Virtual Meetings:

Examining Presence on Group Communication Quality, Performance and Satisfaction in Communication Environments

Author: Amber Loode
Student number: S1665464
Date: 11-02-2021

University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,

Nowadays we live in an era where group communication is increasingly taking place using virtual environments. Virtual teams are characterized by groups that are geographically and temporally distributed whereby communication is maintained through electronic means. The effect of virtuality on groups has been discussed in literature as an essential factor in shaping the performance of a team, and in particular in the area of communication. Nevertheless, very few studies have investigated the effects of more recent communication environments (e.g. video conference and virtual reality) on group communication, even though they may be greatly deployed within highly virtual teams. Presence has been important to theorizing sophisticated human-computer interfaces such as virtual reality and video conference systems. Therefore, in order to assess these communication environments, the concepts of presence (e.g. telepresence, social presence, and self-presence) were used in this study. By means of an empirical study, groups of students were asked to solve assignments in different communication environments (e.g. in face-to-face, videoconference, and virtual reality environment). Through self-reported measures, perceived telepresence, social presence, self-presence and satisfaction in each communication environment were measured. In addition, the communication quality of a group (e.g. effectiveness, completeness, clarity, fluence and promptness) was measured by means of an observation scheme. And last, the results of the assignments were a measurement of the performance of a group. An analysis was performed to assess the effect of presence and the differences in communication environments. The results of this study suggest that in a FTF environment communication is very complete and team members feel most satisfied, whereas in a video conference environment communication is more effective and teams perform better. In a VR environment, the quality of communication is lowest because team members interact more difficultly and discussions are limited. In addition, social presence turned out to be the biggest positive predictor for communication quality and satisfaction. However, social presence turned out to negatively influence the effectiveness of a communication and indirectly the performance through an increase in completeness. These new insights could help academics to make optimal use of presence in the design of a virtual environment to enhance communication and consequently improve the performance and satisfaction of a group.

Supervised by Mirjam Galetzka and Thomas van Rompay

Keywords
Virtuality, virtual teams, telepresence, social-presence, self-presence, group communication quality, group performance, satisfaction

TABLE OF CONTENTS

1. INTRODUCTION

Nowadays we live in an era where group communication is increasingly taking place using virtual tools (Price, 2020). Besides the main motivation to reduce negative impact on the environment (Shujaat, Manzoor & Nadeem, 2014), the circumstances surrounding Covid-19 are now an additional motivation. Business travel has become less prevalent and meetings are more often taking place virtually whenever possible. With the current situation of Covid-19, many companies are stimulated to give virtual meetings a more powerful position within the organization (Tracy-Taylor, 2020). Many employees and students work more often from home and use the available communication tools to continue the work. Appointments with customers and partners also take place virtually more often (Tracy-Taylor, 2020). Moreover, an increasing number of companies are experimenting with virtual possibilities to hold meetings in order to allow business operations to continue even without coming to the office (Deloitte, 2020).

Virtual teams are characterized by groups that are geographically and temporally distributed whereby communication is maintained through electronic means (Morgan, Paucar-Caceres, & Wright, 2014). Here, groups are relying on a virtual environment in order to communicate. Using technology alone does not make a team virtual. Nearly every team is using technology to some extent. Virtuality only exists when there is a dependence on electronic communication (Orhan, 2014). Teams that are geographically dispersed often have no alternative but to communicate electronically, despite the fact that some team members may prefer face-to-face communication (Cohen & Gibson, 2013). As Johansson (2020) stated, a rising number of businesses are adopting state-of-the-art technology to communicate and optimise their activities. Especially video conference turned out to be a widely used virtual communication environment (Johansson, 2020). In addition, Grudzewski, Awdziej, Mazurek and Piotrowska (2018) indicated that more and more companies are experimenting with virtual reality as a possible new alternative for facilitating meetings. According to Grudzewski et al. (2018), virtual reality is the promising future for remote communication.

The effect of virtuality on groups has been discussed in literature as an essential factor in shaping the performance of a team, and in particular in the area of communication (Lu et al., 2014). Virtual teams that are effectively designed, managed and implemented, can leverage expertise and knowledge from any location and can operate on a 24/7 basis. This approach is usually cost-effective. However, if these teams are organised and controlled poorly, team dynamics can become weak and results may be incompetent (Gilson, Vartianen, Maynard, & Hakonen, 2014). Connelly and Turel (2016) observed that members of virtual teams appear to exchange less feedback than face-to-face team members. In addition, Biocca et al. (2003) indicate that in virtual teams it is more difficult to observe the body language and facial expressions of team members. Consequently, team members may not share the same objectives due to a lack of feedback and understanding of each other. This in turn may negatively affect a team's

performance. According to Cohen and Gibson (2013), the lack of physical presence is perceived by others as the main disadvantage of virtual teams. Members of a virtual team may be less effective or satisfied because they feel less connected to both the task and the team members. However, to balance these limitations, the study by Oeppen and Brennan (2020) proposes that working virtually mitigates the often experienced face-to-face team process losses that arise from stereotyping, personality, authority or political conflicts, and cliques. According to Marlow, Lacerenza and Salas (2017), an understanding and assessment of the differences between virtual and face-to-face communication is essential in order to develop and facilitate effective communication in a virtual team.

Additional virtual tools have become accessible to groups as technology has progressed. However, the majority of studies continue to focus on traditional virtual tools such as email, text message, and teleconference, which have been studied in great detail in the past. Nevertheless, very few studies have investigated the effects of these more recent tools (e.g. video conference and virtual reality) on team communication, even though they may be deployed within highly virtual teams to a greater extent than the traditional communication tools studied (Koutsabasis, Vosinakis, Malisova, & Paparounas, 2012).

Since communication systems have developed gradually to replicate experiences with individuals and environments, computer scientists, psychologists, and communication academics have devoted more attention to this (Lee, 2004). Presence has been important to theorizing sophisticated human-computer interfaces such as virtual reality and video conference systems (Fägersten, 2010). For the design and assessment of interactive media and computer interfaces, the principle of presence has significant practical relevance, particularly in telecommunications (videoconferencing, computer-supported collaborative work, etc.) and education (online education, training classes, etc.) (Whitmer & Singer, 1998). According to Lee (2004), presence can be divided into 3 types of presence: telepresence, the feeling that one is present in a real place; social presence, the feeling that one is present with someone else; and self-presence, the degree to which one recognizes the virtual self as the true self. Based on these types of presence, communication environments can be assessed (Lee, 2004).

As previously stated by Koutsabasis et al. (2012), more research needs to be done on recent communication environments (e.g. video conference and virtual reality) and their effects on communication quality, performance, and satisfaction. In order to assess the communication environments, this study used the concepts of presence (e.g. telepresence, social presence, and self-presence). A study was conducted on communication quality, performance and satisfaction of a group by examining the presence of face-to-face, videoconference and virtual reality communication environments.

This study aims to provide insight into the optimization potentials of a virtual environment. New insights could help academics to make optimal use of these types of presence in the design of a virtual

environment to enhance communication and consequently improve the performance and satisfaction of a group. A general research question has been developed:

'To what extent does presence (telepresence, social presence and self-presence) impact the group communication quality (effectiveness, completeness, clarity, fluence and promptness) and in turn, performance and satisfaction in a problem-solving context?'

In order to compare the communication environments, it was interesting for this study to examine how presence is perceived in each communication environment. Therefore, the differences in presence between the three communication environments were identified. For this reason, a sub question was developed:

'To what extent do communication environments differ in terms of telepresence, social presence and self-presence?'

In order to answer these questions, an empirical study has been carried out. In the present study, groups were asked to solve assignments in a virtual reality, video conference, and face-to-face environment. Based on observations and self-reported measures, the relationship between presence and communication quality, performance and satisfaction was examined for each communication environment.

2. THEORETICAL FRAMEWORK

The growth of virtual teams has led to extensive research into how these teams function in comparison to face-to-face teams and into ways of making virtual teams more effective (Morrison-Smith & Ruiz, 2020). A variety of studies have shown that providing the opportunity for face-to-face conversations improves group engagement and socialization (Connaughton & Daly, 2004; Kiesler & Cummings, 2002; Kraut, Fussell, Brennan, & Siegel, 2002). Kraut et al. (2002) argued that when people are face-to-face, they can interact and cooperate by using a wide variety of linguistic, paralinguistic and non-verbal actions. Deictic gestures (i.e., pointing) may be used to refer to persons, places, and objects rapidly and effortlessly (Connaughton & Daly, 2004). Furthermore, since face-to-face interaction occurs in real time, speakers receive immediate input about how their message is received when it is transmitted (Fussell et al., 2002).

Videoconferencing has been studied for many years in terms of mutual gaze and head orientation (Palmero et al., 2018), remote guidance (Fussell et al., 2004), the sense of presence (Baños et al., 2004), and the richness of the communication channels (Bos, Olson, Gergle, & Wright, 2002). Van der Kleij, Schraagen, Werkhoven and Dreu (2009) compared video conferencing groups with face-to-face groups in their study. They found that video conferencing groups took more time, but team members interrupted each other significantly less than face-to-face groups. They argued that the interaction process in video

conferencing groups was more formal. Listeners were found to be more courteous by waiting for a speaker to finish before adding to the dialogue. In addition, Olson, Appunn, McAllister, Walters, and Grinnell (2014) found that adding video to an existing virtual team increased trust and collaboration. Furthermore, Akkirman and Harris (2005) found lower levels of perceived satisfaction with group processes and outcomes in video conferencing groups as compared to face-to-face groups.

An evolving platform that offers modern and creative approaches to problem solving, entertainment, education and a variety of other aspects of our lives is virtual reality (Kaplan et al., 2020). According to Hammick and Lee (2014), the lack of visual/auditory cues in virtual reality is an important factor affecting the quality of a communication in teams. As Seele, Misztal, Herpers, Schild and Buhler (2017) argued, a lack of visual or auditory cues can cause misunderstandings in the transmission of information, which can lead to teams not working effectively. However, compared to a FTF world, shy people are less likely to perceive negative or inhibitory feedback signals from others due to the lack of visual and auditory stimuli in virtual reality (Stritzke, Nguyen, & Durkin, 2004). As a result, virtual reality has a positive effect on shy people, making them feel less anxious to communicate.

2.1 Group communication quality factors

Group communication is defined as a group process that refers to the exchange of information among group members and is essential for the performance of a group (Kraut et al., 2002). A high-quality group communication generates multiple perspectives, where shared knowledge allows members to understand the problem space and to successfully define the problems (Burgoon et al., 2002). According to González-Romá and Hernández (2014), group communication quality is composed of five subconstructs, including effectiveness, completeness, clarity, fluence and promptness. *Effectiveness* indicates the relevance of group communication. Great effectiveness in group communication creates important information communication that is to the point. *Completeness* refers to the extent a group communication covers all issues important for the topic. High completeness has no piece of important information missing. *Clarity* indicates the group's understanding of the information shared and received. High clarity in group communication is achieved when all members of the group understand the information. *Fluence* indicates the extent of free and easily sharing information among a group. In fluent group communication, information can be exchanged without interruptions. *Promptness* indicates a group's responses and feedback in terms of time. Group communication is high on time when one receives timely answers and feedback with minimal delays (González-Romá & Hernández, 2014). This study used these five subconstructs to asses group communication quality in communication environments.

2.2 Presence

Presence has been important to theorizing sophisticated human-computer interfaces such as virtual reality and video conference systems, and therefore has been the focal point of both applied and academic work (Cummings et al., 2012). Presence can be additionally separated into three particular subcategories: telepresence, social presence, and self-presence (Lee, 2004).

2.2.1 Telepresence

Telepresence is the perceptual illusion of non-mediation (Steuer, 1992). It is the sensation of "being there" in a world created by a medium (Heeter, 1992). In telepresence, the user does not observe or recognize the existence of a medium in his communication environment and interacts as he would in the absence of the medium. Although the medium is important for facilitating telepresence, cognitive perception of the user's environment is essential for developing a feeling of telepresence (Baños, Botella, Guerrero, & Rey, 2004). Lombard and Ditton (1997) stated that telepresence is of a subjective nature as it involves various sensory, psychological, and emotional processes. In addition, Biocca (1997) argued that telepresence is concerned with transport, meaning that the consciousness of a user is transported to a location that is alternative to the actual location, where one feels and acts as if one is in a real place (Sanchez-Vives & Slater, 2005). This alternative location, telepresence, can be triggered by a sense of "place illusion" which is created within a virtual environment (Slater, 2009). According to Esteban-Millat, Martínez-López, Luna and Rodríguez-Ardura (2014), telepresence is related to flow. When one is in flow, one's engagement with the activity is strong but effortless, one is able to exert a sense of control over their actions, the concerns for the self vanish, and the perception of time is distorted. During a flow state, focus and involvement are particularly high (Esteban-Millat et al., 2014). According to Pelet, Ettis and Cowart (2017), the more users are engaged and feel present in the mediated simulated world, the more likely they are to concentrate, enjoy, feel challenged, feel in control and show interest. In addition, Finneran and Zhang (2003) argued that telepresence is an important factor in helping an individual to stay concentrated on the task, thereby decreasing distraction and off-topic communication. As previously mentioned by Olson et al. (2002), teams that felt as they were in the same room (e.g. collocated teams), were twice as productive as teams that did not felt as if they were in the same room (uncollocated teams) regarding project outcomes. They linked collocated team productivity to fluid communication practices, particularly frequent and impromptu feedback, which makes it easier to find mutual understanding within groups. Based on these past researches it can be argued that telepresence is related to group communication effectiveness, clarity, fluence, and promptness. Since no evidence is found for group communication completeness, it is excluded from the hypothesis. Therefore, the following hypotheses are stated:

H1: Telepresence is positively related to group communication effectiveness (a), clarity (b), fluence (c), and promptness (d).

