoint.

4.2 Findings

Given the scope and time of this research it is not possible to discuss all the findings found in chapter 4.1.1 to 4.1.5. Only the most important findings are discussed to draw conclusions on. Results are found by exploring, examining and testing all the groupware against each variable. Different findings are possible, however, the aim of this research is to find

major differences between groupware to determine success factors. The literature, interviews and researcher's groupware knowledge support these findings.

4.2.1 Eight groupware challenges

For each use case, groupware will face some degree of a challenge. However, some groupware technologies have a higher likelihood of successfully tackling the challenge then others. Some answers are very straightforward, while others are further discussed.

Table 16 Results of groupware challenges

	Use cases					
Challenge	**A**	**B**	**C**	**D**	**E**	**F**
Disparity between work and benefit	✓	✓	✓	✓	×	×
Critical mass	×	×	×	×	✓	✓
Social, political and motivational factors	×	×	×	×	✓	✓
Exception handling	×	×	×	×	✓	✓
Infrequently used features	✓	✓	✓	✓	×	×
Difficulty of evaluation	✓	✓	✓	✓	×	×
Intuitive decision making	✓	✓	✓	✓	×	×
Managing acceptance	✓	✓	✓	✓	×	×
Total	5	5	5	5	3	3

Findings

Earlier or well-known groupware do not face much disparity between work and benefit anymore. Someone may work more to plan a meeting, but the same person is most likely to start or lead the meeting as well, which probably leads to more benefit. Besides, most groupware is well known in the business environment and all use case groupware are easy to learn. However, due to the many features in the Hub 2, it requires more training for efficient use. The same goes for Microsoft Teams. Many individuals still struggle to switch from Skype for business to Microsoft Teams.

In general, all use cases faced challenges; however, the type of challenge is different. There is a correlation between the number of features and the type of challenges a groupware technology face. The less features groupware has, the easier it is to control infrequently used features, evaluation, decision making, and acceptance. A manger deciding on groupware with one or two features can easily do this. Groupware with over ten features makes this more difficult. More knowledge, time and people are required to evaluate

and decide. In addition, more groups within the organization are affected by an implementation of groupware with many features.

In contrast, the more features a groupware technology includes, the easier it is to control critical mass, social factors, and exception features. Groups have less alternatives to use because everything can be done within the same groupware. Furthermore, groups interact a lot within the same groupware, this opens more discussion about social, political, motivation and exception handling. This correlation is depicted in figure 21.

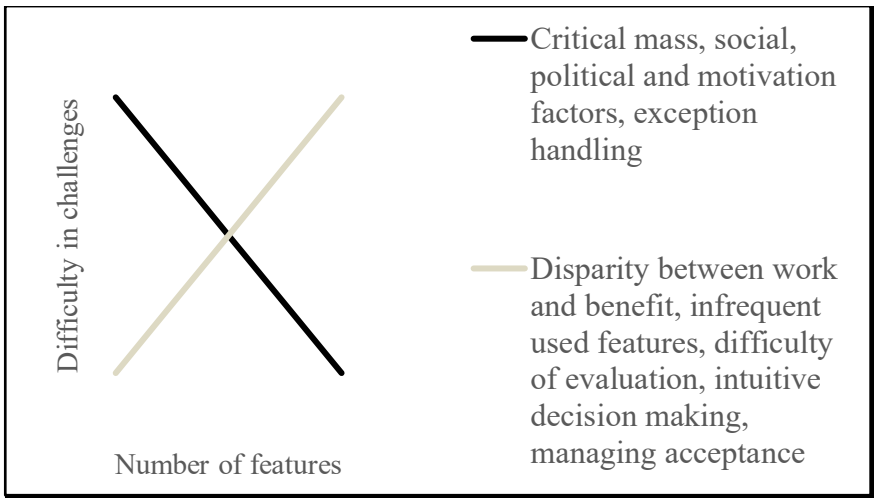

Figure 21 Number of features compared to the type of challenges

4.2.2 The four-square matrix

Each groupware technology was measured against the four-square matrix. Some groupware covered multiple areas in the matrix, others only covered one.

Table 17 Results of the four-square matrix

	Same place	**Different place**
Same time	F	B, C, D, E, F
Different time	F	A, D, E, F

Findings

Most groupware falls within the different place category, because of the need in supporting distributed teams. The availability of information is a major advantage of groupware in use cases D, E and F over A,B and C. Group members can access their information at any time, which positively contributes to common ground, grounding and joint actions.

The Hub 2 (use case F) completely changed the way distributed groups collaborate. The Hub 2 also includes the same place category. Traditional conference rooms kill creativity because people sit down and become passive. The Hub 2 encourage people to stand up, collaborate, innovate, and work together. Even though organizations encourage flex spaces, people still tend to sit on the same place every day. With the Hub 2, the conference room comes to the team instead of the team going to the conference room.

The Hub 2 illustrates the importance of the same place criteria for successful collaboration. People feel connected in the same place. The next successful groupware technology may be the Microsoft HoloLens 2, where distributed people are brought even closer together. Distributed organizations pulled teams apart, the Hub 2 brings them back together.

4.2.3 Common ground

Each groupware tries to support the finding of shared bases. Shared bases lead to common ground, which supports group collaboration. Each groupware technology provides some sort of shared basis. However, some provide more than others: Microsoft Teams provide more than Microsoft Outlook for example. Besides, some groupware provides an easier creation of shared bases and are therefore ranked higher.

