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AN EXPLORATORY STUDY OF THE EFFECTS OF VIRTUALITY ON TEAM EFFECTIVENESS

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Abstract

Recent studies on virtual teams reveal that team virtuality may be considered from different levels which have a considerable impact on team processes and management. However, as a recent concept introduced to virtual team literature, virtuality and its effects on team effectiveness are still under studied. The purpose of this paper is twofold. On the one hand, it aims to define the concept of virtuality and provide a multidimensional approach to assess its different levels based on the main characteristics of virtual teams expressed in the literature. On the other hand, it analyzes how variations in virtuality influence team effectiveness. The effectiveness measures retained in this study are: work performance, attitudes and behaviours. A longitudinal qualitative study was conducted on ten virtual teams composed of three to five students involved in online Master degree programmes at a French university. The results highlighted the importance of differentiating technological and social virtuality to improve our understanding of team virtuality and to better apprehend its effects on team effectiveness.

Keywords: *Team Virtuality, Technological Virtuality, Social Virtuality, Virtual Team Effectiveness, Qualitative Longitudinal Study*

1 INTRODUCTION

Virtual teamwork, enabled by advances in information and communication technologies (ICTs), is now a prerequisite in the network economy. Virtual teams enable the organisations that use them to be more competitive by reducing functioning costs and acquiring more flexibility (Cousins et al. 2007; Levina and Vaast 2008). They are composed of interdependent individuals geographically dispersed and working together via ICTs to accomplish an organizational task (Bell and Kozlowski 2002; Lipnack and Stamps 1997; Thomas and Bostrom 2008, Townsend et al. 1998). Many studies have explored the dynamics and processes of virtual teams such as trust, leadership, communication, coordination mechanisms and effectiveness (Anderson et al. 2007; Avolio et al. 2001; Järvenpää et al. 1998; Maznevski and Chudoba 2000). The results of these studies show that the way virtual teams function changes depending on the extent to which members use ICTs to communicate and to coordinate their work, the distance between them, whether they already know each other or are working together for the first time, etc. These and other variables define the concept of team virtuality that may be considered at different levels and lead to different configurations of virtual teams (Chudoba et al. 2005; Gibson and Gibbs 2006; Griffith et al. 2003; Kirkman and Mathieu 2005). This assumption of the varying level of virtuality has considerable implications on team configurations as it implies different communication needs, interaction patterns, communication tools, work habits, behaviours, etc. As a result, managerial practices have to adapt to the specificities of virtual teams resulting from their virtuality level.

A first step recorded in virtual team literature to better understand the concept of virtuality is to draw up typologies. Typologies have identified a number of relevant determinants such as distance, communication media, and team lifespan, and they describe different configurations resulting from

the combinations of these characteristics (Bell and Kozlowski 2002; Dubé and Paré 2002; Järvenpää and Leidner 1999). However, several limitations may be noted in these typologies as they only describe extreme cases such as pure or traditional virtual teams, and give no information about other possible configurations that may exist. In addition, typologies may be considered as a simplistic tool for studying virtuality, unable to cover all aspects of the concept as the variables considered are limited and do not reflect all the relevant determinants of team virtuality (such as intensity of ICT use or the nature of the communication, etc.).

Given the limits of typologies, the development of a multidimensional approach to understand and assess team virtuality appears to provide a solution for identifying the many kinds of virtual teams that exist. It also constitutes an effective means for understanding the way they function so as to subsequently develop appropriate management practices. However, as a recent concept in virtual team literature, virtuality and its effects on team dynamics and processes are still under studied (Gibson and Gibbs 2006). Little is known about how to define and evaluate team virtuality, what are the relevant dimensions that have to be considered to determine the level of team virtuality and what are the effects of its variability on team effectiveness (Schweitzer and Duxbury, 2009). To fill this gap in the literature, our paper tries to address these issues with a dual objective. On the one hand, our aim is to propose a relevant definition of the concept of virtuality and a multidimensional approach to assess its level. This purpose can be achieved by identifying the relevant dimensions of virtuality and the factors that influence its level. On the other hand, we aim to explore the effects of the level of virtuality on team effectiveness (Chudoba et al. 2005; Gibson and Gibbs 2006; Lin et al. 2008). Studying virtuality effects may help virtual team managers to formulate adapted and innovative managerial effectiveness practices.