2.2.2 Social Presence

Biocca, Harms and Burgoon (2003) describe social presence as a "feeling of being with someone else". In a virtual context, Lowry (2006) defined presence as the extent to which a communication tool enables the group members to observe (feel) the actual presence of the team members and the resulting valuation of inter-personal relationships, even though they are situated in distinct locations, operate at different moments in time, and all communication takes place via electronic means. Supporting evidence indicates that a reduced level of social presence within virtual teams can lead to a quality reduction in communication (Roberts et al., 2006). The Social Presence Theory (SPT) notes that media with a low social presence may not be appropriate for inter-subjective interpretation when communication is accompanied by interactivity and reciprocity (Lombard & Ditton, 1997). Fundamental to SPT is the conviction that the sender's presence affects the receiver 's perception of the information given. Correspondingly, common, unmediated face-to-face spoken interactions offer the highest social presence (Miranda & Saunders, 2003), whereas computer-aided media offer lower social presence (Roberts, Lowry, & Sweeney, 2006). A low social presence can reduce the performance of group members by ignoring or delaying particular comments or information. Since low social presence leads to a decrease in social signals, it is likely to cause less interaction and reciprocity, that in turn, are essential for high qualitative communication. Kraut et al. (2002) examined the communication of people that were placed in each other's presence. This communication included the creation of greater common ground, more accurate timing of messages, improved off-topic coordination, better misconception repair, and fluid patterns of communication (Lu, Watson-Manheim, Chudoba, & Wynn, 2006). Therefore, the following hypotheses are stated:

H2: Social presence is positively related to group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

2.2.3 Self-presence

Self-presence is defined as the degree to which one recognizes the virtual self as the true self (Aymerich-Franch, Karutz, & Bailenson, 2012). This presence aspect is linked to how attached one feels to one's virtual self, thoughts, or personality (Ratan, Santa Cruz, & Vorderer, 2007). Schwartz and Steptoe (2018) found that visual representation, spatialized audio, and movements of one’s body relate to the increased sense of self in virtual environments. These three elements represent the observable signals that develop the immersive self, in which each element is linked and influenced by the others in order to construct self-presentation. Biocca et al. (2003) indicate that representation of one's real physical body to one's virtual body may affect someone's body schema or image. They note that a discrepancy may occur between one's real body and virtual body, physically as well as socially. Physically, misunderstandings can occur in the transmission of information via unclear, non-verbal communication (e.g., through limited facial expressions, gestures or posture). Socially, inconsistencies may occur in the absence of appropriate answers to the user's feedback (e.g. limited promptness, relevance or validity of

feedback to user questions). Findings by Biocca et al. (2003) showed that non-verbal cues played a key role in the clear transfer of information between communicators in communication environments. According to Kang and Watt (2013), one adopt more non-verbal communication when one experience the possibility for copying facial expressions and body movements in a communication environment. As communicators use more non-verbal communication when one perceives more embodiment and self-presence, this can cause one to communicate more quickly and clearly with others. As Roberts et al. (2006) stated, a reduced self-presence within virtual teams could reduce the quality of communication within a team, and therefore, could affect its productivity in terms of project outcomes. Based on these past researches it can be argued that self-presence is related to group communication effectiveness, clarity, and promptness. Since no evidence is found for group communication completeness and fluence, it is excluded from the hypothesis. Therefore, the following hypotheses are stated:

H3: Self-presence is positively related to group communication effectiveness (a), clarity (b), and promptness (c).

2.3 Team effectiveness

Two key measures of the effectiveness of teams are performance and satisfaction. Piccoli, Powell and Ives (2004) specified effectiveness as group output and the effect of a group on its members. With regard to work experience and satisfaction, effective teams need to be able to deliver a higher level of output quality and reward group members (Jarvenpaa & Ives, 1994). In addition, performance can be interpreted as the degree to which the outcomes of a group fulfil the requisite expectations or measurements (Lurey & Raisinghani, 2001), whereas satisfaction can be described as the degree of the members' assessment of the actions and agreements with the group output (Chidambaram, 1996). As previously mentioned, literature state the positive relationship of performances with telepresence, social presence and self-presence which is mediated by group communication quality. It is argued that when the perception of presence in virtual teams increases, the quality of group communication also increases, and in turn, leads to more group productivity. Nevertheless, no study examined the relationship of presence and satisfaction. As effectiveness of virtual teams are not only measured by performances but also satisfaction, it becomes of great interest to study this relationship. Raluca and Romulus (2018) stressed that a worker's satisfaction is determined by the degree to which one feels satisfied with one's work. This satisfaction is based on a number of factors, in which one of the key factor is communication. In addition, Shujaat et al. (2014) found that group work and communication quality have a significant impact on employee satisfaction. Considering these theoretical arguments, the following hypotheses are stated:

H4: The effect of telepresence on performance will be mediated by group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

H5: The effect of social presence on performance will be mediated by group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

H6: The effect of self-presence on performance will be mediated by group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

H7: The effect of telepresence on satisfaction will be mediated by group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

H8: The effect of telepresence on satisfaction will be mediated by group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

H9: The effect of telepresence on satisfaction will be mediated by group communication effectiveness (a), completeness (b), clarity (c), fluence (d), and promptness (e).

2.4 Communication environments

The principle of presence has significant practical relevance for the design and assessment of interactive media and computer interfaces, and is therefore used to theorizing communication systems such as virtual reality and video conference systems (Whitmer & Singer, 1998).

2.4.1 Perceived telepresence

Virtual Reality (VR) involves computer technology applied to simulate a virtual environment (Biocca & Levy, 1995). Contrary to conventional communication interfaces such as video conferencing, VR places the user in an immersive experience. As opposed to having a computer screen in front of them, it allows users to interact with their world (Lin et al., 2017). Pallavicini, Pepe and Minissi (2019) investigated telepresence among players using a virtual reality game and a desktop game. Participants reported a significantly higher feeling of telepresence at the end of the virtual reality game in relation to the level of presence perceived at the end of the desktop gameplay. In addition, several studies (e.g. Steed et al., 1999; Slater & Steed, 2000; Moreno & Mayer, 2004) examined immersive virtual platforms (e.g. HMD, cave automatic virtual environment; CAVE) compared to non-immersive platforms (e.g. Desktop). These studies support a common understanding that immersive virtual environments generate a greater sense of telepresence than non-immersive virtual platforms. Since face-to-face communication does not take place in a virtual environment, telepresence was interpreted in this case as the feeling of being present in the room. Considering this, this study hypothesised that face-to-face communication allow for the highest perceived telepresence, followed by virtual reality, and then videoconferencing.

H10: Telepresence is perceived highest with face-to-face, followed by virtual reality and lowest with video conferencing.

2.4.2 Perceived social presence

According to Roberts, Lowry and Sweeney (2006), normal, unmediated face-to-face interactions allow for the highest perceived social presence, while computer-assisted media provide a lower perceived social presence. Norris, Weger, Bullinger and Bowers (2014) argue that VR experiences that utilise avatars to produce real time verbal and non-verbal social responses affect the perceived social presence, the feeling of being present with others. Avatars are presumed according to studies (Blascovich et al., 2002; Slater & Steed, 2000) to transmit social signals and improve social presence. Recent research of Bente et al. (2008) presents findings that (1) visual representation and (2) realistic behavioral representation of actions (e.g. eye and mouth gestures and body computation) improve social presence. This research highlights the importance of behavioral realism in promoting a sense of social presence in virtual reality facilitated by virtual avatars. However, avatars in virtual reality do not resemble the user and have a limited level of behavioral realism. This is expected to improve in the future. Considering these studies on visual representation and behavioral realism, virtual reality was expected to generate at the moment a moderate sense of social presence. Furthermore, the use of online video conferencing in this study was expected to have a valuable impact on social presence as it is defined as' the capacity of individuals to reflect their personal attributes into the group, introducing themselves as "real persons" towards others (Garrison, Anderson, & Archer, 2000). Giesbers, Rienties, Gijselaers, Segers and Tempelaar (2009) claim that perceived social presence is strengthened by the users being able to communicate themselves in a group more socially and emotionally when participants can be seen and heard simultaneously and have access to a common workspace through online video conferencing. Since in this study visual representation and behavioral realistism are greater in videoconferencing than in virtual reality, it is hypothesised that the perceived social presence will be greater in videoconferencing than in virtual reality.

H11: Social presence is perceived highest with face-to-face, followed by video conferencing and lowest with virtual reality.

2.4.3 Perceived self-presence

Biocca (2014) claims that in a virtual environment, the self-avatar reflects one 's behavior. However if the self-avatar that one encounters does not seem to reflect the physical body, it may be challenging to associate with. According to the principle of objective self-awareness (Wicklund, 1979), self-awareness is enhanced through the use of cameras and/or one's own appearance in a social setting. Slater (2009) proposed that self-presence relates back to the possible usefulness of a virtual reality self-avatar. If a feeling of self-presence is perceived, a self-avatar should be "invisible" as an interface mediator and users will interact in it unconsciously. Supportive studies from Bente et al. (2008) present findings that when visual and realistic behavioral actions in body movements and facial expressions can be represented in a virtual environment, perceived self-presence can increase. Nevertheless, in the identification and use of a self-avatar in a simulated world, humans seem to have a lot of versatility.

Certainly, in social contexts, users can use avatars to interact effectively (Schultze, 2010). Dodds, Mohler and Bülthoff have demonstrated, for example, that a self-avatar is a valuable resource in a virtual reality environment to interact with others. Steed, Pan, Zisch and Steptoe (2016) state that when analyzing self-presence, the feeling of embodiment inside a self-avatar should be regarded. In certain cases, when embodied within a self-avatar, the individual considers the self-avatar as their true entity. According to Roberts, Lowry and Sweeney (2006), one starts to gain self-presence by specifically monitored hand controls, enabling one to perceive one's own hands movements and connect throughout the environment. However, the appearance of avatars in virtual reality do not resemble the user. It has a limited level of visual representation and behavioral realism in terms of eye and mouth movements compared to video conferencing. According to Roberts, Lowry and Sweeney (2006), normal, unmediated face-to-face interactions allow for the highest perceived self-presence, while computer-assisted media provide a lower perceived self-presence. Considering this, it is hypothesised that the perceived self-presence will be the highest in a face-to-face environment, followed by videoconference, and then virtual reality.

H12: Self-presence is perceived highest with face-to-face, followed by video conferencing and lowest with virtual reality.

The present study emphasized the presence, which are telepresence, social presence, and self-presence, of the communication environments and its relationship to group communication quality, performance and satisfaction. The theoretical concepts and relationships are presented in the conceptual model in figure 1.

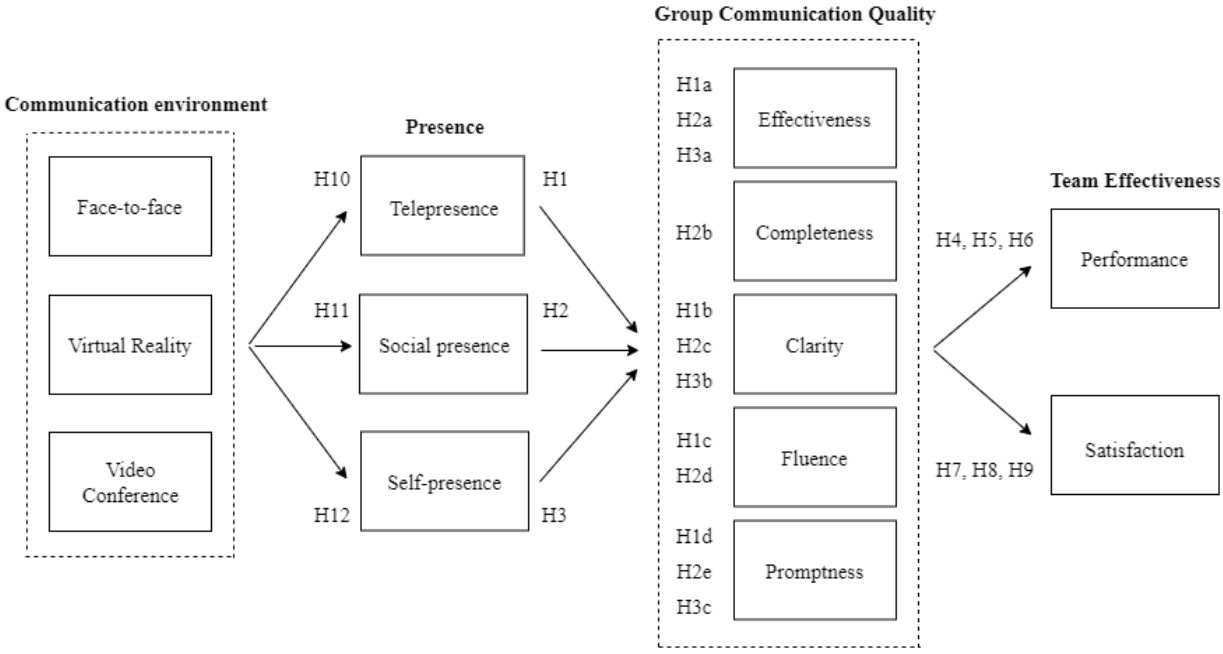

Fig. 1. An conceptual model of virtual team effectiveness.

3. METHOD

3.1 Design

For this study, a within-subject design is used to examine the mediating effect of the five group communication factors on performance and satisfaction for the different dimensions of virtuality (e.g. telepresence, social presence, and self-presence). The communication environments (e.g. virtual reality, video conference, and face-to-face), which in the hypotheses were assumed to differentiate in the degree of telepresence, social presence, and self-presence, was the within-subject factor. By using a within-subject design, random noise such as participant's characteristics, intelligence, and/or relationships could be minimized. However, it could have create a learning effect and fatigue could have occurred (Charness, Gneezy, & Kuhn, 2012). Therefore, randomization in the order of the within factor (e.g. the communication environment) and assignments were conducted (Appendix C) to minimize order effects, transfer and learning across conditions (Budiu, 2018). In addition, the duration and complexity of the questionnaire were taken into account, so that participants did not get fatigued.

3.2 Pre-test

A pre-test with 10 participants was conducted to clarify the relationships between the types of presence and communication environments. During this pre-test participants were provided with explanations and images of the communication environments and the different concepts of presence. Subsequently, the participants had to rank the communication environments for telepresence, social presence and self-presence. The results of the rankings of the 10 participants in the pre-test all corresponded to the hypotheses that had been made in this study.

In addition, a second pre-test was conducted to test whether fatigue could happen when performing the assignments. For this, a group of three students had to make the three assignments one after the other and for each assignment, the time was recorded. After they finished, their opinion about the assignments and the process was discussed. It was also noticeable that the last assignment was completed faster than the first. These two references of information indicated that the motivation decreased per assignment. Therefore, for this study we decided to provide a competitive aspect to the assignments by means of a prize. By doing this it was possible to motivate the participants.

A third pre-test was done for the observation scheme to exclude inter-observer bias. In order to test whether the observation scheme had clear guidelines for assigning scores, a pre-test was conducted with two other observers. These observers had to judge a short fragment that was recorded during the experiments. It turned out that the two observers gave exactly the same scores during this pre-test, suggesting that the observation scheme can be accepted for the use in this study.

3.3 Procedure

The study mainly took place in the BMS lab of the University of Twente. Due to the circumstances surrounding Covid-19, extra measures had to be taken to allow the physical experiments to take place. For this, approval had to be obtained from the Ethics Committee and the BMS lab. Furthermore, the planning of the physical experiments was taken into account and a maximum of one group of three students per day was allowed in the flex-experiment rooms. Additional measures that were taken concerning Covid-19 were disinfectants, mouth masks, special face masks and hairnets for the virtual reality glasses, and special conference rooms that guaranteed 1.5 metres and ventilation. Figure 2, 3, and 4 represent these rooms. At the end of the day, the devices and materials used in the experiment were cleaned.

Before the participants started the experiments they were each given a binder. This binder consisted of the Informed Consent, Covid-19 papers, the assignments and the questionnaires. They were asked to read the Informed Consent, and when they had done so and agreed to it, to sign it. In addition to the informed consent, participants were also screened for Covid-19 symptoms beforehand. They had to fill in a special form and have it signed by the researcher. These forms were then submitted to the BMS lab.

Before starting the assignments, participants were told that they could win a prize when they obtained the best group results. They were explicitly told that time was not an important factor. The prize was used as a means of motivation since the participants were to spend two hours completing three tasks that resembled each other. Afterwards, it appeared that playing in VR was also a great means of motivation.