Table 18 Results of support in common ground

	Use cases					
Variables	**A**	**B**	**C**	**D**	**E**	**F**
Communal bases	×	✓	✓	×	✓	✓
Perceptual bases	×	×	✓	✓	✓	✓✓
Actional bases	×	✓	✓	✓	✓	✓
Lexical bases	×	×	×	×	✓	✓
Sum of personal bases	×	×	×	×	✓	✓✓
Total	0	2	3	2	5	7

Findings

The evolution of groupware demonstrate that the closer technology can bring us to reality, the more common ground is created. The more common ground, the better groups collaborate. Google Meet looks very similar to Skye for Business; both focus on video and conferencing. However, communal bases, lexicon bases, and the sum of personal bases do not have much support in these types of groupware. After a meeting is completed, the information may not be saved, and a shared basis is partially lost. Microsoft Teams solved

this issue by providing extra features within a meeting: Microsoft Whiteboard and file sharing. Because of these features, extra shared bases are saved and can be used for a later process in the collaboration. For more common ground, it is critical for groupware to provide more features beyond audio and video conferencing. Each extra feature has the possibility to find, share or save additional common ground. In addition, organizations should use minimal different groupware. Centralized information that can be accessed by the entire group supports group collaboration. Distributed information, found in different groupware, leads to less common ground and make group collaboration worse.

Even though Microsoft Teams produces all five shared bases, the Hub 2 can create even more. As the interview findings demonstrate, the Hub 2 brings people closer together. People who work with the Hub 2 tend to be more active and physically, emotionally more engaged with each other. Groupware should support and find ways to engage and let people be more active in collaboration. Active collaboration is more successful than passive collaboration. People share, collaborate and create more in active collaboration. All the extra information leads to more common ground.

4.2.4 Grounding

Each groupware technology to supports some grounding. All groupware technologies indicate some form of closure of actions, joint closure, or contributions. However, some indicate more than others and therefore provide more support to group collaboration. Take note that the variable of "contribution" is different from the action of "making a contribution." The variable is explained in chapter 2.3. For this situation, the closure of actions is supported when the entire group knows that a task is executed.

Table 19 Results of support in grounding

		Use cases					
Variables	**Sub variables**	**A**	**B**	**C**	**D**	**E**	**F**
Closure of actions	Validity	×	×	×	✓	✓	✓
	Economy of effort	×	×	✓	✓	✓	✓✓
	Timeliness	×	×	✓	✓	✓	✓
Joint closure	Evidence of success	×	✓	✓	✓	✓	✓✓
	Evidence of failure	×	×	×	×	✓	✓
Contributions	Discourse	×	✓	✓	✓	✓	✓✓
	Concluded	×	×	×	✓	✓	✓✓
	Continuous	×	×	×	✓	✓	✓✓
Total							

Findings

Microsoft Outlook barely supports any grounding; it is very difficult for group members to close their actions or make any form of contribution. When an e-mail is sent, no closure of action takes place, and other group members cannot contribute. Audio conferencing produces some support for grounding. However, it is still very difficult to contribute because nobody can see each other. Imagine a group of five people talking at the same time without seeing anyone: the result is complete chaos that takes up a significant amount of time and effort. Video conferencing provides significant support in the closure of actions, but validity is still an issue. People can lie about whether they have completed a task or not. File sharing solves this issue, other group members can see if a certain task is executed. More features in groupware lead to more ways of grounding.

The Hub 2 supports grounding in various ways. Everyone is included and participates at an active level, this enables more grounding. Besides speech and gestures, people can touch the screen for extra points of discourse. The screen also significantly supports continuous contributions. People can collaborate at a high level without many interruptions. Devices can be easily connected, group members can easily join and leave, the time to start a meeting is shorter compared to conference meetings and more advantages are found in the interview Six key elements support grounding and groupware should support these features: speech, gestures, live content on screen, touchscreen, integration of all the features, and a fast workflow without interruptions.

A seventh key elements may be found in virtual reality where visuals contribute to new ways of grounding.

4.2.5 The 3C model

Each groupware should support the 3C model, group interaction. The better the communication, coordination, and collaboration, the better the group collaborates. The visual element in Microsoft Outlook is not included because e-mails have a maximum data capacity.

Table 20 Results of support in group interaction

		Use cases					
Variables	**Sub variables**	**A**	**B**	**C**	**D**	**E**	**F**
Communication	Text	✓	✓	✓	✓	✓	✓
	Visual	×	×	✓	✓	✓	✓✓
	Verbal	×	✓	✓	✓	✓	✓
	Non-verbal	×	×	✓	✓	✓	✓✓
Coordination	Distribution of work	×	×	×	✓	✓	✓
	Conflict management	×	×	×	✓	✓	✓
	Information access	×	×	×	✓	✓	✓
Collaboration	Membership	×	×	×	×	×	✓
	Communication	×	×	×	×	×	✓
	Purpose	×	×	×	×	×	✓
Total							

Findings

Coordination is not possible without proper communication. Collaboration is not possible without proper coordination. Communication and coordination are the foundation for collaboration. Groupware technologies should first focus on the communication, then coordination, and finally collaboration.

The effectiveness of the Hub 2 in collaboration was emphasized in all interviews. Distributed group collaboration through teams is very passive by comparison: group members sit back and talk when needed. The same happens in conference meetings. The focus is on communication and coordination between group members, and there is not much space for actual collaboration.

The Hub 2 does support collaboration. The Hub 2 stimulates people out of their passive behavior and pushes them to actively collaborate. Touchscreen enables people to explain certain topics by drawing, similar to a whiteboard. The advantage of the Hub 2, however, is that it enables distributed teams to feel included. People can see others and live content on their screen at the same time. People feel included within the team. Kanban applications are developed for the Hub 2 to support even more collaboration. People stand up and actively collaborate with others. The Hub 2 can be moved to informal meeting rooms and the screen can be touched. In addition, the screen can be placed in the middle of a group instead of against a wall.

Finally, the workflow of the Hub 2 supports group collaboration. People can connect, disconnect, draw, participate, collaborate, talk, gesture, and take the screen over without

a problem. Nothing distracts the group from stopping to collaborate. Each interruption groupware hinders collaboration.