To this end, the paper is organized as follows. The following section presents our conceptual framework, which defines the concept of virtuality, provides a multidimensional approach to evaluate it and the measures adopted to assess team performance. We then present the methodology based on a longitudinal qualitative study of ten virtual teams. In the fourth section, we present the results of the empirical investigation concerning our evaluation of the virtuality and effectiveness of the teams observed. We then explain our findings and discuss them in the fifth section. The conclusion sum-up our aims and the main findings, formulates some of the implications of our findings for the theory and management of virtual teams before setting out its limitations and possible future extensions.

2 CONCEPTUAL FRAMEWORK

2.1 What is virtuality?

The Concise Oxford Dictionary provides a clear definition of “virtual reality.” This definition states that virtual reality is: *“a computer simulation of a real or artificial environment that gives the user the impression of actually being within the environment and interacting with it. The virtual reality systems could have important applications in the training of surgeons, aircraft pilots, astronauts, and military personnel, and would enable architects to “walk” through the interior of proposed building designs. They could also be used in interactive learning programmes, video games, etc.”*

According to this definition, virtuality refers to a situation generated by ICT use to substitute a difficult organising face-to-face situation (a simulation of war situations for surgeons, or plane flights for aircraft pilots). In this sense, Davis et al. (2009) argue that the improvement of technological capabilities have allowed the development of effective interaction in virtual worlds. Thus, ICTs are used in virtual simulation to build the parameters of a real face-to-face context. The purpose is to create a virtual environment that is as near as possible to the face-to-face context. Through their communication and apparent capabilities, ICTs allow users to interact in virtual settings (Davis et al., 2009). In this regard, ICTs are considered as both generators and reducers of virtuality. They enable

users to build virtual situations through simulation and to approach the real situation as much as possible and hence reduce virtuality.

On the other hand, along with other authors (Cohen and Gibson, 2003; Kirkman et al., 2004; Schweitzer and Duxbury, 2009), we argue that the definition of Virtual teams found in the literature is too simplistic: teams are either considered virtual or proximate. In this sense, Schweitzer and Duxbury (2009) pointed out that “the question is not whether a team is virtual, but rather, ‘how virtual is the team?’(p.9). Thus, team virtuality is considered as a continuum (Griffith et al., 2003). Teams have different degree of virtuality which vary from pure face-to-face to pure virtuality. In this sense, different dimensions have been put through in order to evaluate the level of virtuality (Bell and Kozlowski, 2002; Dubé and Paré, 2002; Gibson and Gibs, 2006; Griffith et al., 2003; Kirkman and Mathieu, 2005; O’Leary and Cummings, 2007; Fiol & O’Connor, 2005). Schweitzer and Duxbury (2009) identified five dimensions of virtuality which are frequently cited in the literature. They consist of “the distance between team members”, “the extent that the members work face-to-face”, “the amount of work or interaction that is asynchronous”, “the configuration of team member locations and the extent that the team relies on information technologies” (p.9).

However, Schweitzer and Duxbury (2009) argue that the use of ICTs should not be considered a measure of virtuality as it depends on its level. While they acknowledge the usefulness of some additional aspects of virtuality such as the richness and information value (Kirkman and Mathieu, 2005) which may affect the interaction of virtual teams, they point out that the nature of ICTs used is relevant to any team. Thus, the dependence on ICTs use is excluded from the dimensions of virtuality retained by Schweitzer and Duxbury (2009). Three dimensions of virtuality have been identified. They consist of “the extent that the team members do not work face-to-face”, “the distance between team members and the extent that they work asynchronously” (p.12).