Depending on the order in which a group had to perform in a certain communication environment, the three students were guided to their places. While the participants were engaged in the assignments, they were video recorded. These recordings were used to assess the communication variables using an observation scheme. After completing an assignment in a particular communication environment, they were asked to complete a questionnaire. Participants had to fill in statements about telepresence, social presence, self-presence and satisfaction. Participants therefore completed a total of three questionnaires. In addition, participants were asked to fill in their experiences with FTF, video and VR to examine potential covariance.

The duration of each assignment remained under 20 minutes. The overall procedure took approximately two hours. After the experiments, participants were offered a small gift as a token of appreciation.

3.4 Materials

For each assignment a different environment was used to manipulate presence. The first communication environment was traditional face-to-face communication in which students were placed together in one room. Due to the circumstances concerning Covid-19, the 1.5 meter distance had to be taken into account. For this purpose a room was used that allowed enough space to sit 1.5 meters apart with a group

of 3 students. These face-to-face meetings took place in a conference room at the University of Twente. Using the assignment in their binder, participants were able to begin. In order to assess the communication of the group, the process was recorded using a camera. For this purpose a JVC 4k camera was used. Figure 2 represents the face-to-face communication environment that is used for these experiments.

The second communication environment was a video conference. The video conference meeting took place in the Flex-experiment rooms in the BMS lab at the University of Twente. Students were placed individually in separate rooms to ensure that no face-to-face confrontation was made with each other. These rooms contained a seat and a table equipped with a laptop and webcam. The students were virtually connected through Google Meet. Google Meet is a software from Google that facilitates video conferences. Participants received a link that opened the conference room on their laptop. Participants simply had to click on participate and they could start with the assignment they had on a paper in front of them. During the process the Google Meet meeting was recorded in order to observe and assess the group communication. Figure 3 represents the Flex experiments rooms used for this experiment.

The third communication environment was virtual reality. Two Oculus Rift S glasses, an Oculus Rift glass with two sensors, and three Dell Alienware Aurora computer systems were used from the BMS-lab to support virtual reality. The software AltSpace VR was used to create a virtual world in which participants experience as they are together in an office. Noteworthy, AltSpace VR uses avatars that do not resemble the users. Therefore, the visual representation and behavioral realism of users were limited. Again, students were placed in separate Flex-experiment rooms so they could not have face-to-face interaction with each other. These rooms had sufficient space for participants to move around. Figure 4 represents the Flex experiments rooms for this experiment. Many participants had no experience with VR. For this reason participants were introduced step by step to the VR environment in AltSpace VR and received an explanation of the controllers. After the explanation, they were placed in a virtual community space called 'The Campfire'. This is where people from all over the world are seated, with whom you can communicate through your VR headset. The participants were asked to go and discover VR for themselves. After the participants had experimented with VR in this shared virtual environment for a while, and had become more familiar with the system, they were invited to join the constructed 'Virtual Office' to start the experiment. Since participants wore VR glasses and therefore could not see the paper assignment, the assignment was incorporated in the virtual office. By means of an API, the assignment and a list of 15 items was built in the virtual office, enabling the participants to complete the assignment in virtual reality without any interruption. Figure 5, 6, and 7 shows the VR environment used in AltSpace VR.

Fig. 2. FTF conference room

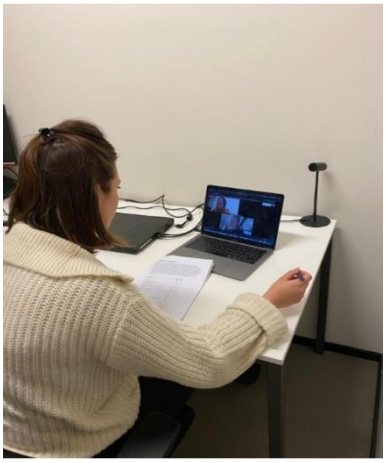

Fig. 3. Video Flex-experiment rooms

Fig. 4. VR Flex-xperiment rooms

Fig. 5. Virtual office in AltSpace VR

Fig. 6. Virtual office in Altspace VR

Fig. 7. Virtual office with integrated assignment in AltSpace VR

To ensure the data privacy of the participants, the recordings of the JVC 4k camera, Google Meet meetings and the meetings in AltSpace VR were stored in a special protected data warehouse of the BMS lab.

3.5 Tasks

Groups were faced with three assignments that each time contained a different dilemma. The assignments consisted of the collaborative tasks 'the Desert Survival Problem', 'the Moon Landing', and 'Lost at Sea' (Appendix D). These tasks required participants to cooperate as a team to solve, interpret and clarify issues and to assess alternatives. For each dilemma, groups were asked to rank 15 items according to priority in order to survive, and therefore, best solve the dilemma. The students had to communicate as a group in order to come to a group consensus on the rankings. Due to randomization, the communication environment (e.g. virtual reality, video conferencing and face-to-face) differed for each assignment. Since this experiment involved three sets of assignments, the experiment was completed within two hours. As much time was required of students, it was essential that no fatigue occurred to ensure that they remained motivated to complete each assignments adequately. To reduce boredom, the assignments were provided with a competitive challenge and dilemmas were used that contained a compelling subject. The emphasis was on achieving the best result as a group. The duration of the assignment was not regarded as a priority.

3.6 Participants

Before the experiment took part, a pre-test with 10 students (all female, range 22 – 25 years old) was done to test the communication environments and the perceived presence in advance. In addition, a second pre-test with 3 students (all female, range 22 – 24 years old) was performed to test the assignments. Subsequently, the experiments were conducted.

This study employed data on nine teams engaged in virtuality, in which each team consisted of three students. Therefore, a total of 27 participants (age: M = 22.15, SD = 2.72; 96.30% female), took part in the study. Participants were signed in via the BMS SONA system (7.41%) or were personally recruited (92.59%), based on whether they were students, fluent in Dutch, and whether they lived in the vicinity of the University of Twente (Due to Covid-19 and limited public transportation). All participants were students enrolled in graduate programs of the University of Twente (77.78%) and Hogeschool Saxion Enschede (22.22%). An online planner was used where participants were able to select the time slots (09:00 – 11:00 and 14:00 – 16:00) they were available for each day. Based on this information, groups were created. Due to Covid-19, it was decided to construct the experiment with a maximum of one group of three student per day. 27 students participated in the experiment, and all obtained data was used for this study. Table 1 gives an overview of the demographics of the participants.

Table 1

Participants demographics

Group number	1	2	3	4	5	6	7	8	9	Total
Female	3	3	3	3	3	3	3	3	2	26
Male	0	0	0	0	0	0	0	0	1	1
Age	22.33	21	23.67	22	20.33	21.67	19.33	21.33	27.67	22.15
HBO	0	0	0	1	1	1	1	1	1	6
WO	1	2	1	1	1	1	2	1	0	10
WO master	2	1	2	1	1	1	0	1	2	11
Experience with FTF*	5	5	5	5	5	5	5	5	5	5
Experience with video*	4.33	5	5	4.33	4	5	4.67	5	4.67	4.67
Experience with VR*	2	1.67	1.67	1.33	1.33	1.33	1.67	1.33	1.67	1.56

*. Mean score based on a 5-point Likert scale

Table 1 shows that the study levels were evenly distributed among groups. Similarly, the average age of groups did not differ. Only group 9 differed somewhat from the other groups in terms of age and gender. On average, this group had a higher age than other groups and included one male. The data also shows that all groups had the most experience with face-to-face communication (Total mean = 5 out of 5), followed by video (Total mean = 4.67 out of 5) and then VR (Total mean = 1.56 out of 5). The data shows that participants had little experience with VR.

3.7 Measures

To examine to what extent the dimensions of virtuality influence performance and satisfaction, mediated by the five communication quality variables, several variables were measured.

3.7.1 Telepresence, social presence, self-presence, and satisfaction

To measure participants' perceived telepresence, social presence, self-presence, and satisfaction in each communication environment, this study used self-reported measures. After participants (a total of 27 students) finished the task in a given communication environment, they were asked to complete a questionnaire. This questionnaire was composed of various statements about telepresence, social presence, self-presence and satisfaction that were derived from literature (Appendix B). The questionnaire was based on a 7 point-Likert scale and consisted of 20 statements in total.

The definition of telepresence in this experimental study was ‘’the feeling that one is present in a real place’’. Five statements were used to measure the perceived telepresence in a communication environment. These statements are equivalent to the questions used by Kim and Biocca (1997) and

Schubert, Friedmann and Regenbrecht (2001). Here, the aim was to measure the extent to which participants felt that they were transferred into the communication environment, to what extent participants perceived as they were in the same place as their team members, and to what extent visual aspects and noises involved participants.

The definition of social presence in this study was ‘’the feeling that one is present with someone else’’. The five statements that were used to measure the perceived social presence are based on questions used by Lin (2004) and Kim (2011). These statements aimed to measure to what extent participants felt socially present, to what extent they felt part of the team, and to what extent they were able to form impressions of other participants’ intentions, emotions, and reactions.

The definition of self-presence in this study was ‘’the degree to which one recognizes the virtual self as the true self’’. The five statements that were used in this study derived from Ratan and Hasler (2009). Here, it was aimed to measure the extent to which participants felt attached to their virtual self, the extent to which participants relate to the visual representation, spatialized audio, and movements of one’s virtual body.

And last, the satisfaction of participants was measured. Five statements derived from Suh (1999) were used to measure the extent to which participants felt satisfied with the quality of the outcome, how confident they were about their solution, and how satisfied they felt with the commitment, process and cooperation of the group.

In order to analyse the reliability of the four constructs, a Cronbach’s alpha test was performed for each communication environment. Cronbach's alpha measured the degree of consistency (internal consistency) between multiple statements in the questionnaire. Table 2 represents the Cronbach’s Alpha scores for the four constructs telepresence, social presence, self-presence, and satisfaction (Cronbach’s Alpha > .70). These scores are based on 20 items, measured by a 7-point Likert scale.

Table 2

Reliability overview of the four constructs

	FTF		**Video**		**VR**	
Construct	**α**	**Items**	**α**	**Items**	**α**	**Items**
1. Telepresence	.76	5	.84	5	.75	5
2. Social presence	.84	5	.80	5	.81	5
3. Self-presence	.83	5	.80	5	.86	5
4. Satisfaction	.73	5	.72	5	.84	5

All constructs showed a Cronbach’s Alpha higher than .70. Therefore, all constructs were included in the data analysis.

3.7.2 Communication quality variables

To measure the five variables of group communication quality in each communication environment, this study used observation measures. The observation scheme that was used consisted of a 5-point Likert scale rating of behavior. The observation scheme can be found in Appendix A. Before the communication was assessed, a pre-test was conducted with two other observers in order to test whether the observation scheme had clear guidelines for assigning scores. To test his, Landis and Koch (1977) presented standards for interpreting κ, indicating that κ values of 0.81 to 1.00 showed almost perfect agreement. This pre-test resulted in full inter-rater reliability ($\kappa = 1.00$, $p < .001$), which is the degree of agreement among observers. Based on this pre-test, it was accepted to work with the observation scheme.

During the experiments, group communication was video recorded, observed, analyzed and assessed based on the observation scheme. To ensure intra-observer reliability, i.e., the degree to which measurements from the same observer are consistent, group communication was analyzed three times by the same researcher. Based on the guidelines of Landis and Koch (1977), the Cohen's Kappa of the observations ($\kappa = .893$, $p < .001$) was measured, representing high levels of agreement. Therefore, it was concluded that the observations were reliable to analyse in the study.

3.7.3 Performance

Performance was measured by the results of the assignments. Experts have reviewed the assignments in the past and provided the correct answers for the dilemmas. Based on the experts' answers, the results are calculated. In order to measure the performances of a group, the absolute difference between the group priority ranking and expert priority ranking (e.g. error points) was assessed. A lower number of error points signified a greater group performance. The three assignments that a group had to complete were similar to each other but each involved a different dilemma. However, the level of difficulty of the assignments were not the same. As a result, the scores of the three assignments were not comparable, and therefore, the absolute scores of the assignments could not be used as comparative data. Therefore, this study examined how well a particular group did on the assignment compared to other groups. In other words, performance was determined by assessing the relative score compared to the rest of the groups.

3.8 Data Analysis

In order to test the hypotheses, an One-way Repeated Measures analysis of variance (ANOVA) and Multivariate regression was conducted.

3.8.1 Repeated measures

An one-way repeated measures analysis of variance (ANOVA) was used to compare 27 students' ratings of three different communication environments. This analysis was conducted to compare the effect of

face-to-face, video conference and virtual reality environments on telepresence, social presence, and self-presence. The Bonferroni post hoc test, e.g. Pairwise comparison, was used to conclude significant differences. This information determined whether we rejected or accepted hypotheses 10, 11 and 12. In addition to answering the hypothesis, a repeated measures analysis was done for the five communication variables, performance, satisfaction, and duration of the assignment. The purpose of the repeated measures analysis was to answer the hypothesis, as well as to provide valuable insights into the differences between the communication environments. To test the possibility of covariances such as duration of an assignment and experience in a communication environment, a covariance analysis was done within the one-way repeated measures analysis of variance (ANOVA). Boxplots and Shapiro-Wilk statistics indicated that the assumption of normality was supported for all variables tested. Furthermore, homogeneity of variances were demonstrated and Mauchly's test was used to indicate the assumption of sphericity.

3.8.2 Multivariate regression

In order to answer hypothesis H1, H2 and H3, a multivariate regression analysis of variance (MANOVA) was performed. In this analysis, further research was conducted into the collective influence of telepresence, social presence and self-presence as independent variables on the communication quality variables, performance and satisfaction as dependent variables. In addition, a regression analysis was performed for the communication quality variables as independent variables on performance and satisfaction as dependent variables.

And finally, in order to answer hypothesis H4, H5, H6, H7, H8 and H9, the mediating effect of the communication variables was analyzed. This was done by analyzing the regression results of the five communication quality variables together with the three types of presence as independent variable on the dependent variables performance and satisfaction.

4. RESULTS

This chapter reports the findings of one-way analysis of variance (ANOVA) and multivariate regression. First, the findings that relate to the impact of the communication environment on presence, communication quality, performance and satisfaction are presented. Then, the effect of presence on the communication quality of a group is discussed. Finally, the role of presence and the quality of communication in predicting the performance of a group and the satisfaction of its members is explored.

4.1 Effectiveness of the communication environments

This section elaborates on the effects of the communication environments on presence, communication quality, performance and satisfaction and demonstrates significant differences. Table 3 and Table 4 give an overview of these findings.

4.1.1 Perceived Presence

The following section presents results of the statistical analyses related to perceived telepresence, social presence and self-presence of the three communication environments. In this analysis, hypotheses H10, H11, and H12 were tested based on an one-way repeated measures of analysis of variances (ANOVA).

4.1.1.1 Telepresence

Telepresence had a F_{max} of 5.277, demonstrating homogeneity of variances. Mauchly's test indicated that the assumption of sphericity was not violated, $\chi^2(2) = 1.061$, $p = .588$. The ANOVA results show that telepresence in a FTF, video, and VR environment was not equally perceived ($F(2,52) = 509.29$, $p < .001$, $\eta_p^2 = .951$). Bonferroni post hoc test, using pairwise comparisons, further revealed that participants perceived telepresence significantly the highest when communicating face-to-face (M = 6.87, SD = .24), followed by virtual reality (M = 5.62, SD = .56), and the lowest when communicating in a video conference (M = 2.69, SD = .62). Table 3 and Table 4 give an overview of these findings.