5 CONCLUSION

This paper finds an answer on the following main research question: which factors of CSCW supports group collaboration? First of all, groups need to actively participate in group collaboration. Active groups generate more creativity and ideas. In addition, active participation results in more knowledge and information sharing. This results in more shared bases that lead to more grounding and common ground. Common ground supports group collaboration and prevents miscommunication. Secondly, many features (audio conferencing, video conferencing, touchscreen, centralized data, smooth workflow, live content sharing) must be integrated in a single groupware. This enables groups to communicate and coordinate everything in once place and prevents disparity in information. All group members must have access to group information at any time, in any location. Centralized information supports grounding and finding common ground. It supports joint decisions and the entire group is aware of the decisions being made. Microsoft Teams and Kanban applications are examples that support centralized information. Thirdly, the same features support different forms of grounding and group interaction (3C model). Allow group members to interact with different technologies to create as much grounding and group interaction as possible. For example, by text, speech, gestures, touch and content sharing. Groupware should bring people closer to reality, everyone should feel included within the group. Fourthly, do not exaggerate with features in groupware, this leads to infrequent used features and more complex evaluation and decision making. Fifth, distributed groups pulled groups apart, groupware should bring them back together. But at the same time, not too little. This causes challenges in critical mass, social, economic and motivation factors. Avoid working in meeting rooms that results in passive behavior. Bring technology closer to the work environment of teams. Finally, an overview of aspects affecting CSCW is depicted in the appendix chapter 7.2.

The following paragraphs give an overview of the research questions. The literature has presented many different definitions for groupware. This paper's comparison and evaluation of the various interpretations helped to construct a new definition. Groupware (or collaboration technology) are computer-based systems that support groups of participants to achieve a common task in a shared environment. The aim of this research is to discover factors that influence group collaboration. In addition to groupware, CSCW plays a major role in the success of group collaboration. Computer-supported cooperative work is the research area that discusses the intersection between collaborative group behavior and computer-based technologies. Different use cases were researched to measure the effectiveness of different groupware-related variables on the overall success of group collaboration.

Research has demonstrated that groupware challenges are still a major issue for most organizations. There is no easy approach to solve all the challenges. However, there is a

correlation between the number of features within groupware and the type of challenges it will face. Groupware that has many features is likely to encounter disparity of work and benefit, infrequently used features, difficulty of evaluation, intuitive decision making, and managing acceptance. By contrast, critical mass; social, political, and motivational factors; and exception handling challenges are more likely to arise when groupware does not include many features.

Findings in the four-square taxonomy model and interviews demonstrate that groups need synchronization. The first step is to make information available at all times and in all places. The second step is to create a shared environment. Even though groups are distributed, group members need inclusiveness to collaborate. Groups prefer to bring the virtual environment to them instead of to create a new shared virtual environment. One example is bringing the Hub 2 into the working area as a trusted nexus for most group members to collaborate.

Finding shared bases that lead to common ground is critical for the success of group collaboration. Groupware should support finding common ground. Group members need to work closely together and be physically and emotionally engaged with each other. Passive conference meetings must be replaced by active collaboration meetings to create as much common ground as possible. In addition, the same groupware must save all common ground and make it accessible for all group members at all times. Common ground is the foundation of successful collaboration. It supports joint activities and prevents miscommunication.

Grounding enables people to create shared bases. For this to happen, it is crucial that groupware supports the following three factors: closure of actions, joint closure, and contributions. Groupware should enable people to share and work together in a trusted environment. Everyone within the group should be included so that they can share their ideas. The key elements in groupware that support group members to ground joint actions are speech, gestures, live content sharing, live collaboration on touchscreen, and an efficient workflow.

Finally, the 3C model demonstrates that most meetings are very passive and do not include much collaboration. Most meetings focus on communication and coordination of tasks. Active participation between group members is needed to support collaboration in groups. Groupware should motivate people to stand up, to use groupware together, to create, to innovate, and to interact with each other. Distributed people want to feel included and part of a team. Groupware should bring people closer together. The Microsoft Hub 2 supports active group collaboration.

5.1 Limitations and further research

The focus of this research is on groupware and CSCW. These concepts are measured against groupware challenges, groupware taxonomy levels, common ground, grounding, and group interaction. This research was executed within a time frame of four months. Therefore, the scope of the research was necessarily limited. However, there may be more factors that influence and support group collaboration. More research can build on the factors included in this research and add relevant other factors to them.

The interviewees all worked for Microsoft and may have a positive bias towards the advantages of the Hub 2. More research needs to be done on other collaborative distributed group devices. Google Jamboard, for example, could be compared with the Hub 2. Both collaboration devices need to be tested against the same factors in order to find similarities or differences. In addition, the interviewees covered Europe, the Middle East, Africa, and the U.S.A. More research could be done in other geographical areas such as Asia and Oceania.

In addition, future technologies are very promising to support group collaboration. Virtual reality, augmented reality and AI most likely influence group collaboration. It is interesting to research how these technologies support common ground, grounding and group interaction. It may result in even more active collaboration.

Finally, research in infrequent used features. Searching for the optimal number of features in groupware that support group collaboration. Research whether a feature is used or not, and why. What is the impact of training on infrequent used features and what is the impact on group collaboration? Groups can be interviewed or examined to find these results.

6 BIBLIOGRAPHY

Abrahamsson, P., Salo, O., Jussi, R., & Warsta, J. (2017). Agile Software Development Methods: Review and Analysis.

Achmatowicz, R. (1994). *Object Groups for Groupware Applications: Application Requirements and Design Issues.*

Bannon, L. (1994). Challenging Perspectives on Work and Technology. *Information Technology & Organisational Chang*, (pp. 1-20). Nijenrode .

Chagas, B., Fuks, H., & Souza, C. d. (2015). Towards micro-groupware: Supporting Small Group Activities Around Assistive Technology. *Proc. of Third International Workshop on Cultures of Participation in the Digital Age*, 65-71.