Still, we argue that the dependence of a team on ICTs use is a key component to apprehend its level of virtuality. Indeed, whatever the distance between different team members, they can overcome these constraints through their use of ICT tools and adjust their level of virtuality. Moreover, while previous studies posit that virtuality increases when intensity of ICT use increases (Griffith et al., 2003; Kirkman and Mathieu, 2005), we believe that high ICT use may contribute to reducing the level of virtuality. Indeed, the former assumption may be true if we compare face-to-face with computer-mediated communication (CMC). However, this loses its relevance if we compare different levels of CMC, which is the case for most virtual teams. Frequent CMC, when face-to-face meetings are difficult or impossible to hold, helps virtual team members to build a shared social context and to reflect the parameters of a face-to-face work context.

It turns out that contrary to (Schweitzer and Duxbury, 2009), we argue that ICTs are a key component to evaluate virtuality. However, contrary to Griffith et al. (2003) and Kirkman et Mathieu (2005), we posit that ICT use can reduce virtuality. We thus propose a multidimensional approach to evaluate virtuality which is based on how people use and appropriate ICT tools. We thus distinguish between technological and social virtuality which will be developed in the following paragraph.

2.2 A multidimensional approach to evaluate team virtuality

ICTs are essential for virtual teams (Bélanger and Watson-Manheim 2006) as their use allows virtual teams to overcome spatial and temporal constraints. However, further investigation is needed to understand how virtual teams use different media forms and the results of this use. Indeed, few studies have examined how ICT use may impact on virtuality and, hence, on team effectiveness. ICTs are either compared to face-to-face communication or classified according to their richness (Daft and Lengel 1984; 1986) or their synchronicity (Dennis and Valacich 1999). Moreover, studies to date have not detailed the specificities of each media they refer to. This is the case of Kirkman and Mathieu (2005), for instance, who referred to virtual tools without any further specifications.

In addition to its technical and objective features, media can be used and appropriated in different ways (Dennis et al. 2008). We posit that the study of virtuality should not only take into consideration the characteristics of the ICTs used but also the way they are appropriated and enacted by users (DeSanctis and Poole 1994; Orlikowski 2000). We argue that while the level of virtuality depends on the objective features of the media, the way the media are appropriated can reduce and even overcome the constraining features of the ICTs used. Thus, while virtual team members rely extensively on ICTs which have either enabling or constraining features (Dennis et al. 2008; Leonardi and Barley 2008), we posit that they can surmount their virtuality through the way they use media and mix their characteristics, which we refer to as technological virtuality, as well as the way they interact through the media, which refer to as social virtuality.

2.2.1 *Technological virtuality*

Technological virtuality is defined as the extent to which virtual team members use media and combine the characteristics of ICTs in order to take full advantage of their features and reduce their constraints. We argue that it is possible to combine different media and to maintain regular and frequent communication through these tools. Thus, we consider that the level of technological virtuality is influenced by the set of media used, their informational value and the rhythm of communication.

Media combination. Virtual team members use a set of media to accomplish and coordinate work. They may rely extensively and even exclusively on ICTs when they can rarely meet face-to-face (Bélanger and Watson-Manheim 2006; Dubé and Paré 2002; Kalika et al. 2008; Massey and Montoya-Weiss 2006; Watson-Manheim and Bélanger 2007). We argue that in virtual settings where problems of shared understanding and communication are exacerbated by members reliance on ICTs (Vlaar et al. 2008), combining different media tools enables team members to manage these issues more effectively. In this sense, choosing a set of communication media may be more effective than a single media use (Dennis et al. 2008).

Proposition P1.a: Using a set of communication media in a simultaneous, sequential or repetitive fashion reduces the technological level of virtuality.