4.1.1.2 Social presence

Social presence had a F_{max} of 2.043, demonstrating homogeneity of variances. Mauchly's test indicated that the assumption of sphericity was violated, $\chi^2(2) = 8.558$, $p = .014$. A repeated measures ANOVA with a Huynh-Feldt correction determined that social presence in Ftf, video, and VR environment were not equally perceived, $F(1.6, 42.4) = 270.73$, $p < .001$, $\eta_p^2 = .912$. Bonferroni post hoc test, using pairwise comparisons, further revealed that participants perceived social presence significantly the highest when communicating face-to-face (M = 6.80, SD = .31), followed by video conference (M = 5.46, SD = .44), and the lowest when communicating in virtual reality (M = 4.30, SD = .45). Table 3 and Table 4 give an overview of these findings.

4.1.1.3 Self-presence

Self-presence had a F_{max} of 3.861, demonstrating homogeneity of variances. Mauchly's test indicated that the assumption of sphericity was violated, $\chi^2(2) = 6.664$, $p = .036$. A repeated measures ANOVA with a Huynh-Feldt correction determined that self-presence in Ftf, video, and VR environment were not equally perceived, $F(1.7, 44.5) = 323.15$, $p < .001$, $\eta_p^2 = .926$. Bonferroni post hoc test, using pairwise comparisons, further revealed that participants perceived social presence significantly the highest when communicating face-to-face (M = 6.84, SD = .29), followed by video conference (M = 5.69, SD = .44), and the lowest when communicating in virtual reality (M = 3.90, SD = .57). Table 3 and Table 4 give an overview of these findings.

As indicated, hypothesis H10 was supported, that is, the telepresence is perceived highest with face-to-face (a), followed by virtual reality (b) and lowest with video conferencing (c). Hypothesis H11, indicating that social presence is perceived highest with face-to-face (a), followed by video conferencing (b), and lowest with virtual reality (c), is also supported. And at last, Hypothesis H12 was also supported, indicating that self-presence is perceived highest with face-to-face (a), followed by video conferencing

(b), and lowest with virtual reality (c). A summary of the results of the hypotheses testing section can be found in Table 10.

4.1.2 Communication quality

A one-way repeated measures analysis of variance (ANOVA) was performed for the group communication quality variables. Table 3 represents the results of the within-subject test and Table 4 represents the descriptive statistics and the pairwise comparison test.

4.1.2.1 Effectiveness

The comparison of the communication environments revealed that the group communication in a FTF environment was of a higher quality than in a video conference or VR environment. However, this was not the case for the effectiveness of the communication. The effectiveness of communication is highest when using a video conference (M = 4.67, SD = .34) or VR environment (M = 4.72, SD = .42), and lowest when using a FTF environment (M = 3.78, SD = .76). This may indicate that people tend to go less off-topic and have more straight-to-the-point conversations when using video conferencing or a VR environment, which could be very effective and efficient in this respect.

4.1.2.2 Completeness

The Bonferroni post hoc test, using pairwise comparisons, revealed that completeness in group communication was significantly the highest when communicating face-to-face (M = 4.17, SD = .87), followed by video conference (M = 3.61, SD = .92), and the lowest when communicating in virtual reality (M = 2.61, SD = .86). This may indicate that one tends to go into less detail when using an environment as VR, but tends to share more information when using a FTF environment.

4.1.2.3 Clarity

The clarity in communication is highest when communicating face-to-face (M = 4.67, SD = .34) or in a video conference (M = 4.67, SD = .42), and the lowest when communicating in virtual reality (M =4.00, SD = .72). This may indicate that one has more difficulties to interpret the information shared and received by group members when communicating in virtual reality.

4.1.2.4 Fluence

The fluence of the conversation in a group was both in a face-to-face (M = 3.72, SD = .25) and video conference environment (M = 3.56, SD = .38) higher than in a VR environment (M = 3.00, SD = .59). This may indicate that in VR, information is less free and easily shared and interruptions may occur more often in a group than in a FTF and Video conference environment.

4.1.2.5 Promptness

The promptness of group communication was significantly the highest when communicating face-to-face (M = 4.89, SD = .21), followed by video conference (M = 4.67, SD = .24), and the lowest when

communicating in virtual reality (M = 3.17, SD = .68). This may indicate that in a VR environment communication is not as quick as in a FTF or video conference environment.

4.1.3 Performance and satisfaction

A one-way repeated measures analysis of variance (ANOVA) was performed for the performance of a group and the satisfaction of team members. Table 3 and Table 4 give an overview of these findings. The analysis revealed that a group significantly performed the assignment better in a video conference environment (M = .91, SD = .15), than in a FTF (M = 1.05, SD = .16) or VR environment (= 1.00, SD = .08). This may indicate that a video conference environment may be best suited for problem-solving tasks where team members need to reach a group consensus. Furthermore, the analysis showed that team members felt significantly most satisfied when communicating face-to-face (M = 6.42, SD = .44), then in a video conference (M = 6.06, SD = .35), and least in virtual reality (M = 5.16, SD = .52).

Table 3

Within-Subject Effects Test

	df	**F**	**P**	η_p^2
Telepresence	2,52	509.29	.000	.951
Social presence	1.63, 8.10	270.73	.000	.912
Self-presence	1.71, 44.54	323.15	.000	.926
Effectiveness	1.19, 30.88	53.77	.000	.674
Completeness	1.70, 44.13	46.05	.000	.639
Clarity	2, 52	20.80	.000	.444
Fluence	2, 52	31.98	.000	.552
Promptness	1.27, 33.01	106.12	.000	.803
Performance	2, 52	12.09	.000	.317
Satisfaction	2, 52	67.39	.000	.722
Duration of assignment	2, 52	1.30	.281	.048

Table 4

Descriptive Statistics

Concepts	Communication environment	M	SD	N
Telepresence[a]	FTF	6.87	.24	27
	Video	2.69	.62	27
	VR	5.62	.56	27
Social presence[a]	FTF	6.80	.31	27
	Video	5.46	.44	27
	VR	4.30	.45	27
Self-presence[a]	FTF	6.84	.29	27
	Video	5.69	.44	27
	VR	3.90	.57	27
Effectiveness[b]	FTF	3.78	.76	27
	Video	4.67*	.34	27
	VR	4.72*	.42	27
Completeness[b]	FTF	4.17	.87	27
	Video	3.61	.92	27
	VR	2.61	.86	27
Clarity[b]	FTF	4.67*	.34	27
	Video	4.67*	.42	27
	VR	4.00	.72	27
Fluence[b]	FTF	3.72*	.25	27
	Video	3.56*	.38	27
	VR	3.00	.59	27
Promptness[b]	FTF	4.89	.21	27
	Video	4.67	.24	27
	VR	3.17	.68	27
Performance[b]	FTF	1.05*	.16	27
	Video	.91	.15	27
	VR	1.00*	.08	27
Satisfaction[b]	FTF	6.42	.44	27
	Video	6.06	.35	27
	VR	5.16	.52	27

*. According to the Pairwise Comparison test, the mean difference is not significant at the .05 level

a. Based on a 7-point Likert scale

b. Based on a 5-point Likert scale

4.2 Effect of presence on communication quality

A multiple linear regression was calculated to predict the five communication quality variables (e.g. effectiveness, completeness, clarity, fluence, and promptness) based on the independent variables telepresence, social presence, and self-presence. Together, telepresence, social presence and self-presence significantly predicted each of the communication variable. The significant regression equation

are represented in Table 7 and the results of the standardized coefficients beta are represented in Table 8.

Table 7

Regression equation

Effect	df	R^2	F	p
Effectiveness	3, 77	.45	20.58	.000
Completeness	3, 77	.41	18.03	.000
Clarity	3, 77	.29	10.62	.000
Fluence	3, 77	.39	16.52	.000
Promptness	3, 77	.78	91.81	.000

a. Predictors: (Constant), Telepresence, Social presence, Self-presence

Table 8

Regression Coefficients

	Telepresence[a]			Social presence[a]			Self-presence[a]		
Dependent variables	**β**	**t**	**p**	**β**	**t**	**p**	**β**	**t**	**p**
Effectiveness	-.23	-2.37	.020*	-.68	-2.74	.008**	.15	.62	.534
Completeness	-.06	-.60	.547	.54	2.10	.039*	.13	.53	.597
Clarity	-.30	-2.71	.008**	.62	2.21	.030*	-.06	-.23	.823
Fluence	-.19	-1.83	.071	.57	2.20	.031*	.09	.37	.713
Promptness	-.30	-4.83	.000**	.52	3.31	.001**	.42	2.79	.007**

* $p < .05$, ** $p < .01$

a. Predictors: (Constant), Telepresence, Social presence, Self-presence

As can be seen in Table 8, perceived telepresence did not significantly predict completeness ($\beta = -.061$, $p = .547$) and fluence ($\beta = -.187$, $p = .071$). However, it did significantly predict effectiveness ($\beta = -.232$, $p = .020$), clarity ($\beta = -.299$, $p = .008$), and promptness ($\beta = -.296$, $p < .001$) in a negative way which was not hypothesized. Therefore, from this analysis was concluded that hypothesis H1, which indicates that telepresence is positively related to effectiveness, clarity, fluency and promptness, was rejected.

The analysis demonstrates that perceived social presence was significantly the strongest predictor for all the variables that were tested. However, from the analysis was concluded that effectiveness ($\beta = -.680$, $p = .008$) was not positively related with social presence. Therefore, hypothesis H2, indicating that social presence is positively related to group communication effectiveness, completeness, clarity, fluence, and promptness, was partly accepted, whereas hypothesis H2a was rejected.

And at last, the analysis shows that self-presence did significantly predict promptness ($\beta = .415$, $p = .007$) in a positive way. However, it did not significantly predict effectiveness ($\beta = .148$, $p = .534$) and

clarity (β = -.060, p = .823) as was assumed in hypothesis H3. Therefore, hypothesis H3c was accepted and hypothesis H3a and H3b were rejected.

4.3 Effect of presence and communication quality on performance and satisfaction

In order to examine the role of presence and the quality of communication in predicting the performance of a group and the satisfaction of its members, the five communication quality variables and the types of presence were used in the multivariate regression as independent variables to respectively predict performance and satisfaction. A significant regression equation was found for performance ($F(8,72) = 5.583$, $p < .001$), with a R^2 of .676. For satisfaction a significant regression equation was found, ($F(8,72) = 25.749$, $p < .001$), with an R^2 of .741. An overview of the results of this multivariate regression analysis of variance (MANOVA) can be found in Table 9.

Table 9

Effect of presence and communication quality on performance and satisfaction

	Performance			Satisfaction		
Independent variables	**β**	**t**	**p**	**β**	**t**	**p**
Effectiveness	.15	1.07	.288	.09	.25	.731
Completeness	-.54	-2.84	.006**	.16	1.27	.207
Clarity	-.22	-1.14	.258	.28	2.31	.024*
Fluence	.28	1.85	.069	-.09	-.89	.378
Promptness	.05	.15	.883	.40	2.58	.012*
Telepresence	.46	3.73	.000**	-.01	-.11	.916
Social presence	-.42	-1.28	.206	.36	1.69	.096
Self-presence	.67	2.36	.021*	.34	1.88	.064

* p < .05, ** p < .01

a. Predictors: (Constant), Effectiveness, Completeness, Clarity, Fluence, Promptness, Telepresence, Social presence, Self-presence

2.575

4.3.1 Performance

As can be seen in Table 9, completeness (β = -.536, p = .006), telepresence (β = .459, p < .001), and self-presence (β = .668, p = .021) significantly predicted performance, all indicating a strong relationship with performance. However, effectiveness (β = .145, p = .288), clarity (β = -.215, p = .258), fluence (β = .279, p = .069), promptness (β = .045, p = .883), and social presence (β = -.419, p = .206) did not. Therefore, hypothesis H4 and H6, which assumed that the effect of telepresence and self-presence on performance is mediated by group communication quality, was rejected, as these presence directly influence performance. Although social presence did not have a direct influence on performance in the analysis, it can be noticed from Table 8 that social presence had a significant positive effect on completeness, which shows in Table 9 a significant negative effect on performance. This may indicate

that the effect of social presence on performance could be negatively mediated by completeness. Therefore, only hypothesis H5b was supported, indicating that the effect of social presence on performance will be mediated by group communication completeness.

4.3.2 Satisfaction

As can be seen in Table 9, clarity (β = .283, p = .024) and promptness (β = .396, p = .012) significantly predicted satisfaction in a positive way. However, effectiveness (β = .089, p = .731), completeness (β = .156, p = .207), fluence (β = -.087, p = .378), telepresence (β = -.008, p = .916), social presence (β = .359, p = .096), and self-presence (β = .344, p = .064) did not. Although presence did not have a direct influence on satisfaction in the analysis, it can be noticed from Table 8 that telepresence had a significant negative effect on clarity and promptness, which shows in Table 9 a positive effect on satisfaction. This may indicate that the effect of telepresence on satisfaction could be negatively mediated by clarity and promptness. Therefore, hypothesis H7c and H7e were supported. Furthermore, social presence had a significant positive effect on clarity and promptness. This may indicate that the effect of social presence on satisfaction could be positively mediated by clarity and promptness. Therefore, hypothesis H8c and H8e were supported. At last, self-presence had a significant positive effect on promptness. This may indicate that the effect of self-presence on satisfaction could be positively mediated by promptness. Therefore, only hypothesis H9e was supported.

4.4 Results of the hypotheses

The results in this chapter show which hypotheses are supported and which are rejected. An alpha value of .05 and below is applied to the significant outcomes. A summary of the results of the hypotheses testing section can be found below in Table 10. In addition, new findings from this study are represented in this table.