Clark, H. (1996). *Using language.* Cambridge: Cambridge University Press.

Coleman, D. (1997). *Groupware : collaborative strategies for corporate LANs and intranets.* New Jersey: Prentice Hall PTR.

Coleman, D., & Levine, S. (2008). *Collaboration 2.0: technology and best practices for successful collaboration in a Web 2.0 world.* Silicon Valley\: Happy About.

Ebrahim, N., Ahmed, S., & Taha, Z. (2009). Virtual Teams and Management Challenges. *1st Executive MBA Conference*, (pp. 1-9). Tehran.

Ellis, C., & Wainer, J. (2004). Groupware and Computer Supported Cooperative Work. In G. Weiss, *Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence* (pp. 425-455). Cambridge: The MIT Press.

Ellis, C., Gibbs, S., & Rein, G. (1991). Groupware: some issues and experiences. *Communications of the ACM*, 38-58.

Fouss, J., & Chang, K.-H. (2000). Classifying Groupware. *Proceedings of the 38th annual on Southeast regional conference* (pp. 117-124). New York: ACM.

Google. (2019). *Get Gmail, Docs, Drive, and Calendar for business.* . Retrieved from G Suite: https://gsuite.google.com/intl/en_ie/

Greenberg, S. (1991). Computer-Supported Cooperative Work and Groupware: An Introduction to the Special Edition. *International Journal of Man Machine Studies*, 1133-143.

Grudin, J. (1994). Computer-supported cooperative work: history and focus . *Computer*, 19-26.

Grudin, J. (1995). Groupware and social dynamics: eight challanges for developers. *Readings in Human–Computer Interaction*, 762-774.

Grudin, J. (1999). CSCW and Groupware: Their History and Trajectory. In Y. Matsushita, *Designing Communication and Collaboration Support Systems* (pp. 1-16). Singapore: Gordon and Breach Science Publishers.

Grudin, J., & Poltrock, S. (1997). Computer-supported cooperative work and groupware. *Advances in computers*, 269-320.

Grudin, J., & Poltrock, S. (2012). Taonomy and Theory in Computer Supported Cooperative Work. *The oxford handbook of organizational psychology*, 1323-1348.

Grudin, J., & Poltrock, S. (2013). Computer Supported Cooperative Work . In M. Soegaard, & R. Friss Dam, *The Encyclopedia of Human-Computer Interaction, 2nd Ed.* The interaction Design Foundation.

Hulstijn, J. (2000). *Dialogue models for inquiry and transaction.* Enschede: Universiteit Twente.

Johansen, B. (2010). Four Square Model. In A. Lowy, & P. Hood, *The Power of the 2 x 2 Matrix: Using 2 x 2 Thinking to Solve Business Problems and Make Better Decisions* (pp. 236-238). San Francisco: Jossey-Bass.

Johansen, R., Sibbet, D., Benson, S., Martin, A., Mittman, R., & Saffo, P. (1991). *Leading business teams: How teams can use technology and group process tools to enhance performance.* Boston: Addison-Wesley.

Jong, T. d., & Penris, I. (2016, May 11). *Knop bij het verkeerslicht: placebo of echt?* Retrieved from AD: https://www.ad.nl/utrecht/knop-bij-het-verkeerslicht-placebo-of-echt~a546f6f3/

Kim, S., Ko, D., & Lee, W. (2017). Utilizing Smartphones as a Multi-Device Single Display Groupware to Design Collaborative Game. *Proceedings of the 2017 Conference on Designing Interactive Systems - DIS 17* (pp. 1341-1352). Edinburgh: ACM.

Klein, M. (1996). Coordination science: Challenges and directions. *Annual Asian Computing Science Conference* (pp. 161-176). Berlin: Springer.

Lausen, H. (2004). *Groupware Evaluation.* Galway: Digital Enterprise Research Institute .

Lazarin, C., & Almeida, L. (2016). Distributed Participatory Design web-based groupware: gathering requirements through BrainDraw. *ACM*, 3-12.

Lewis, D. (1969). *Convention: a philosophical study.* Cambridge: Harvard university press.

Mattessich, P., & Monsey, B. (1992). *Collaboration: what makes it work.* Saint Paul: Amherst H. Wilder Foundation.

McCarthy, J. (1990). Formalizations of two puzzles involving knowledge. In J. McCarthy, *Formalizing Common Sence: Papers (Ablex Series in Artificial Intelligence)* (pp. 158-166). New York: Ablex Pub.

Microsoft Cooperation. (2019). *What is Office 365?* Retrieved from Products Office: https://products.office.com/en-us/home

Microsoft Coorporation. (2019, April 9). *Introducing Hub 2S*. Retrieved from Microsoft: https://www.microsoft.com/en-us/surface/business/surface-hub-2

Mohammed, A., & Dahiru, U. (2015). Groupware applications as a tool for organizational development. *International Journal of Advanced Studies in Business Strategies and Management*, 40-49.

Olson, G., & Olson, J. (2010). Groupware and computer-supported cooperative work. In H. Donelan, K. Kear, & M. Ramage, *Online Communication and Collaboration: A Reader* (pp. 39-57). London: Routledge.

Peters, L., & Manz, C. (2007). Identifying antecedents of virtual team collaboratio. *Team Performance Management: An International Journal*, 117-129.

Poltrock, S., & Grudin, J. (1994). Computer-Supported Cooperative Work and Groupware. *Computer*, 19-26.

Poltrock, S., & Grudin, J. (1999). CSCW, Groupware and Workflow: Experiences, State of Art, and Future Trends. *ACM*, 120-121.