Informational value. Kirkman and Mathieu (2005) defined the informational value of the virtual tools used as the extent to which information exchanged through ICTs is relevant to work tasks and whether it helps to execute these tasks effectively. It expresses the suitability of the virtual tools used to the work to be accomplished even if they are considered as lean media by media richness theory (Daft and Lengel, 1986; Daft et al. 1987; Dubé and Robey, 2008; Majchrzak et al. 2000). This means that the relevance of virtual tools to task accomplishment is not related to their characteristics and ability to deliver a large amount of rich information. Instead, it is related to their consistent use by team members in order to adapt to the work situation and to provide some help in reaching the fixed performance objectives (Majchrzak et al. 2004). We thus posit that:

Proposition P2.b: Using a set of communication media with higher informational value reduces the levels of technological virtuality.

Communication frequency. Furthermore, when unable to meet face-to-face most of the time, communicating frequently through different ICTs can reduce discontinuity related to distance (Chudoba et al. 2005; Hambley et al. 2007). Indeed, frequent communication can reduce misunderstandings and ambiguities related to ICT use in virtual settings and help to build the team members' mutual knowledge and overcome language barriers and cultural differences (Dubé and Robey 2008; O'Leary and Cumming 2007).

Proposition P1.c: Frequent communication through ICT enables virtual team members to reduce the level of their technological virtuality.

Regular communication. Maznevski and Chudoba (2000) demonstrated that regular face-to-face meetings are essential to global team effectiveness and thus effective teams maintain a rhythm of regular face-to-face meetings. However, some virtual teams are unable to meet face-to-face. In addition, as Dennis et al. (2008) argued, face-to-face is not always the richest medium. Hence, we posit that keeping a regular rhythm of communication through a set of ICTs is also crucial for team effectiveness. We thus posit that:

Proposition P1.d: Regular rhythm of communication through different ICT tools reduces technological team virtuality.

2.2.2 Social virtuality

Studies on media have emphasized the capacity of users to adapt ICT use to their tasks and social needs (Beaudry and Pinsonneault 2005; Majchrzak et al. 2000; Tee'ni 2001; Thomas and Bostrom 2008). We argue that exploring how people interact through different media is crucial to improving our understanding of different levels of virtuality. We posit that social virtuality can be explained by the nature of communication, the style of interaction and communication norms.

Social versus task related communication. We argue that while task-focused communication is essential for work coordination, social-related communication is also needed to guarantee team cohesion and relationship building (Iacono and Weisband 1997; Järvenpää and Leidner 1999). Thus, we posit that through socially focused communication, virtual team members cope with the constraints related to their geographic dispersion (O'Leary and Cummings 2007) and the absence of prior shared knowledge and work experience (Meyerson et al. 1996). Socially focused communication is therefore crucial to reduce the limits imposed by their virtuality. While face-to-face communication has been demonstrated as mandatory for virtual teams (Maznevski and Chudoba 2000), research has also demonstrated that over time, team members communicating through ICTs develop the same relational level as those communicating face-to-face (Walther 1995; Chidambaram and Jones 1993; Chidambaram 1996).

Proposition P2.a: Socially focused communication enables virtual team members to cope with the limits related to their virtuality and hence reduces the level of their social virtuality.

Virtual teams' interaction style. A few studies have investigated the effect of interaction style on team virtuality and its effectiveness (Hambley et al. 2007). Potter and Balthazard (2002) found that the style of interaction correlates significantly with the team's performance. They identified three styles of interaction: constructive, passive and aggressive. We posit that having a constructive style of interaction enables team members to develop a positive social climate, while passive and aggressive style favours conflict. Both the aggressive and passive style destroys social relations as well as the collaborative climate between team members. This slows down the construction of a shared social context which restores the parameters of face-to-face context between team members. We thus argue that through their style of interaction, virtual team members can promote either team cohesion or team conflict and subsequently reduce or reinforce their social virtuality.

Proposition P2.b: Social virtuality is reduced through constructive interaction styles while it increases with passive and aggressive styles.

Virtual team communication norms. We argue that having shared work experience in virtual settings enables team members to develop shared expectations and communication norms about the use of different media and the way they communicate through these tools. Virtual team members stick to these norms when choosing and communicating through ICTs. The existence of these tacit rules and shared norms on the way of communicating (Zack 1993; 1994) can overcome constraints related to the objective features of the ICTs used (Fulk 1993; Markus 1994; Watson-Manheim and Bélanger 2007). We posit that the development of such shared norms is crucial to overcoming the constraints related to virtuality.