Table 10

Overview of supported and rejected hypotheses

Hypotheses	**Supported/rejected**	**Remarks**
H1: Telepresence is positively related to group communication		
(a) effectiveness	Rejected	Negatively related
(b) clarity	Rejected	Negatively related
(c) fluence	Rejected	Not significant related
(d) promptness	Rejected	Negatively related
H2: Social presence is positively related to group communication		
(a) effectiveness	Rejected	Negatively related
(b) completeness	Supported	
(c) clarity	Supported	
(d) fluence	Supported	
(e) promptness	Supported	

H3: Self-presence is positively related to group communication		
(a) effectiveness	Rejected	Not significant related
(b) clarity	Rejected	Not significant related
(c) promptness	Supported	
H4: The effect of telepresence on performance will be mediated by group communication		Telepresence is directly positive related to group performance
(a) effectiveness	Rejected	
(b) completeness	Rejected	
(c) clarity	Rejected	
(d) fluence	Rejected	
(e) promptness	Rejected	
H5: The effect of social presence on performance will be mediated by group communication		Social presence is not directly related to group performance, however, may be negatively mediated by completeness.
(a) effectiveness	Rejected	
(b) completeness	Supported	
(c) clarity	Rejected	
(d) fluence	Rejected	
(e) promptness	Rejected	
H6: The effect of self-presence on performance will be mediated by group communication		Self-presence is directly positive related to group performance
(a) effectiveness	Rejected	
(b) completeness	Rejected	
(c) clarity	Rejected	
(d) fluence	Rejected	
(e) promptness	Rejected	
H7: The effect of telepresence on satisfaction will be mediated by group communication		Telepresence is not directly related to satisfaction, however, may be negatively mediated by clarity and promptness.
(a) effectiveness	Rejected	
(b) completeness	Rejected	
(c) clarity	Supported	
(d) fluence	Rejected	
(e) promptness	Supported	
H8: The effect of social presence on satisfaction will be mediated by group communication		Social presence is not directly related to satisfaction, however, may be positively mediated by clarity and promptness.
(a) effectiveness	Rejected	
(b) completeness	Rejected	
(c) clarity	Supported	
(d) fluence	Rejected	
(e) promptness	Supported	
H9: The effect of self-presence on satisfaction will be mediated by group communication		Self-presence is not directly related to satisfaction, however, may be positively
(a) effectiveness	Rejected	
(b) completeness	Rejected	

(c) clarity (d) fluence (e) promptness	Rejected Rejected Supported	mediated by promptness.
H10: Telepresence is perceived highest with face-to-face, followed by virtual reality and lowest with video conferencing.	Supported	
H11: Social presence is perceived highest with face-to-face, followed by video conferencing and lowest with virtual reality.	Supported	
H12: Self-presence is perceived highest with face-to-face, followed by video conferencing and lowest with virtual reality.	Supported	
New: Completeness in group communication is negatively related to group performance.		
New: Clarity in group communication is positively related to satisfaction.		
New: Promptness in group communication is positively related to satisfaction.		

5. DISCUSSION

This research investigated the impact of communication environments on presence, communication quality, performance and satisfaction. In addition, the role of presence in predicting the communication quality, performance and satisfaction of team members was explored. Results provide support for the assumed perceived presences in communication environments, whereas in an FTF environment, people appeared to experience the strongest presence. In a video conference environment, the feeling of social and self-presence were moderately high and telepresence was low. In a VR environment, the feeling of social presence and self-presence was moderately and telepresence was moderately high. The results suggest that in a FTF environment communication is most complete and team members feel most satisfied, whereas in a video conference environment communication is more effective and teams perform better. In a VR environment, the quality of communication is lowest because team members interact more difficultly and discussions are limited. In addition, social presence turned out to be the biggest positive predictor for communication quality and satisfaction. However, social presence turned out to negatively influence the effectiveness of a communication and indirectly the performance through an increase in completeness.

The results of the study suggest that social presence causes people to share more information, however, it reduces the effectiveness of a communication. As a result, social presence has a negative impact on the performance of a group. This may suggests that social presence reduces the relevance of conversations and thus the effectiveness and efficiency of a meeting in a problem-solving context. Consistent with the findings of this study, Lowry, Roberts, Romano, and Cheney (2006) found that the richness of information shared in a group increases when one perceives more social presence. Tu and McIsaac (2002) found that when social presence increases, individuals are more likely to communicate informal and are more inclined to exchange personal details, which creates more interaction. This might explain why the presence of others causes people to converse more off-topic. In addition, in this study

was observed that more humour was used when social presence was high. A study of Polhemus et al. (2001) confirms this observation, as they also described indicators of social presence, in which social sharing, self-disclosure and humor were three of these indicators.

In contrast to the findings of this study, Lowry et al. (2006) argued that low social presence may reduce group members' performance by causing individual comments or feedback to be ignored or delayed altogether. This current study in fact showed that social presence is not automatically beneficial for the performance of a group, as it can also cause excessive information sharing, which reduces the effectiveness of a meeting. In addition, Robert and Dennis (2005) proposed that a medium can be so rich that it becomes distracting or displaces focus away from a task. It is not only the richness of communication that can reduce performance through social presence. Dennis et al. (2008) found that the decline in performance can be related to evaluation apprehension that is reinforced by social presence (Aiken et al., 1994; Nunamaker et al., 1991). Evaluation apprehension arises when individuals withhold knowledge because they are concerned about being criticised by other individuals (Diehl & Stroebe, 1987; Lamm & Trommsdorff, 1973). Typically, this phenomenon is more pronounced in face-to-face groups than in virtual groups (Valacich, George, Nunamaker, & Vogel, 1994). The information richness and evaluation apprehension might explain the results of this study which suggest that the performance of a group in a FTF environment is lower than in a video conference environment, which can be caused by the perceived social presence in the communication environment.

Furthermore, the results of this study suggest that team members are most satisfied when they communicate in a FTF environment, then video conference, and the least in a VR environment. This is presumably attributed to perceived social presence and self-presence in an environment, which, in this study, have found to contribute strongly to the promptness and clarity of a communication. The results suggest that the rapid feedback and clear communication in an environment increases the satisfaction of team members. One of the aspects of the immediacy principle that may affect communication satisfaction is prompt feedback (Wegmann and McCauley, 2014). Plante and Asselin (2014) found that timely feedback, clarification of problems, and responsiveness in online communication were all likely to increase the immediacy impact for communication satisfaction in a virtual space. Nonverbal interactions such as providing fast or modest feedback have also been shown to improve social presence and stimulate immediacy in the virtual environment, resulting in communication satisfaction (Zydney, 2014). Moreover, Cunningham (2015) has disputed that the use of other features such as avatars to supplement social presence in a virtual communication environment might not induce closeness or satisfaction, but rather facilitate more rapid feedback from interactants which may contribute to an immediacy effect towards achieving satisfaction. Karahoca and Kurnaz, (2016) disputed the concept that virtual speakers perceive communication satisfaction when they get timely responses, however they did add that willingness to respond on time can be strengthened if the messages are clear and sent by familiar persons.

In addition, previous studies support the findings of this study suggesting that communication clarity positively influences satisfaction. According to Ocker (2002), the absence of certain social cues, such as touch, gestures, voice intonation and facial expressions in virtual environments, can affect the satisfaction of virtual teams. According to Greenberg et al. (2007) a miscommunication resulting from a lack of social presence can affect a person's satisfaction in a team. Musa, Nadianatra and Pollard (2004) argued that increased velocity in feedback, decreased difficulty in communication, and increased common ground would be associated with a higher level of satisfaction. Dennis et al. (2008) pointed out the concept of Transmission Velocity, defined as the speed of conveying a message and associated with prompt feedback, enhances understanding by allowing misleading or misinterpreted information to be corrected immediately (Dennis & Valacich, 1999). Since transmission velocity allows a better shared focus, it facilitates the achievement of satisfaction in a team (Dennis et al., 2008). Previous studies therefore support the findings of this study.

And last, the findings of this study suggest that telepresence has a negative impact on effectiveness, clarity and promptness in group communication. In addition, it indirectly contributes negatively to satisfaction. A presumption was made that when one is more consciously aware that one is looking at a screen instead of having the feeling that one is present in a communication environment, one starts to communicate more effective, clearer and faster. In other words, when one experiences a detachment from the communication environment, one will talk less off-topic and seek to communicate more clearly. These findings contradict previous studies on telepresence and communication. According to Pelet, Ettis and Cowart (2017), the more users are engaged and feel present in the mediated simulated world, the more likely they are to concentrate, enjoy, feel challenged, feel in control and show interest. Furthermore, Finneran and Zhang (2003) argued that telepresence is an important factor in helping an individual to stay concentrated on the task, thereby decreasing distraction and off-topic communication. However, Finneran and Zhang based their findings on previous research on the Flow theory of Csikszentmihalyi (1988), which analysed different tasks such as chess playing and mountain climbing. These tasks cause a person to lose themselves completely in the moment, which increases concentration. However, the problem-solving tasks used in this study required less attention from the participants, which may have caused them to move less into a flow state. Therefore, the differences in tasks may be a reason why the findings of this study deviate from expectations.

5.1 Limitations and future research

Even though this study has offered several insights into the relationship between presence, communication quality, performance and satisfaction, several limitations need to be considered when interpreting the results and giving incentives for future studies on this related topic.

First, it is necessary to mention that one has to be cautious with the interpretation and generalization of the results. The experiments of this study took place at a time when Covid-19 interfered with daily life. As a result, some measures had to be taken to allow the experiments to continue. It was therefore not possible to conduct the experiments with a large group size. This study was restricted to nine small groups containing three participants per group.. The size of a group could affect a communication, performance and satisfaction. Past research has demonstrated that group size is negatively linked to the production of ideas (Gallupe et al., 1992; Valacich et al., 1995) and positively linked to group conflicts (Steiner, 1972; Valacich et al., 1995). Substantially, the communication process losses have shown to increase with large group sizes (Gallupe et al., 1992; Hackman & Vidmar, 1970; Valacich et al., 1995). Furthermore, production blocking usually arises in larger groups (Gallupe, Cooper, & Grisé, 1994), because individuals are constrained to speak one after the other; the time to assess each other's ideas is then limited (Diehl & Stroebe, 1987). However, other studies related to group size have shown that virtual environments can help large groups - particularly in terms of brainstorming productivity (Dennis, Heminger, Nunamaker, & Vogel, 1990; Dennis & Valacich, 1993; Gallupe et al., 1992; Valacich, Dennis, & Nunamaker, 1992; Valacich et al., 1995). When the size of a group increases, nearly all groups experience some deterioration in group communication processes, even with virtual support (Chidambaram & Tung, 2005).

In addition, a limitation of this study is that almost all participant were women. This may have affected the results. Consistent with Social Role Theory (Eagly, 1987), it is assumed that men are agentic (i.e. independent and task-oriented). In contrast, women are assumed to be more communal (i.e. focused on building connections within social interactions). This may suggest that men communicate more effectively than women. Academic studies on psychological gender differences have demonstrated that women use communication as a means to strengthen social bonds and develop connections, whereas men use communication to express power and deliver concrete results (Leaper, 1991; Maltz & Borker, 1982; Wood, 1996; Mason, 1994). Women tend to use more expressive, cautious and polite form of language compared to men, particularly in conflict settings (Basow & Rubfield, 2003). Contrary, men are more likely to provide problem solving solutions to prevent unnecessary discussion of interpersonal problems (Baslow & Rubenfield, 2003). These differences in communication of gender might have affected the results of the quality of communication and the performance of this study.

Moreover, in this study, AltSpace VR software was used. This is a software that facilitates virtual communication environments. Because this software determines the visual characteristics of users, i.e. the avatars, but also the environment in which one finds himself, this has an influence on the presence that one experiences. In this study, the results of the experienced presence from AltSpace VR are used to provide a general picture for virtual environments. However, it is possible that if this research were to take place in a different VR software, the presence and perhaps also the communication quality, performance and satisfaction could be different from that measured in AltSpace VR. Communication

software such as Facebook spaces, Rec Room, VR chat and MeetinVR offer a way to represent participants as artificial avatars, which are non-realistic. This may be effective for some use-cases (e.g. games), however, it can interrupt the immersion and presence in many different use-cases, such as business meetings, family call and others. For this reason, there have been services that attempt to portray users in a photorealistic manner (Gunkel, Dohmen, Stokking, & Niamut, 2019). These realistic avatars include blinking, eye gazing and facial expressions. These features are essential to the quality of communication in VR (Thies et al., 2018) Kang and Watt (2013) conducted research on visual and behavioural realism of avatars, showing that higher levels of avatar realism increased perceived communication richness and higher avatar anthropomorphism led to higher levels of psychological copresence and communication satisfaction. It was further stated by Latoschik (2017) that a realistic avatar elicits a significantly high acceptance of the virtual body to be one's own. Furthermore, Thies et al. (2018) found that a realistic avatar of others appeared to improve one's perceptions of the altered own body. They found that the presence of other people's avatars affects our self-perception in virtual reality. Not only in the case of avatar realism, one's perception of presence can increase, but also when the visual realism of an environment become more advanced. Hvass (2017) suggests that when one is faced with a more visually realistic environment, one perceives a stronger sense of presence. Some aspects of realism, such as the inclusion of shadows and reflections tend to have a positive impact on presence (Slater, Khanna, Mortensen, & Yu, 2009). As visual realism and photo-realistic avatars are developing, it becomes interesting for future research to examine its role on perceived presence and communication of a group.

In addition, this study did not take into account the external differences in communication environments. For example, the face-to-face meetings took place in a conference room that did not resemble the conference room used in virtual reality. Thus, there may be external variables in the different environments that could have affect perceived presence, communication quality, performance or satisfaction. As argued previously, the visual realism could affect one's perceived presence in an virtual reality environment. In addition, a study by Brager (2020) found that the amount of details and items in a minimalist setting significantly impacted the participants' creative performance. Sommer (1969) discovered that a warm or sociofugal environment of roses, books, vases, and other items increased female participants' interaction rates. Furthermore, Chaikin, Derlega, and Miller (1976) observed that in a soft room (i.e. picturewall, cushioned chairs, rugs, and soft lighting), higher levels of self-disclosure was measured to others than when interacting in a hard room (cement walls and fluorescent lighting). To overcome the influence of external variables, future research could make use of a 360 degree photo in virtual reality in order to exactly copy a face-to-face communication environment and confront these external variables that may influence perceived presence.

And lastly, observations were made of groups working together to solve a problem. As companies are increasingly looking at how to implement business processes in virtual environments, it also becomes

very interesting for future research to investigate how virtual environments and presence affect communication, performance, and satisfaction when teams perform other tasks outside of a problem-solving context, such as daily stand-up meetings or creative meetings. In the literature, various theories on the effectiveness of communication media have been presented. Among these, two influential perspectives are the social presence theory (Lombard & Ditton, 1997) and the media richness theory (Daft, Lengel, & Trevino, 1987), which both describe communication media according to their functionalities and consider a medium to be effective to the degree that its characteristics correspond to the requirements of the task. Roberts, Lowry and Sweeney (2006) suggest that the performance of a virtual group improves when the ability of a medium to convey social presence matches the social requirements of a task. They argue that a problem-solving task may demand less social presence than other tasks. This may explain the findings of this study, which showed that social presence negatively influences the performance in a problem-solving assignment, as it did not fit the social needs of the task. The role of presence in different types of tasks, such as creative meeting and daily stand-up meetings, becomes therefore of great interest to study.

Creative teams can be defined as teams in which the production of new and useful ideas is fluid (Amabile, 1983). Brainstorming events may be challenging for teams that are globally dispersed as team members are no longer co-located and lack a shared physical space to develop ideas. It is argued that the feeling of co-presence will facilitate communication and knowledge sharing between the team members (Appel-Meulenbroek, 2010). According to Chandra and Leenders (2012), the concept of co-presence, or working in a shared space, is linked to the creativity of a team. In addition, Bhagwatwar, Massey, and Dennis (2013) showed that virtual environments can assist a team in its brainstorming process by fostering creativity and engaging the members as they perform the task. Hidden technology, as a result of telepresence, improves not only success but also commitment, inspiration, satisfaction, and imagination (Roberts & Heldal, 2006). According to Waterworth (2001), presence aids in the development of imaginative perceptions that can elicit strong emotions. This may have an effect on social creativity. Furthermore, Uziel (2010) found that individuals who perceived a high social presence had a relatively more fluid flow of ideas. Finally, the concept of avatars innovation (Kohler et al., 2011) links avatars as self-representations of users to open innovation in virtual teams (Merrick, Gu, & Wang, 2011). These findings may indicate that teams are more creative and thus effective when the perception of telepresence, social presence and self-presence is high.