Rouse, M. (2019, February). *Computer hardware*. Retrieved from TechTarget: https://searchnetworking.techtarget.com/definition/hardware

RTL Nieuws. (2016, May 03). *Hou maar op met drukken: stoplichtknoppen zijn vaak nep*. Retrieved from RTL Nieuws: https://www.rtlnieuws.nl/editienl/artikel/623286/hou-maar-op-met-drukken-stoplichtknoppen-zijn-vaak-nep

Schelling, T. (1960). *The strategu of conflict.* Cambridge: Harverd university press.

Schiffer, S. (1972). *Meaning.* Oxford: Oxford university press.

Schmidt, K. (2016). Computer-Supported Cooperative Work (CSCW. *The International Encyclopedia of Communication Theory and Philosophy* , 1-4.

Soni, V. (2018, 06 01). *Over half of organizations have now deployed Office 365, while G Suite adoption seems to have slowed to a halt: Bitglass report* . Retrieved from Wire 19: https://wire19.com/over-half-of-organizations-have-now-deployed-office-365/

Statista. (2019). *Statista*. Retrieved from Market share of major office suites technologies in the United Sates as of January 2019*: https://www.statista.com/statistics/961105/japan-market-share-of-office-suites-technologies/

Teruel, M., Navarro, E., López-Jaquero, V., Montero, F., & González, P. (2017). A comprehensive framework for modeling requirements of CSCW systems. *Journal of Software: Evolution and Process*, 1-19.

Teruel, M., Navarro, E., Lopez-Jaquero, V., Montero, F., & Gonzalez, P. (2017). A comprehensive framework for modeling requirements of CSCW systems. *Journal of Software: Evolution and Process*, 1-19.

Thissen, M., Page, J., Bharathi, M., & Austin, T. (2007). Communication Tools for Distributed Software Development Teams. *ACM*, 28-35.

Valacich, J., & Schneider, C. (2014). *Information Systems Today Managing in the Digital World.* Harlow: Pearson.

Wallace, J., Oji, S., & Anslow, C. (2017). Technologies,Methods,andValues:ChangesinEmpirical ResearchatCSCW1990–201. *Proceedings of the ACM on Human-Computer Interaction*, 1-18.

Wulf, V., Rohde, M., Pipek, V., & Stevens, G. (2011). Engaging with Practices: Design Case Studies as a Research Framework in CSCW. *ACM*, 505-512.

Yasrab, R., Ferzund, J., & Razzaq, S. (2019). *CHALLENGES AND ISSUES IN COLLABORATIVE SOFTWARE DEVELOPMENTS.* Cornell: Cornell University.

7 APPENDIX

7.1 Interviews

Interviews 1 and 2 were conducted in Dutch and through Microsoft Teams. Interview 3 was conducted in English through e-mail.

7.1.1 Interview 1: technical solution manager for Microsoft EMEA.

1. What is your role/function within the organization?
    - Wat is je rol/functie binnen de organisatie?

Technical solution manager for Microsoft EMEA. Host in the Netherlands. Part of the Surface Devices team.

2. What type of companies/industries/organizations purchase the Hub 2?
    - Wat voor type bedrijf/industrie/organisatie koopt een Hub 2?

The Hub 2 (Hub 2) is mainly for organizations that are distributed globally or operate globally. Many organizations have interest in the Hub 2, there are no specific companies against the device. The investment in the Hub 2 is quite high. Therefore, some small companies may not have enough funds to invest in the Hub 2. However, practice shows that even the smallest companies get the funds together to purchase a Hub 2. Industries like finance/banking, software developing, and high-tech companies invest a lot in the Hub 2. Even the public sector, but less.

3. What business need solves the Hub 2? (As far as you know, for the organization?)
    - Wat voor zakelijke behoefte vervult de Hub 2? (Voor zover jij weet, voor de organisatie)

Remote collaboration. The goal is to do more than just remote video conferencing. Companies aim at the next level: remote collaboration. Besides video conferencing, employees work together during the meeting on screen.

4. Who is using the Hub 2? (Which type of users? Which not?)
    - Wie gebruikt de Hub 2? (Welk type gebruiker? Welke type niet?)

Mostly scrum and agile teams. But it is also dependent on the industry. Within the public sector it is mostly used by top-management. In banking industries by the software developers.

5. What are the advantages of the Hub 2 compared to older computer-based communication support systems?
    - Wat zijn de voordelen van de Hub 2 vergeleken met oudere *computer-based communication support sytems?*

Probably the biggest advantage is the creation of a mobile workstation/device. Instead of going to formal meeting rooms, meetings can be held in more informal areas.

Another advantage, the ease of collaboration. Microsoft Whiteboard helps to collaborate with people working remotely. The pen touch feeling is very natural which encourage people to use them. It is the way people like to work, but now on a screen.

Another great example is the integration with Microsoft Office 365. Other applications will work, but the best experience is with Microsoft applications.
Besides, the workflow is very smoothly. It only takes 1-2 minutes to start a meeting with the Hub 2. Traditional meetings take around 10-15 minutes to start. Furthermore, when someone connects his device to the Hub 2, everyone can see the content on their own screen directly and everyone is able to edit. This improves the workflow and the way we collaborate.

At the end of a session, all the information is stored and can be accessed by anyone from the meeting. Nobody has to worry about confidential information, once the session is over, the Hub 2 will wipe all the information from the session.

6. What are the disadvantages of the Hub 2 compared to older computer-based communication support systems? Are there any challenges?
    - Wat zijn de nadelen van de Hub 2 in vergelijking met oudere *computer-based communication support sytems?* Zijn er uitdagingen?

The cost of the device. Even though it is a big investment, many companies are still interested. Another challenge is the user adaptation. People need to change the way they work. Besides, one part of the organization needs training in order to use the device. A big challenge that keeps coming back are the infrequent used features.

Critical mass is not an issue for the Hub 2 since it is well integrated with Microsoft Office 365. However, when clients decide to use other applications, than there might be an issue of critical mass. The issue will be even bigger for infrequent used features.

7. Could you point out the most important hardware features of the Hub 2?
    - Kunt u de meest belangrijke hardware functies van de Hub 2 aangeven?