Proposition P2.c: Existing communication norms shared by virtual teams on media use reduce their level of social virtuality.

2.2.3 Virtuality evaluation

When virtual team members have both high technological and social virtuality, it means that they do not take full advantage of the characteristics of the media available and their communication may not be regular and frequent. They fail to profit from ICT characteristics to build shared work norms and a social context that can substitute face-to-face interactions. For these reasons, we believe that high technological virtuality associated with high social virtuality leads to high global team virtuality.

However, when teams are characterised by low technological virtuality and low social virtuality, then their global virtuality level is low. In this case, virtual team members take advantage of the different characteristics of the media by combining their use. In this way, they are able to manage the constraints related to virtuality by developing a shared understanding of the virtual situation and of the other members' behaviour.

To evaluate virtuality of teams characterised by high or low technological virtuality combined respectively with low or high social virtuality, we argue that social issues play a more important role in team virtuality than technological ones. Given these arguments, we posit that high technological virtuality combined with low social virtuality leads to low global team virtuality, and that low technological virtuality associated with high social virtuality generates high global team virtuality.

2.3 Virtual team effectiveness

We apply three measurement categories to evaluate team effectiveness, namely work performance, members' attitudes and their behaviours.

Work performance. This may be defined as "the extent to which the group's output meets the required standards or measures" (Lin et al. 2008: p. 1033). It can be assessed through output quality (Aubert and Kelsey 2003; Paul et al. 2004), task achievement processes (Lurey and Raisinghani 2001; Maznevski and Chudoba 2000; Montoya-Weiss et al. 2001), efficiency, profits, innovation, creativity and value creation (Furumo and Pearson, 2006; Gibson and Gibbs 2006; Paul et al. 2004).

Concerning the effects of the level of virtuality on work performance, we consider that low virtuality positively influences the quality of work. If members use appropriate ICTs to accomplish their work and if these tools have a high informational value leading to improvements in work, the results are expected to be satisfying and to correspond to the fixed quality criteria. In addition, high interaction frequency helps team members to share a large amount of information in order to achieve high-quality work, and allows brainstorming, knowledge creation and sharing. Immediate and constructive feedback and synchronous communication can help establish effective work processes leading to high output quality.

Proposition P3.a: High work performance is associated with a low level of virtuality.

Members' attitudes. Effective team attitudes are expressed through their satisfaction and agreement with decisions, and their participation in work achievement (Lin et al., 2008). Members' satisfaction is assessed through their satisfaction with output quality and team processes (Montoya-Weiss et al. 2001). Agreement with team decisions implies they are accepted by all the members and there is a high degree of consensus, resulting from participative decision-making processes involving all the team members. Participation in work activities refers to their contribution to the collective output and respect for their share of work.

Concerning the possible effects of virtuality on members' attitudes, we argue that low levels of virtuality result in effective and positive attitudes. Indeed, regular and frequent communication, constructive and motivational feedback, shared norms and accepted team rules, and a constructive

interaction style enable members to achieve satisfying work output and to build effective mechanisms. All these factors can also generate a climate of consensus and lead to effective participation in goal achievement.

Proposition P3.b: Effective and positive attitudes result from a low level of virtuality.

Members' behaviours. We used motivation and commitment to the team as the two indicators to evaluate behavioural performance. Teams whose members develop high levels of motivation and commitment are expected to demonstrate strong cohesion and group identity. Cooperative and trusting relationships consequently develop between team members and lead to effective team processes and high quality output. Geister et al. (2006) noted that motivation in virtual teams is influenced by regular and immediate feedback.

In this regard, we think that low virtuality logically entails high motivation and commitment toward the team. In fact, frequent and regular interaction, and rich and synchronous exchanges contribute to reinforcing team cohesion and identity. Frequent communication helps team members to build a shared social context with accepted work and behavioural norms. Respecting these norms reinforces the relationship between team members and leads to greater motivation and commitment.