However, a meeting that is expected to be effective with less presence is a stand-up meeting. A daily stand-up meeting is characterised by its speed and high energy, which support the goal of establishing focus in a meeting (Stray, Moe, & Bergersen, 2017). Long meetings with low energy tend to distract, which is not effective for daily stand-up meetings. According to Yip (2006), there should be no domination in a stand-up meeting. Due to the limited time available, everybody must concisely communicate important information. Therefore, effectiveness of a communication is an

important aspect for daily stand-up meetings (Andriyani, 2017). According to Diehl and Stroebe (1987), social presence can lead to production blockage, which happens when a person is busy listening to other group members, especially when one speaker dominates the interaction or takes too long, and therefore cannot express his or her ideas. Tu and McIsaac (2002) found that when social presence increases, people tend to be more informal and are more willing to share personal information, thereby causing people to converse more off-topic. In addition, the results of this study suggest that telepresence and social presence negatively influence effective communication. These findings may indicate that teams do not need high telepresence and social presence in order to achieve effective stand-up meetings. Future research should explore the role of presence on communication, performance, and satisfaction for different types of tasks.

REFERENCES

Aiken, M., Krosp, J., Shirani, A., & Martin, J. (1994). Electronic brainstorming in small and large groups. *Information & Management, 27*(3), 141-149.

Akkirman, A., Harris, L. (2005). Organizational communication satisfaction in the virtual workplace. *Journal of Management Development, 24*(5), 397-409

Amabile, T.M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology, 45*(2), 357-376.

Andriyani, Y. (2017, May). Knowledge Management and Reflective Practice in Daily Stand-Up and Retrospective Meetings. *International Conference on Agile Software Development, 24,* 285-291.

Appel-Meulenbroek, R. (2010). Knowledge sharing through co-presence: added value of facilities. *Facilities, 28*(3), 189-205.

Armstrong, D.J., & Cole, P. (2002). Managing distances and differences in geographically work groups. In P.J. Hinds, & S. Kiesler (Eds.), Distributed Work (pp. 167-186). Cambridge, MA: The MIT Press.

Aymerich-Franch, L., Karutz, C., & Bailenson, N. (2012). Effects of facial and voice similarity on presence in a public speaking virtual environment. *Proceedings of the International Society for Presence Research Annual Conference, 5*(2), 234-252.

Baños R., Botella C., Alcañiz, V., Guerrero B., Rey. B (2005). Immersion and Emotion: Their Impact on the Sense of Presence. *Cyber Psychology & Behaviour, 7*,6, 123-141. Doi: https://doi.org/10.1089/cpb.2004.7.734

Baños, R. M., Botella, C., Alcañiz, M., Liaño, V., Guerrero, B., & Rey, B. (2004). Immersion and emotion: their impact on the sense of presence. *Cyberpsychology & behavior, 7*(6), 734-741.

Baslow, S. A., & Rubenfeld, K. (2003). Troubles talk: Effects of gender and gender-typing. *Sex Roles: A Journal of Research, 48*, 183-187.

Benbunan-Fich, R., Hiltz, S., Turoff, M. (2001). A comparative content analysis of face-to-face vs. ALN-mediated teamwork. *Paper presented at the Proceedings of the 34th Hawaii International Conference on System Sciences*

Bente, G., Rüggenberg, S., Krämer, N. C., and Eschenburg, F. (2008). Avatar-mediated networking: increasing social presence and interpersonal trust in net-based collaborations. *Human Communication Resources, 34,* 287–318. doi: 10.1111/j.1468-2958.2008.00322.x

Biocca, F. (1997). The cyborg's dilemma: progressive embodiment in virtual environments. *Journal of Computer-Mediated Communication, 3*(2), 89-102 Doi: https://doi.org/10.1111/j.1083-6101.1997.tb00070.x

Biocca, F. (2014). Connected to My Avatar: Effects of avatar embodiments on user cognitions, behaviors, and self-construal. *Social Computing and Social Media, 15,*. 421-429

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and Virtual Environments, 12*, 456-480

Biocca, F., Levy, M. R. (1995). Communication in the Age of Virtual Reality.

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., and Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Journal of Psychology and Computers 13*, 103–124. doi: 10.1207/S15327965PLI1302_01

Bos, N., Olson, J., Gergle, D., Olson, G., Wright, Z. (2002). Effects of four computer-mediated communications channels on trust development. *Proceedings of CHI*, 135-140.

Brager, M.E.M. (2020) *Less is more creativity : The possible influence of minimalist interior designs in office environments on the creativity of millennials.*

Budiu, R. (2018). Between-subjects vs within-subjects study design. *World Leaders in Research-Based User Experience.* Retrieved from https://www.nngroup.com/articles/between-within-subjects/

Burgoon, J. K. & Walther, J. B. (1990). Nonverbal expectancies and the evaluative consequences of violations. *Human Communication Research, 17*(2), 232-265

Burgoon, J. K., Bonito, J., Ramirez, A., Kam, K., Dunbar, N. E., & Fischer, J. (2002). Testing the interactivity principle: Effects of Mediation, Propinquity, and verbal and nonverbal modalities in interpersonal interaction. *Journal of Communication, 52*(3), 657-677.

Burke, K., & Chidambaram, L. (1999). How much bandwidth is enough? A longitudinal examination of media characteristics and group outcomes. *MIS Quarterly, 23*, 557-580.

Burke, K., Aytes, K., Chidabaram, L., & Johnson, J. (1999). A study of partially distributed work groups: The impact of media, location, and time on perceptions and performance. *Small Group Research, 30*, 453-490.

Campbell, D. E. (1979). Interior office design and visitor response. *Journal of Applied Psychology, 64,* 648-653.

Chaikin, A. L., Derlega, V. J., & Miller, S. J. (1976). Effects of room environment on selfdisclosure in a counseling analogue. *Journal of Counseling Psychology, 23,* 479-481.

Chandra, Y., & Leenders, M. (2012). User innovation and entrepreneurship in the virtual world: A study of Second Life residents. *Technovation, 32*(7), 464–476. doi:10.1016/j.technovation.2012.02.002

Charness, G., Gneezy, U., Kuhn, M. (2012). Experimental methods: Between-subject and within-subject design. *Journal of Economic Behavior & Organization, 81*(1), 1-8.

Chesney, T., Chuah, S., Dobele, A.R., & Hoffmann, R. (2017). Information richness and trust in ecommerce: implications for services marketing. *Journal of Services Marketing,* 295-307.

Chidambaram, L. (1996). Relational development in computer-supported groups. *MIS Quarterly, 20*(1), 143–165.

Chidambaram, L., & Tung, L. L. (2005). Is out of sight, out of mind? An empirical study of social loafing in technology-supported groups. *Information Systems Research, 16*(2), 149-160.

Christie, B. (1985). Human factors of information technology in the office. *New York: John Wiley*

Cohen, G., & Gibson, B. (2003). In the beginning: Introduction and framework. In C. B. Gibson & S. G. Cohen (Eds.), Virtual teams that work: Creating conditions for virtual team effectiveness. S*an Francisco: Jossey-Bass*

Connaughton, S. L., & Daly, J. A. (2004). Leading from afar: Strategies for effectively leading virtual teams. *Virtual and collaborative teams: Process, technologies and practice.* Florida, IGI Global

Connelly, C. and Turel, O. (2016). Effects of Team Emotional Authenticity on Virtual Team Performance. *Front. Psychology 7*, 1336. doi: 10.3389/fpsyg.2016.01336

Cramton, C. (2001). The Mutual knowledge problem and its consequences for dispersed collaboration. *Journal of Organization Science, 12*(1), 346-371

Csikszentmihalyi, M., 1988. The flow experience and human psychology. In: Csikszentmihalyi, M., Csikszentmihalyi, I.S. (Eds.), Optimal Experience: Psychological Studies of Flow in Consciousness. Cambridge University Press, New York, 15–35.

Cunningham, J. M. (2015). Mechanizing People and Pedagogy: Establishing Social Presence in the Online Classroom. *Online Learning, 19*(3), 34-47.

Daft, R. L. (2013). Information richness theory. *Encyclopedia of Management Theory: Sage Publications*.

Daft, R.L., Lengel, R.H. and Trevino, L.K. (1987). Message equivocality, media selection, and manager performance: implications for information systems. *MIS Quarterly, 11*(3), 355-366.

Deloitte. (2020). Remote Collaboration: Facing the challenges of COVID-19. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/de/Documents/human-capital/Remote-Collaboration-COVID-19.pdf

Dennis, A. R., & Valacich, J. (1993). Computer brainstorms: More heads are better than one. *Journal of Applied Psychology, 78*, 531-537

Dennis, A. R., Heminger, A. R., Nunamaker, J. F., Jr., & Vogel, D. R. (1990). Bringing automated support to large groups: The Burr-Brown experience. *Information & Management, 18*(3), 111-121.

Dennis, A.R., & Valacich, J.S. (1999). Rethinking media richness: Towards a theory of media synchronicity. *Proceedings of the 32nd Hawaii International Conference on System Sciences, 1*, 1-10

Dennis, A.R., Fuller, R.M, & Valacich, J.S. (2008). Media, tasks, and communication processes: A theory of media synchronicity. *MIS Quarterly, 32*(3), 575-600.

Dieck, T., Jung, T., Han, I. (2016). Mapping requirements for the wearable smart glasses augmented reality museaum application. *Journal of Hospitality and Tourism Technology, 7*(3), 230-253.

Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology, 53*, 497-509.

Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology, 53*(3), 497–509. https://doi.org/10.1037/0022-3514.53.3.497

Dodds, T. J., Mohler, B. J., Bülthoff, H. H. (2011). Talk to the virtual hands: Self-animated avatars improve communication in head-mounted display virtual environments. *PloS one, 6*(10). 1-12

Dubé, L., & Robey, D. (2008). Surviving the paradoxes of virtual teamwork. *Information Systems Journal, 19*(1), 3-20.

Eagly, A. H. (1987). Sex differences in social behavior: A social-role interpretation. Hillsdale, NJ: Erlbaum.

Ekman, P., & Friesen, W. (1969). The repertoire of nonverbal behavior: Categories, origins, and coding. *Semiotica, 1*, 49–98.

Eom, M.T. (2009). Cross-cultural virtual team and its key antecedents to success. *The Journal of Applied Business and Economics, 10*, 1-14.

Esteban-Millat, I., Martínez-López, F., Luna, D., and Rodríguez-Ardura, C. (2014). The Concept of Flow in Online Consumer Behavior. *Handbook of Strategic e-business management*. 371-402

Fägersten, K. B. (2010). Using discourse analysis to assess social co-presence in the video conference environment. *Journal of Communication, 42*(5). 1-19

Finneran, C. & Zhang, P. (2003). A person–artefact–task (PAT) model of flow antecedents in computer-mediated environments. *International Journal of Human-Computer Studies, 59*(1), 475-496. doi: 10.1016/S1071-5819(03)00112-5.

Flavián, C. (2019). The impact of virtual, augmented and mixed reality technologies on the customer experience. *Journal of Business Research, 100*(1), 547-560. doi: 10.1016-/j.jbusres.2018.10.050

Fussell, S., Setlock, L., Yang, J., Ou, J., Mauer, E., and Kramer, A. (2004). Gestures Over Video Streams to Support Remote Collaboration on Physical Tasks. *Human-Computer Interaction, 19*(3), 273–309

Galegher, J. (1994). Computer-mediated communication for intellectual teamwork: an experiment in group writing. *Information System Research, 5*(1), 110–138.

Gallupe, R. B., Cooper, W., & Grisé, M.-L. (1994). Blocking electronic brainstorms. *Journal of Applied Psychology, 79*(1), 77-86.

Gallupe, R. B., Dennis, A. R., Cooper, W. H., Valacich, J. S., Bastianutti, L. M., & Nunamaker, J. F., Jr. (1992). Electronic brainstorming and group size. *Academy of Management Journal, 35*, 350-369.

Garrison, D., Anderson, T., Archer, W. (2000). Critical inquiry in a text-based environment: computer conferencing in higher education. *The Internet and Higher Education, 2*(2). 87–105

Gibson, C. B., & Cohen, S. G. (2013). The last word: Conclusions and implication. Virtual teams that work: Creating conditions for virtual team effectiveness. San Francisco, CA: Jossey-Bass.

Giesbers, B., Rienties, B., Gijselaers, W. H., Segers, M., Tempelaar, D. T. (2009). Social presence, Web videoconferencing and learning in virtual teams. *Industry & Higher Education, 23*(4). 301–309.

Gilson, L., Martins, L., & Maynard, T. (2004). Virtual teams: What do we know and where do we go from here? *Journal of Management, 30*(6), 805–835.

Gilson, L., Vartiainen, M., Maynard, M., Hakonen, M. (2014). Virtual Teams Research. *Journal of Management, 41*(5), 1313-1337. doi: 0.1177/0149206314559946

González-Romá, V., & Hernández A. (2014). Climate Uuniformity: Its influence on team communication quality, task conflict, and team performance. *Journal of Applied Psychology, 99*(1), 1042-1058. Doi: https://doi.org/10.1037/a0037868

Greenberg, P.S., Greenberg, R.H., & Antonucci, Y.L. (2007). Creating and sustaining trust in virtual teams. *Business Horizons, 50*(4), 325-333.

Grudzewski, F., Awdziej, M., Mazurek, G., Piotrowska, K. (2018). Virtual reality in marketing communication – the impact on the message, technology and offer perception – empirical study. *Economics and Business Review, 4*(18), 36-50. doi: 10.18559/ebr.2018.3.4

Gunkel, S. N., Dohmen, M. D., Stokking, H., & Niamut, O. (2019). 360-degree photo-realistic VR conferencing. *IEEE Conference on Virtual Reality and 3D User Interfaces, 12,* 946-947.

Guo, W., Chen, Y., Lei, J., & Wen, Y. (2014). The effects of facilitating feedback on online learners' cognitive engagement: Evidence from the asynchronous online discussion. *Education Sciences, 4*(2), 193-208.

Hackman, J. R., & Vidmar, N. (1970). Effects of size and task type of group performance and member reactions. *Sociometry, 33*(1), 37-54.

Hagwatwar, A., Massey, A., & Dennis, A. R. (2013). Creative Virtual Environments: Effect of Supraliminal Priming on Team Brainstorming. *Hawaii International Conference on System Sciences, 46*, 215-224. doi:10.1109/HICSS.2013.152

Hammick, J., Lee, M. (2014). Do shy people feel less communication apprehension online? The effects of virtual reality on the relationship between personality characteristics and communication outcomes. *Computers in Human Behavior, 33,* 302-310

Heeter, C. (1992) Being there: the subjective experience of presence. *Presence: Teleoperators Virtual Environment, 1*(2), 262–271.

Hung, M. L., & Chou, C. (2014). The development, validity, and reliability of communication satisfaction in an online asynchronous discussion scale. *The Asia-Pacific Education Researcher, 23*(2), 165-177.

Hvass, J., Larsen, O., Vendelbo, K., Nilsson, N., Nordahl, R., & Serafin, S. (2017). Visual realism and presence in a virtual reality game. *3DTV Conference,5,* 1-4.