Touch screen and the camera. Less hardware but critical, the stand which enables the device to move.

8. Could you name the top 5 applications that group members should use on the Hub 2?
    - Kunt u de top 5-applicaties noemen die groepsleden zouden moeten gebruiken op de Hub 2?

Microsoft Teams, Microsoft Whiteboard and Microsoft PowerPoint. More applications are very specific for each line of industry. It depends on what type of collaboration is needed. iObeya is used for scrum and agile teams for example.

9. Could you name the top 5 applications that are being used by group members on the Hub 2?
    - Kunt u de top 5-applicaties noemen die groepsleden op dit moment gebruiken op de Hub 2?

Microsoft Teams, Microsoft Whiteboard and Microsoft PowerPoint. As mentioned in the previous questions, many applications are very specific for each type of industry. However, companies have not developed enough applications yet to support their line of business to the fullest. More applications are needed to support those line of businesses. And more companies should develop them.

10. Do teams replicate the real-world environment into a virtual team? (Having certain elements in a virtual team that makes it unique)
    - Reproduceren teams de echte wereld in een virtueel team? (Door het hebben van bepaalde elementen/eigenschappen dat een virtueel team uniek maakt)

Within Microsoft Teams there is an option to create your own team with channels. Nothing much more is included. However, instead of creating a unique virtual team environment. People create take the virtual world to the team. Even though many organizations work with flex spaces, many employees still sit with their teams. If a team is in need of a virtual environment, they bring the Hub 2 to their area and work from there.

11. Is the Kanban method used in the Hub 2? Or similar applications?
    - Wordt de Kanban methode gebruikt in de Hub 2? Of soortgelijke applicaties?

Yes, Microsoft Whiteboard is used most of the times. However, iObeya is a great application which is not well known among the Hub 2 users. Besides there is Microsoft Visio and Jira.

12. How can the Hub 2 help with achieving common ground (shared knowledge) among team members? How can the Hub 2 prevent miscommunication?
    - Hoe kan de Hub 2 helpen bij het bereiken van *common ground* (gedeelde kennis) tussen teamleden? Hoe kan de Hub 2 helpen bij het voorkomen van miscommunicatie?

Inclusion of remote people. People taking part in the collaboration through video and content. Remote located people are easier involved in the creation of common ground Touchscreen allows people to select and point at certain elements easily, this prevents miscommunications. Besides, everyone within the group can give live feedback in case something is unclear.

13. How can the Hub 2 help with achieving the closure of actions?
    - Hoe kan de Hub 2 helpen bij het bereiken van de *closure of actions?*

There are several ways which contribute to the closure of actions. The biggest contribution is the combination between video conferencing and live collaboration. You can see the group members through video but also what they are doing on screen with Microsoft Whiteboard for example. Besides, the touchscreen is very helpful. People can point on screen to show what they are talking about. For the future, machine learning and AI may have a big influence on the closure of actions.

14. How can the Hub 2 help with communication (share a message, creation of a shared reality) of groups?
    - Hoe kan de Hub 2 helpen met de communicatie (het delen van een bericht, een gedeelde realiteit creëren) van groepen?

Live videoconferencing and collaboration on screen. Everyone can see what is happening and everyone is included. Especially for people that are located elsewhere.

15. How can the Hub 2 help with coordination *(coordination of time, place, role and task? This is the content of communication)* of groups?
    - Hoe kan de Hub 2 helpen met de coördinatie (coördinatie van tijd, plaats, rol en taak. Dit is de inhoud van de communicatie) van groepen?

With the use of Microsoft Whiteboard and Microsoft Teams. Through Teams tasks are easily distributed over the team members. Besides, live records of the meeting van be shown on screen for immediate feedback. Information is always saved and online available for anyone who joined the meeting. For the future, Microsoft Teams is developing a tool to automatically distribute action point made in the meeting.

16. How can the Hub 2 help with the collaboration *(working together, tasks equally distributed, everyone helps each other, communicate when somethings succeed or fails)* of groups?
    - Hoe kan de Hub 2 helpen met de samenwerking (samenwerken, gelijke verdeling van taken, iedereen helpt elkaar, communiceer wanneer iets slaagt of faalt) van groepen?

Inclusion of people working remote. People want to feel included in the meeting, it is a psychological thing. People feel more included when they see the content but also participate in video conferencing.

17. Are there additional comments on the Hub 2 which you want to emphasize after the interview?

The advantage of the Hub 2 compared to other computer-based communication support systems is thanks to:
- *Touchscreen functionalities*
- *Short start-up time and efficient workflow*
- *Remote collaboration and inclusion, video conferencing and content availability*
- *Able to connect your device to the Hub 2 and show your screen to everyone in the meeting*
- *Especially compared to Kanban, safety of information after the meeting*

7.1.2 Interview 2: Solution specialist devices for Microsoft Netherlands

1. What is your role/function within the organization?
    - Wat is je rol/functie binnen de organisatie?

Solution specialist devices for Microsoft Netherlands with the focus on the public sector.

2. What type of companies/industries/teams purchase the Hub 2?
    - Wat voor type bedrijf/industrie/organisatie koopt een Hub 2?

Every type of organization within any industry. A lot of companies within the high-tech manufacturing industry (ASML, Philips). It helps organizations to share knowledge, shorten travel time, improve collaboration and faster product development. There are many opportunities in healthcare for the Hub 2.

3. Who is using the Hub 2? (which type of users? Which not?)
    - Wie gebruikt de Hub 2? (Welk type gebruiker? Welke type niet?)

Everyone. Distributed management teams use the Hub 2 to discuss quarterly results for example. They can see the people but also the content (results) on screen. In addition, design teams, teams with high communication needs and scrum teams.

4. What business need solves the Hub 2? (as far as you know, for them?)
    - Wat voor zakelijke behoefte vervult de Hub 2? (Voor zover jij weet, voor de organisatie)

First of all, the quality of the meeting, there are more tools available to support collaboration. Secondly, the speed to the market. Organizations that use the Hub 2 are more flexible to make changes in the product. For example, when a new law is in force. These organizations can adapt quickly and change the product.

5. What are the advantages of the Hub 2 compared to older computer-based communication support systems?
    - Wat zijn de voordelen van de Hub 2 vergeleken met oudere *computer-based communication support sytems?*

Digital transformation, shorten travel time, mobility, collaboration at any place and the way people collaborate changes. People participate and are included in the meeting. The Hub 2 is the integration of everything together. One device which can do everything, run applications, share documents and connects to other devices.

6. What are the disadvantages of the Hub 2 compared to older computer-based communication support systems? Are there any challenges?
    - Wat zijn de nadelen van de Hub 2 in vergelijking met oudere *computer-based communication support sytems?* Zijn er uitdagingen?

Adaptation of the device and the infrequent used features. Some organizations only use the Hub 2 just for video conferencing and presentation. This is fine, but not the purpose of the Hub 2.

7. Could you point out the most important hardware features of the Hub 2?
    - Kunt u de meest belangrijke hardware functies van de Hub 2 aangeven?

Screen, touch, surface pen, camera, connect with other devices and mobility.

8. Could you name the top 5 applications that group members should use on the Hub 2?
    - Kunt u de top 5-applicaties noemen die groepsleden zouden moeten gebruiken op de Hub 2?

Microsoft Teams, Microsoft Whiteboard, iBabs (public sector), Microsoft Office and Mural (Kanban)

9. Could you name the top 5 applications that are being used by group members on the Hub 2?
    - Kunt u de top 5-applicaties noemen die groepsleden op dit moment gebruiken op de Hub 2?

Microsoft Teams, Microsoft Whiteboard, iBabs (public sector), Microsoft Office and Mural (Kanban). In addition, each organization/industry uses their own preferred applications.

10. Do teams replicate the real-world environment into a virtual team? For example: having unique features in virtual teams as they would have had in the real world (items on the desk, a sketch board, a ball etc.).
    - Reproduceren teams de echte wereld in een virtueel team? (Door het hebben van bepaalde elementen/eigenschappen dat een virtueel team uniek maakt)

Microsoft Whiteboard has different lay outs. In addition, Microsoft Teams. However, it is not common to create a unique virtual environment that represents the real world.

11. Is the Kanban method used in the Hub 2? Or similar applications?
    - Wordt de Kanban methode gebruikt in de Hub 2? Of soortgelijke applicaties?

Yes, Mural, Microsoft Whiteboard and other Kanban supportive applications.

12. How can the Hub 2 help with achieving common ground (shared knowledge) among team members? Or: how can the Hub 2 prevent miscommunication?
    - Hoe kan de Hub 2 helpen bij het bereiken van *common ground* (gedeelde kennis) tussen teamleden? Hoe kan de Hub 2 helpen bij het voorkomen van miscommunicatie?

People are sharing the screen; everyone can see what is happening. You can point on the screen to specify what you are talking about. Besides, the information is always available afterwards as well. People can join the meeting at any time and see what already has been discussed. Besides, the combination between video and content.

13. How can the Hub 2 help with achieving the closure of actions?
    - Hoe kan de Hub 2 helpen bij het bereiken van de *closure of actions?*

Applications can support the closure of actions. Next, the live collaboration between group members. Everyone is having an active role. Video, audio and content sharing supports this live process.

14. How can the Hub 2 help with communication *(share a message, creation of a shared reality)* of groups?
    - Hoe kan de Hub 2 helpen met de communicatie (het delen van een bericht, een gedeelde realiteit creëren) van groepen?

People can communicate using different methods. Using text, speech and non-verbal communication.

15. How can the Hub 2 help with coordination *(coordination of time, place, role, task. This is the content of communication)* of groups?
    - Hoe kan de Hub 2 helpen met de coördinatie (coördinatie van tijd, plaats, rol en taak. Dit is de inhoud van de communicatie) van groepen?

Meetings can be quick and ad hoc. Everyone that is invited can join the meeting with one click and have an overview of the participants and the content that is shared. In addition, it is easy to make notes on the Hub 2 that everyone else can see.

16. How can the Hub 2 help with the collaboration *(working together, tasks equally distributed, everyone helps each other, communicate when somethings succeed or fails)* of groups?
    - Hoe kan de Hub 2 helpen met de samenwerking (samenwerken, gelijke verdeling van taken, iedereen helpt elkaar, communiceer wanneer iets slaagt of faalt) van groepen?

Collaboration is the strongest point of the Hub 2. If a professional is needed to join the meeting, they can join the session within seconds. Instead of having to walk to a meeting room.

17. Are there additional comments on the Hub 2 which you want to emphasize after the interview?
    - Zijn er aanvullende opmerkingen over de Hub 2 die u na het interview wilt benadrukken?

Collaboration is key. A lot of features and applications are within the Hub 2, it depends on the organizations which features they want to use. Besides, training is needed for a part of the employees to use the Hub 2. Adaptation and infrequent used features are the biggest issues at the moment.

7.1.3 Interview 3: Surface Global Blackbelt for Microsoft United States

1. What is your role/function within the organization?

   Surface Global Blackbelt at Microsoft

2. What type of companies/industries/teams purchase the Hub 2?

   I have sold Surface Hub into all verticals and industries.

3. Who is using the Hub 2? (which type of users? Which not?)

At the basic level, all users will use the Surface Hub as a content display, which used to be the overhead projector in years past. It is very easy to wireless (or wired) share you content with those in the room with you.

Next, the average user leverages the Surface Hub and its Microsoft communication software (Teams or Skype for Business) to pull remote participants into real-time meetings. This also enables one-way content share to those not in the room.