Ihde, D. (1990). Technology and the lifeworld: from garden to earth. Indiana University Press.

Izard, C. E. (1997). Emotions and facial expressions: A perspective from differential emotions theory. In J. A. Russell & J. M. Fernandez-Dols (Eds.), The psychology of facial expression. 57–77. Cambridge, U.K.: Cambridge University Press.

Jarvenpaa, S., Ives, B. (1994). The global network organization of the future, *Journal of Management Information Systems, 10*(1), 25–58.

Johansson, N. (2020). Productive remote collaboration in VR. *Human Interaction Systems, 5*(4). 362-380

Kang, S. H., & Watt, J. H. (2013). The impact of avatar realism and anonymity on effective communication via mobile devices. *Computers in Human Behavior, 29*(3), 1169-1181.

Kaplan, A. D., Cruit, J., Endsley, M., Beers, S. M., Sawyer, B. D., Hancock, P. A. (2020). The effects of virtual reality, augmented reality, and mixed reality as training enhancement methods: a meta-analysis. Journal of *Human factors 4*, 210-232. Doi: 10.1177/0018720820904229

Karahoca, D., Kurnaz, A. (2016). Analyzing Communication Dimensions in a Ubiquitous Learning Environment. J. *UCS, 22*(1), 124-145.

Kiesler, S., & Cummings, J. N. (2002). What do we know about proximity and distance in work groups? *A legacy of research*. Cambridge, MIT Press.

Kim, J. (2011). Developing an instrument to measure social presence in distance higher education. *British Journal of Educational Technology, 42*(5), 763-777

Knapp, M., & Hall, J. (2007). Nonverbal communication in human interaction. Boston: Wadsworth.

Kohler, T., Fueller, J., Matzler, K., & Stieger, D. (2011a). Co-creation in virtual worlds: The design of the user experience. *MIS quarterly, 35*(3), 773–788.

Koutsabasis, P. & Vosinakis, S. & Malisova, K. & Paparounas, N. (2012). On the Value of Virtual Worlds for Collaborative Design. *Design Studies, 11*(4), 231-244 Doi: 10.1016/j.destud.2011.11.004.

Kraut, R. E., Fussell, S. R., Brennan, S. E., & Siegel, J. (2002). Understanding effects of proximity on collaboration: Implications for technologies to support remote collaborative work. *Cambridge The MIT Press, 12*(1), 137-162.

Kraut, R. E., Fussell, S. R., Brennan, S. E., & Siegel, J. (2002). Understanding effects of proximity on collaboration: Implications for technologies to support remote collaborative work. *Lessons from Collocated Work.* Cambridge, Boston Review

Lamm, H., & Trommsdorff, G. (1973). Group versus individual performance on tasks requiring ideational proficiency (brainstorming): A review. *European Journal of Social Psychology, 3*, 361-388.

Landis, J., Koch, G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159–174.

Latoschik, M. E., Roth, D., Gall, D., Achenbach, J., Waltemate, T., & Botsch, M. (2017, November). The effect of avatar realism in immersive social virtual realities. *Proceedings of ACM Symposium on Virtual Reality Software and Technology*, 23, 44-68.

Leaper. C. (1991). Influence and involvement in children's discourse: Age, gender, and partner effects. *Child Development, 62*, 797-811.

Lee, K. (2004). Presence, explicated. *Communication Theory, 14*(1). 27-50

Leenders, R., Engelen, J. & Kratzer, J. (2003). Virtuality, communication, and new product team creativity: a social network perspective. *Journal of Engineering and Technology Management, 20*(1), 69-92. doi: 10.1016/S0923-4748(03)00005-5

Lin, C. (2008) A model to develop effective virtual teams. *Journal of Decisin Support Systems, 45*(2), 1031-1045. Doi: 10.1016/j.dss.2008.04.002

Lin, J., Han, P., Lee, J., Chen, Y., Chang, T., Chen, K., Hung, Y. (2017). Visualizing the keyboard in virtual reality for enhancing immersive experience. *Journal of Computer Systems, 6*(7), 12-28

Lin. G.Y. (2004). Social Presence Questionnaire of Online Collaborative Learning: Development and Validity. *Annual Proceedings for Educational Communications and Technology, 3*(1), 1-4

Lipnack, J., Stamps, J. (2000). Virtual Teams: People Working Across Boundaries with Technology. *Journal of Interactive Technology,* 11(4), 381-399. ISBN: 978-0-471-38825-8.

Littlejohn, S. (2002). Theories of human communication (7th ed.). Belmont, CA: Wadsworth.

Lombard, M., Ditton, T. (1997) At the Heart of It All: The Concept of Presence. *Journal of Computer-Mediated Communication, 3*(4), 22-45. Doi: https://doi.org/10.1111/j.1083-6101.1997.tb00072.x

Lowry, P. (2006). The Impact of Group Size and Social Presence on Small-Group Communication. *Journal of Small Group Research, 37*(12), 631-661. Doi: 10.1177/1046496406294322

Lowry, P., Roberts, T., Romano, N., Cheney, P., Hightower, R. (2006). The impact of group size and social presence on small-group communication. *Small Grou Research, 37*(6), 631-661

Lu, M., Watson-Manheim, B., Chudoba, K., Wynnm E. (2014). Virtuality and Team Performance: Understanding the Impact of Variety of Practices. *Journal of Global Information Technology Management.* 9, 4-23. Doi: **https://doi.org/10.1080/1097198X.2006.10856412**

Lurey, J., Raisinghani, M. (2001). An empirical study of best practices in virtual teams. *Information and Management.* 38, 523–544.

Maltz, D. N., & Borker, R. (1982). A cultural approach to male-female miscommunication. In J. J. Gumpertz (Ed.), Language and social identity. Cambridge; Cambridge University Press.

Marlow, S., Lacerenza, C., Salas, E. (2017). Communication in virtual teams: a conceptual framework and research agenda. *Human Resource Management Review, 27* doi: 10.1016/j.hrmr.2016.12.005.

Mason, E. S. (1994). Gender differences in job satisfaction. *The Joumal of Social Psychology, 135*, 143-151.

Merrick, K. E., Gu, N., and Wang, X. (2011). Case studies using multiuser virtual worlds as an innovative platform for collaborative design. *Journal of information technology in construction, 16,* 165–188.

Mesmer-Magnus, J. R., DeChurch, L. A., Jimenez-Rodriguez, M., Wildman, J., & Shuffler, M. (2011). A meta-analytic investigation of virtuality and information sharing in teams. *Organizational Behavior and Human Decision Processes, 115*(2), 214–225. Doi: 10.1016.2011.03.002

Miranda, S., & Saunders, C. (2003). The social construction of meaning: An alternative perspective on information sharing. *Information Systems Research (ISR), 14*(1), 87-106.

Miranda, S., & Saunders, C. (2003). The social construction of meaning: An alternative perspective on information sharing. *Information Systems Research (ISR), 14*(1), 87-106.

Moreno, R., Mayer, R. E. (2004). Personalized messages that promote science learning in virtual environments. *Journal of Education and Psychology 96,* 165–173. doi: 10.1037/0022-0663.96.1.165

Morgan, L., Paucar-Caceres, A. & Wright, G. (2014). Leading Effective Global Virtual Teams: The Consequences of Methods of Communication. *Information Systemms Research 27*(4), 607–624. doi: https://doi.org/10.1007/s11213-014-9315-2

Morrison-Smith, S., Ruiz, J. (2020). Challenges and barriers in virtual teams: a literature review. *SN Applied Science 2,* 343-361 doi: https://doi.org/10.1007/s42452-020-2801-5

Morrow, P. C., & McElroy, J. C. (1981). Interior office design and visitor response: A constructive replication. *Journal of Applied Psychology, 66,* 646-650.

Musa, N., & Pollard, C. (2004). User Satisfaction and Trust in Virtual Teams: A Preliminary Investigation. *International Conference on work with computer systems, 23,* 78-132. 10.13140/2.1.4239.6481.

Norris, A. E., Weger, H., Bullinger, C., Bowers, A. (2014). Quantifying engagement: Measuring player involvement in human–avatar interactions. *Computers in Human Behavior, 34,* 1- 11. doi: 10.1016/j.chb.2014.01.044

Nowak, K. L., & Biocca, F. (2003). The Effect of the Agency and Anthropomorphism on Users' Sense of Telepresence, Copresence, and Social Presence in Virtual Environments. *Teleoperators & Virtual Environments, 12*(5), 481-494.

Nunamaker, J. F., Jr., Dennis, A., Valacich, J., Vogel, D., & George, J. (1991). Electronic meeting systems to support group work. *Communications of the ACM, 34*(7), 40-61.

O'Reilly, C. A., & Roberts, K. H. (1977). Task group structure, communication, and effectiveness in three organizations. *Journal of Applied Psychology, 62*(6), 674-681.

Ocker, R. (2002). The mediating effect of group development on satisfaction in a virtual and mixed-mode environment. *Paper presented at the Proceedings of the 35th Hawaii International Conference on System Sciences*

Ocker, R., J. (2002). The mediating effect of group development on satisfaction in a virtual and mixed mode environment. *Proceeding of the 35th Hawaii International Conference on System Sciences, 15,* 234-246.

Oeppen, R. and Brennan, P. (2020). Human factors recognition at virtual meetings and video conferencing: how to get the best performance from yourself and others. *British Journal of Oral and Maxillofacial Surgery, 58(*6), 643-646.

Olson, J., Appunn, F., Walters, K., McAllister, C., & Grinnell, L., (2014). Webcams and virtual teams: An impact model. *Team Performance Management 20*(3), 24-45 http://dx.doi.org/10.1108/TPM-05-2013-0013

Olson, J., Teasley, S., Covi, L. & Olson, G. (2002). The (currently) unique advantages of collocated work. In P. Hinds & S. Kiesler (Eds.), Distributed work (pp. 213-233). *Cambridge, MA: The MIT Press*

Orhan, M. (2014). Extending the Individual Level of Virtuality: Implications of Task Virtuality in Virtual and Traditional Settings. *Administrative Science 4*, 400-412. doi: 10.3390/admsci4040400

Pallavicini, F., Pepe, A., Minissi, M. (2019). Gaming in Virtual Reality: What Changes in Terms of Usability, Emotional Response and Sense of Presence Compared to Non-Immersive Video Games? *Journal of Simulation & Gaming, 24,* 1-24.

Palmero, C., van Dam, E. A., Escalera, S., Kelia, M., Lichtert, G. F., Noldus, L. P., van Wieringen, A. (2018). Automatic mutual gaze detection in face-to-face dyadic interaction videos. *Proceedings of Measuring Behavior 1,* 22-44

Pelet, J., Ettis, S., Cowart, K. (2017). Optimal experience of flow enhanced by telepresence: Evidence from social media use. *Journal of information and management, 54*(1), 115-128

Piccoli, G., Powell, A. Ives, B. (2004). Virtual teams: team control structure, work processes, and team effectiveness. *Information Technology and People, 17*, 359–379.

Plante and Asselin (2014). Best practices for creating social presence and caring behaviors online. *Nursing Education Perspectives, 35*(4), 219-223.

Polhemus, L., Shih, L. F., & Swan, K. (2001). Virtual interactivity: The representation of social presence in an online discussion. *Annual meeting of the American Educational Research Association, 4*, 283-312.

Price, M. (2020). Scientists discover upsides of virtual meetings. *Journal of Science, 368*(6490), 457-458. doi: 10.1126/science.368.6490.457

Raluca, Z. & Romulus, V. (2018). Group Communication, Performance and Satisfaction in Organizations. *Journal of Economics Sciences Series, 18*(1), 135-155.

Ratan, A. & Hasler, B. (2009). Self-presence standardized: Introducing the self-presence questionnaire (SPQ). *Proceedings of the 12th Annual International Workshop on Presence, 2*(4), 98-104

Ratan, R., Santa Cruz, M. & Vorderer, P. (2007). Multitasking, Presence & Self-Presence on the Wii. *Journal of Computer Science, 13*(4), 114-120

Ratan, R.A. & Hasler, B. (2009). Self-Presence Standardized: Introducing the Self-Presence Questionnaire (SPQ). *Proceedings of the 10th Annual International Workshop on Presence*, 3(2), 231-254

Robert, L., & Dennis, A. R. (2005). The paradox of richness: A cognitive model of media choice. *IEEE Transactions on Professional Communication, 48*(1), 10-21.

Roberts, D., Heldal, I., et al.: Factors influencing Flow of Object Focused Collaboration in Collaborative Virtual Environments. *Virtual Reality, Special Issue on Collaborative Virtual Environments for Creative People, 10*(2), 119–133 (2006)

Roberts, L., Lowry, B., & Sweeney, D. (2006). An evaluation of the impact of social presence through group size and the use of collaborative software on group member "voice" in face-to-face and

computer-mediated task groups. *IEEE Transactions on Professional Communication*, 49(2), 28-43.

Roberts, T. L., Lowry, P. B., & Sweeney, P. D. (2006). An evaluation of the impact of social presence through group size and the use of collaborative software on group member "voice" in face-to-face and computer-mediated task groups. *IEEE Transactions on Professional Communication, 49*(2), 28-43.

Rudd, M., Kathleen, D., Vohs, J. (2012). Awe Expands People's Perception of Time, Alters Decision Making, and Enhances Well-Being. *Journal of Psychological Science, 5*(2), 127-146. Doi: https://doi.org/10.1177/0956797612438731

Sanchez-Vives, M. & Slater, M. (2005). From presence to consciousness through virtual reality. *Nat Rev Neurosci,* 6(1), 332–339. Doi: https://doi.org/10.1038/nrn1651

Schubert, T., Friedmann, F., Regenbrecht, H. (2001.) The Experience of Presence: Factor Analytic Insights. *Presence: Teleoperators and Virtual Environments, 10*(3), 266-281

Schultze, U. (2010). Embodiment and presence in virtual worlds: a review. *Journal of Information Technology, 25*(4). 434–449

Schwartz, R. & Steptoe, W, (2018). The Immersive VR Self: Performance, Embodiment and Presence in Immersive Virtual Reality Environments. *A Networked Self and Human Augmentic, 2*(5), 342-352

Seele, S., Misztal, S., Buhler, H., Herpers, R., & Schild, J. (2017, October). Here's Looking At You Anyway! How Important is Realistic Gaze Behavior in Co-located Social Virtual Reality Games?. *Proceedings of the Annual Symposium on Computer-Human Interaction in Play,* 531-540

Shannon L., Marlow S., Christina N., Salas, L. (2017) Communication in virtual teams: a conceptual framework and research agenda. *Journal of Human Resource Management Review, 27*(1), 4. Doi: 10.1016/j.hrmr.2016.12.005

Sherman, W. & Craig, A. (2003). Understanding Virtual Reality: Interface, Application, and Design.

Shujaat, S., Manzoor, A., Nadeem, P. (2014). Impact of team work on employee satisfaction. *Journal of Business Studies, 10*(2), 71-80.