The more advanced users will leverage the co-authoring capabilities of the whiteboard to brainstorm and ideate. Co-authoring on the Surface Hub primarily occurs on the whiteboard, but can also occur within Word, PowerPoint or Excel. The Edge browser is also used to proactively research topics. When interesting content is found on the Internet, it can be injected into the whiteboard to contribute to the brainstorming.

I would classify Surface Hub users by job type. I normally divide end-users into two camps: 1) routine workers, whose job is defined by following repetitive or discrete steps; 2) non-routine workers, whose job does not follow a pattern. Many in second group typically need to solve a thorny problem and do not know where to start. The unstructured, infinite canvas of the whiteboard allows ideas to form across a geographically diverse set of co-workers.

4. What business need solves the Hub 2? (as far as you know, for them?)

   As artificial intelligence and machine learning automate routine work, the work remaining requires critical thinking, problem solving, persuasion, negotiation skills, etc. that computers can't automate. The types of problems that need solving are very complex. Since nobody knows everything, groups of Subject Matter Experts (SME) need to work together in groups to make progress. The Surface Hub offer a great platform to help these geographically disperse group work together across voice, video and content mediums.

5. What are the advantages of the Hub 2 compared to older computer-based communication support systems?

   70% of communication is non-verbal, so video conferencing allows groups of people to gain a level of trust faster than legacy audio conferencing. Trust is

required by groups in order for the member to become vulnerable to share their ideas without feeling like they will be embarrassed.

A picture is worth 1,000 words. There is a reason why nearly all conference rooms have analog whiteboards. Sometimes it is easier to sketch out a diagram to convey a complex idea. The analog whiteboard is limited to those in the room, which means employee hiring must be within driving distance of the office. With digital whiteboard and video conferencing, the best employees, and their ideas, can be hired from anywhere. Regardless, brainstorming is best done in person. The next best option is to use all the available digital tools available.

6. What are the disadvantages of the Hub 2 compared to older computer-based communication support systems? Are there any challenges?

   The software tool set on the Surface Hub is available on all computers, which I often call 'individual productivity device'. I call the Surface Hub a 'group productivity device'. It is designed for several people to use at the same time in the same room. Traditionally, I would invite you to look over my shoulder to see something on my computer.

   Cost does prevent Surface Hub from being in available in all locations. This is balanced with it being a shared resource that individuals reserve for a period of time.

7. Could you point out the most important hardware features of the Hub 2?

   The world class touch and ink are the most important features of the Surface Hub.

8. Could you name the top 5 applications that group members should use on the Hub 2?

Every vertical industry will have their own unique apps. For example, one manufacturer will have a 3-D CAD app to view the objects they manufacture. Another manufacture uses Kanban to design their products. A healthcare provider will have a 3-D human anatomy app. A Service company use Power BI to build an information dashboard. Project teams use Scrum software for their daily standup.

9. Could you name the top 5 applications that are being used by group members on the Hub 2?

   Teams, Skype for Business, Whiteboard, PowerPoint, Edge browser are the top five most used apps.

10. Do teams replicate the real-world environment into a virtual team? For example: having unique features in virtual teams as they would have had in the real world (items on the desk, a sketch board, a ball etc.).

    The Surface Hub does not patriciate that level of virtual world teaming. Microsoft Teams software provides a digital space to bring teams members together, but it revolves around threads of text and emojis. The next frontier is to weave holographic and virtual reality aspects into more of the corporate worlds. Today, Microsoft doing this work with the HoloLens device. The advances made with HoloLens can already be seen creeping into other form factors.

11. Is the Kanban method used in the Hub 2? Or similar applications?

    Absolutely. Several companies use the Surface Hub to facilitate their Kanban process.

12. How can the Hub 2 help with achieving common ground (shared knowledge) among team members? Or: how can the Hub 2 prevent miscommunication?

    Knowledge management, knowledge sharing and keeping team members in sync is very important. I would say software tools like Microsoft Teams achieve this goal. In order to use the cloud-based Microsoft Teams, the end-user or group of people need a device to access those services. This could be an individual productivity device (phone, tablet or computer) or it could be a group productivity device (Surface Hub, video conferencing device or audio phone).

13. How can the Hub 2 help with achieving the closure of actions?

Allowing groups of people to work in the room or join from a far avoids the cost and time of travel, which speeds up the pace of work.

14. How can the Hub 2 help with communication *(share a message, creation of a shared reality)* of groups?

    The Surface Hub is a communication device. It allows for two-way audio, two-way video and two-way content meeting to occur.

15. How can the Hub 2 help with coordination *(coordination of time, place, role, task? This is the content of communication)* of groups?

    The Surface Hub leverages Exchange calendar services to coordinate the time, place and task of the meeting.

16. How can the Hub 2 help with the collaboration *(working together, tasks equally distributed, everyone helps each other, communicate when somethings succeed or fails)* of groups?
    The Surface Hub leverages Microsoft Teams and Skype for Business for real-time communication. The humans in the meeting need to distribute tasks equally and communicate when things fail.

17. Are there additional comments on the Hub 2 which you want to emphasize after the interview?

    Studies show that getting out of our passive behaviors and becoming more physically and emotionally engaged leads to better ideas. Ideas are the currency of creativity and innovation. Creativity and Innovation is how you stay ahead in business.

    Traditional conference rooms are creativity killers — the design of the room and cushy chairs encourage people to sit in a more passive behavior. This is exactly the opposite behavior of what we want to promote with the Surface Hub. We want active energy. We want people to stand and ink and touch the Surface Hub as they create!

    The Surface Hub allows us to define new room spaces for agile work, these adaptable rooms embrace iteration, mobility and flexibility. Yet, most offices and cube farms can't adapt to the changing needs of their end-users. The static spaces of traditional offices actually become a barrier to ideas and creativity.

7.2 Factors influencing CSCW