Slater, M. (2009) Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Biological Sciences, 364*(1535). 3549–3557

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Journal of Psychology, 86*(3), 274-294. Doi: http://doi.org/10.1098/rstb.2009.0138

Slater, M., Khanna, P., Mortensen, J., Yu, I. (2009). Visual realism enhances realistic response in an immersive virtual environment. *IEEE computer graphics and applications, 29*(3), 76–84.

Slater, M., Steed, A. (2000). A virtual presence counter. *Journal of Teleoperators and Virtual Environments 9*, 413–434. doi: 10.1162/105474600566925

Sommer, R. (1969). Personal space. Englewood Cliffs, NJ: Prentice Hall.

Steed, A., Pan, Y., Zisch, F., Steptoe, W. (2016). The impact of a self-avatar on cognitive load in immersive virtual reality. *IEEE Virtual Reality Conference.* 67-76

Steed, A., Slater, M., Sadagic, A., Bullock, A., and Tromp, J. (1999). Leadership and collaboration in shared virtual environments. *Proceedings of IEEE VR (New York, NY: IEEE)*

Steiner, I. (1972). Group process and productivity. New York: Academic Press

Steuer, J. (1992). Defining virtual reality: dimensions determining telepresence, *Communication, 42*(4), 73–93

Stray, V., Moe, N. B., & Bergersen, G. R. (2017, May). Are daily stand-up meetings valuable? A survey of developers in software teams. *International Conference on Agile Software Development, 5*, 274-281.

Stritzke, W.G.K., Nguyen, A., and Durkin K. (2004). Shyness and computer-mediated communication: A self-presentational experiences. *Media Psychology 6*, 1-22

Suh, K. S. (1999). Impact of communication medium on task performance and satisfaction: an examination of media-richness theory. *Journal of Information and Management, 35*(1), 295-312

Sung, E. Richard E. Mayer, F. (2012). Five facets of social presence in online distance education. *Computers in Human Behavior*, *28*(5) 1738-1747. ISSN 0747-5632,

Thies, J., Zollhöfer, M., Stamminger, M., Theobalt, C., & Nießner, M. (2018). FaceVR: Real-time gaze-aware facial reenactment in virtual reality. *ACM Transactions on Graphics (TOG)*, *37*(2), 1-15.

Tracy-Taylor, A. K. (2020). Leading in the Time of Corona. *The Oral History Review*, *47*(2), 260-268.

Tu, C. H., & McIsaac, M. (2002). The relationship of social presence and interaction in online classes. *The American journal of distance education*, *16*(3), 131-150.

Tussyadiah, P., Jung, T., Dieck, M. (2017). Embodiment of wearable augmented reality technology in tourism experiences. *Journal of Travel Research, 57*(5), 597-611. Doi: https://doi.org/10.1177/0047287517709090

Uziel, L. (2010). Look at Me, I'm Happy and Creative: The Effect of Impression Management on Behavior in Social Presence. *Personality and Social Psychology Bulletin, 36,* 1591-602. 10.1177/0146167210386239.

Valacich, J. S., Dennis, A. R., & Nunamaker, J. F., Jr. (1992). Group size and anonymity effects on computer-mediated idea generation. *Small Group Research, 23*(1), 49-73.

Valacich, J. S., George, J. F., Nunamaker, J., & Vogel, D. R. (1994). Physical proximity effects on computer-mediated group idea generation. *Small Group Research, 25*(1), 83-104.

Valacich, J. S., Wheeler, B., Mennecke, B., & Wachter, R. (1995). The effects of numerical and logical size on computer-mediated idea generation. *Organizational Behavior and Human Decision Processes, 62,* 318-329.

van der Kleij, R., Schraagen, J. M., Werkhoven, P., & De Dreu, C. K. W. (2009). How conversations change over time in face-to-face and video-mediated communication. *Small Group Research, 40*(4), 355–381. https://doi.org/10.1177/1046496409333724

Vinayagamoorthy, V., Brogni, A., Gillies, M., Slater, M., Steed, A. (2004). An investigation of presence response across variations in visual realism. *The Annual International Presence Workshop, 7,* 148– 155.

Warkentin, M., Sayeed, L., Hightower, R. (1997). Virtual teams versus face-to-face teams: an exploratory study of a web-based conference system. *Decision Science, 28*(1), 975–996.

Waterworth, E.L., Waterworth, J.A.: Focus, locus, and sensus: The three dimensions of virtual experience. *Cyberpsychology & Behavior, 4*(2), 203–213 (2001)

Wegmann, S. J., & McCauley, J. K. (2014). Investigating Asynchronous Online Communication: A Connected Stance Revealed. *Journal of Asynchronous Learning Network, 18*(1), 243-267

Whitmer, B. G., Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. Presence: *Teleoperators and Virtual Environments, 7*, 225–240.

Wicklund, R. A. (1979). The influence of self-awareness on human behavior. *American Scientist, 67,* 187–193.

Wood, J. T (1996). Gendered lives: Communication, gender and culture (2nd ed). Belmont, CA;Wadsworth

Yip, J. (2006). It's Not Just Standing Up: Patterns of Daily Stand-up Meetings. *Journal of Mediated Communication, 24,* 223-267.

Zydney, J. (2014). Strategies for creating a community of inquiry through online asynchronous discussions. *Journal of online learning and teaching, 10*(1), 153-178.

APPENDIX

Appendix A

Observation scheme of group communication quality variables

Constructs	Level		Behavior
Effectiveness	5	Very effective	Group members shared important information that is to the point and fully understood by others. No unnecessary discussions happened at all and no participant went of topic.
	4	Effective	Group members shared information that is to the point and fully understood by others. Almost no unnecessary discussions happened and almost no participant went of topic.
	3	Semi-effective	The information shared was somewhat to the point but was sometimes off topic.
	2	Little-effective	Some discussions were suited to the topic, but almost all information shared was not relevant or important to solve the dilemma.
	1	Ineffective	Group discussions were unsuited to the topic and no relevant information was shared. The group members failed to deliver the right message, group members were distracted or did respond of topic.
Completeness	5	Fully complete	Group responses were filled with details, messages were very vivid, forms of expressions had high variety, and the amount of information was rich (what and how).
	4	Complete	Group members explained themselves sufficient and most of the time, other members did not need to ask for further information in order to understand the other.
	3	Semi-complete	Group responses contained somewhat rich information, but members sometimes lacked in explaining themselves sufficient.
	2	Little-complete	Group members gave answers with some explanations. Still, these explanations were limited in information and sometimes short.
	1	Incomplete	Group members gave very short answers and did not ask for any additional information of members. Group members did not explain their choices in detail.
Clarity	5	Very clear	Group members understood the information shared and received, no misinterpretations among group members happened, no frustration is expressed among group members, no conflicts ensued while members worked together, both verbal and nonverbal communication was clear, members sometimes summarised feedback or responded properly towards it.
	4	Clear	Group members understood each other, and no frustration is expressed in the group. Sometimes, group members needed to ask information in order to fully understand someone, but no misinterpretation happened.
	3	Semi-clear	Group members' understanding was somewhat sufficient. Members understood the information shared, but sometimes it took some time to make it clear to each other.

	2	Little-clear	Some frustration was expressed and sometimes misunderstandings happened. Also, nonverbal communication was vague.
	1	Unclear	Group members were not able to understand and respond appropriately to the ideas of others. A lot of misunderstandings happened, and frustration was expressed among group members. Also verbal and nonverbal communication was unclear.
Fluence	5	Very fluent	Information is easily shared among group members, information is exchanged without interruptions, group members have easily communicated openly with each other, communication between members went fluent, group members responded naturally to each other and all members equally shared information
	4	Fluent	The group communication felt natural, with hardly any quiet moments. The group members interacted well with each other and the conversation went smoothly.
	3	Semi-fluent	Group communication was sometimes fluid, but there were some interruptions, and group members were disproportionate to the conversation.
	2	Little-fluent	The group discussion felt a little uncomfortable. There were sometimes quiet moments. And group members sometimes asked each other to repeat themselves because they didn't hear something well or because they didn't get it right.
	1	Non-fluent	There was fragmentation in the groups discussion, there were a lot of pauses and silent moments in the group, the group started already with a false start, group members hesitated to speak of say things, members had repeat themselves, group members did not hear or see their group members properly, the group conversation felt unusual and problematic, and members did not share information equally.
Promptness	5	Very prompt	Group members received timely answers, feedback of members had minimal delay, efficient responses were made as feedback, and group communication was high on time
	4	Prompt	Group members reacted sufficiently well and promptly to each other.
	3	Semi-prompt	Group members usually reacted well and sometimes quickly to each other. But it happened that some information arrived later.
	2	Little-prompt	Group members reacted to each other but sometimes late and were distracted.
	1	Slow	Group members did receive information late, or responded late on feedback, group members had a hard time with the technology used and therefore were responding distracted and late.

Appendix B

Measurement items of variables

Constructs	Measurement items	Sources
Telepresence	The visual aspects of the virtual environment involved me	(Kim & Biocca, 1997; Schubert, Friedmann, & Regenbrecht, 2001)
	The noises of the virtual environment involved me	
	I found it easy to forget that I was watching a display	
	I felt like I was really in the virtual environment	
	It felt like I was in the same place as my group members	
Social presence	It felt like my group members were really there	(Kim, 2011; Lin, 2004)
	I felt like I was a member of the group	
	I was able to form distinct individual impressions of my group members during the meeting	
	I saw the avatars of my group members as real people	
	I easily understood how the other participants reacted to my comments	
Self-presence	My avatar looks like it is really me	(Ratan & Hasler, 2009)
	My avatar's body movements feels natural	
	My avatar sounds like it is really me	
	My avatar's appearance is related to my identity	
	I would feel happy when happy events happen to my avatar	
Satisfaction	I feel satisfied with the process within the group	(Suh, 1999)
	I feel confident about our solution	
	I feel satisfied with the teamwork of the group	
	I feel satisfied with the commitment of the group	
	I feel satisfied with the quality of the solution	

Appendix C

Randomization of assignments and communication environments

Groups	Communication environments	Assignments
1	Face-to-Face	Desert Survival Problem
	Virtual Reality	The Moonlanding
	Video Conference	Lost at Sea
2	Face-to-Face	Lost at Sea
	Virtual Reality	Desert Survival Problem
	Video Conference	The Moonlanding
3	Face-to-Face	The Moonlanding
	Virtual Reality	Lost at Sea
	Video Conference	Desert Survival Problem
4	Virtual Reality	Desert Survival Problem
	Video Conference	The Moonlanding
	Face-to-Face	Lost at Sea
5	Virtual Reality	Lost at Sea
	Video Conference	Desert Survival Problem
	Face-to-Face	The Moonlanding
6	Virtual Reality	The Moonlanding
	Video Conference	Lost at Sea
	Face-to-Face	Desert Survival Problem
7	Video Conference	Desert Survival Problem
	Face-to-Face	The Moonlanding
	Virtual Reality	Lost at Sea
8	Video Conference	Lost at Sea
	Face-to-Face	Desert Survival Problem
	Virtual Reality	The Moonlanding
9	Video Conference	The Moonlanding
	Face-to-Face	Lost at Sea
	Virtual Reality	Desert Survival Problem

Appendix C

Randomization of assignments and communication environments

		Face-to-face			**Virtual Reality**			**Video Conference**		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Desert Survival	1st	x			x			x		
Problem	2nd		x			x			x	
	3rd			x			x			x
The	1st	x			x			x		
Moonlanding	2nd		x			x			x	
	3rd			x			x			x
Lost at Sea	1st	x			x			x		
	2nd		x			x			x	
	3rd			x			x			x

Appendix D

Survival Assignments the moonlanding, lost at sea, and desert survival plane crash.

'Moon Landing'

You are a member of a space crew scheduled to rendezvous with a mother ship on the lighted surface of the moon. However, due to mechanical difficulties, your own ship was forced to land at a spot 200 miles from the rendezvous point. During re-entry and landing, much of the equipment aboard was damaged and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200-mile trip. 15 items are listed as being intact and undamaged after landing. Your task is to rank them in terms of their importance for your crew, to allow them to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so on through to number 15 for the least important.

Items	**1. Team ranking**	**2. NASA ranking**	**Differences between 1 & 2**
Box of matches		15	
Food concentrate		4	
50 feet of nylon rope		6	
Parachute silk		8	
Portable heating unit		13	
Two .45 caliber pistols		11	
One case of dehydrated milk		12	
Two 100 lb. tanks of oxygen		1	
Stellar map		3	
Self-inflating life raft		9	
Magnetic compass		14	
5 gallons of water		2	
Signal flares		10	
First aid kit, including injection needle		7	
Solar-powered FM receiver-transmitter		5	
			Team total score (sum)

'Lost at Sea'

You have chartered a yacht with three friends, for the holiday trip of a lifetime across the Atlantic Ocean. Because none of you have any previous sailing experience, you have hired an experienced skipper and two-person crew. Unfortunately in mid Atlantic a fierce fire breaks out in the ships galley and the skipper and crew have been lost whilst trying to fight the blaze. Much of the yacht is destroyed and is slowly sinking. Your location is unclear because vital navigational and radio equipment have been damaged in the fire. Your best estimate is that you are many hundreds of miles from the nearest landfall. You and your friends have managed to save 15 items, undamaged and intact after the fire. In addition, you have salvaged a four man rubber life craft and a box of matches. Your task is to rank the 15 items in terms of their importance for you, as you wait to be rescued. Place the number 1 by the most important item, the number 2 by the second most important and so forth until you have ranked all 15 items.

Items	**1. Team ranking**	**2. Coast Guard ranking**	**Differences between 1 & 2**
A sextant		15	
A shaving mirror		1	
A quantity of mosquito netting		14	
A 25 liter container of water		3	
A case of army rations		4	
Maps of the Atlantic Ocean		13	
A floating seat cushion		9	
A 10 liter can of oil/petrol mixture		2	
A small transistor radio		12	
20 square feet of opaque plastic sheeting		5	
A can of shark repellent		10	
One bottle of 160 proof rum		11	
15 feet of nylon rope		8	
2 boxes of chocolate bars		6	
An ocean fishing kit & pole		7	
			Team total score (sum)

'Desert Survival Plane Crash'

It is now almost midday in mid- August and you have just crash landed in the Sonara Desert in the South Western United States. The plane, containing the bodies of the pilot and the co-pilot, is burning. None of the rest of you have been injured. The pilot was unable to notify anyone of your position before the crash. However, he said before the plane crashed that you were about 110 km south-west from a mining camp (the nearest known habitation), and that you were approximately 100 km off the course that was filed on your flight plan (Hope – Dead Man's Peak).
The immediate area is quite flat and, except for the occasional cactus, appears to be empty. The last weather report said the temperature would reach 45 degrees °C (which means that the temperature at ground level will be 55 degrees °C).

Items	**1. Team ranking**	**2. Survival Expert ranking**	**Differences between 1 & 2**
Flashlight		4	
Pocket Knife		6	
Air map of the area		12	
Plastic Raincoat		7	
Magnetic compass		11	
First Aid kit		10	
0.45 Caliber Pistol (loaded)		8	
1 Red and White Parachute		5	
100 Salt tablets		15	
1 litre of water per person		3	
A book entitled: 'edible animals of the desert'		13	
1 Pair of Sunglasses		9	
Vodka		14	
1 Topcoat per person		2	
Cosmetic mirror		1	
			Team total score (sum)