Proposition P3.c: Effective and positive behaviours result from a low level of virtuality.

To summarize our theoretical developments concerning the conceptualisation and evaluation of virtuality, on the one hand, and its effects on team effectiveness, on the other, we present our conceptual framework in figure 1.

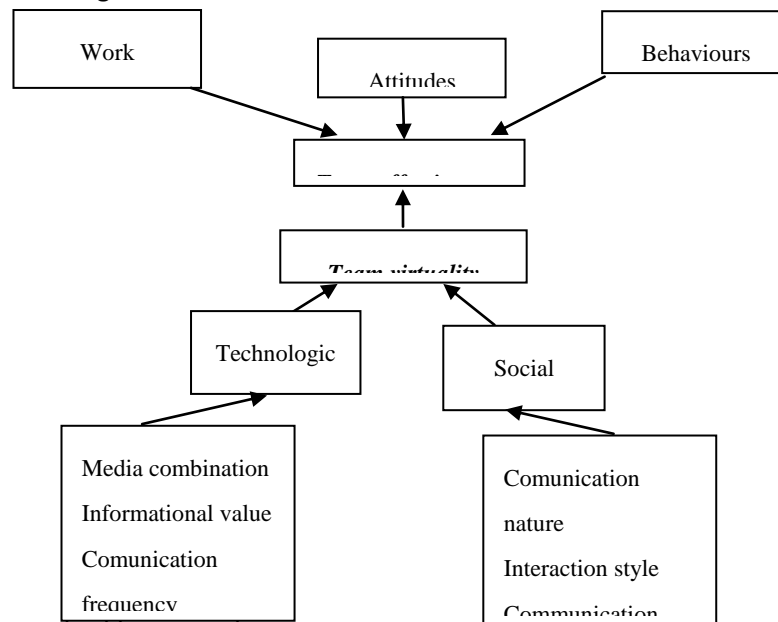


Figure 1. Conceptual framework

3 METHOD

In our empirical study, we adopted a longitudinal qualitative method. We observed ten virtual teams over a five-month period: three months of intensive observation, followed by administration of a questionnaire, and two months of in-depth interviews. Data was thus collected from three sources: e-mails, interviews and a qualitative questionnaire.

3.1 Sample

The virtual teams we observed were composed of three to five graduate students attending online courses at a French university to obtain a Master's degree. This kind of course is designed for people who wish to gain a better degree but who cannot attend ordinary classes because of their

professional obligations. Thus, all the team members in our study were professionals who were working at the same time as they were studying. These courses are also accessible to all individuals wherever they live. That is why some of the teams observed were international and included members living outside of France, which made face-to-face meetings impossible or difficult to organize because of professional obligations and geographical dispersion. This meant the team had to rely heavily on ICT to communicate and complete their work. Another characteristic of these courses is that they rely heavily on teamwork with students organized into teams to complete their coursework.

We decided to study the “Strategy and Organization” course, which is supervised by one of the co-authors of this paper. In this course, students have to complete two collective case studies, which are assessed and account for 50% of the global course mark. Three dates were retained to analyse evolution of team dynamics and work: the beginning of the task, completion of the first case study and the end of the second case study.

As all the courses in this degree programme are online, students have access to an advanced technological web-based platform containing communication tools (general forum, team forums, chat rooms, e-mail) and collaborative tools to understand the lessons, etc. In addition, team members use other electronic tools such as *skype*, personal email, conference calls, and collaborative tools. The teams observed were created following calls for participation posted on the general forum to form a new team or to join two or three members who already knew each other and who needed a third or fourth member. We present some of the characteristics of the teams observed in table 1.

3.2 Data collection

Data was collected via three sources: observations, questionnaires and interviews. The team observations lasted three months, enabling us to collect 795 e-mails exchanged between team members. The repartition of e-mails varied from one team to another. In addition to e-mails, the observations enabled us to collect messages posted on the general and team forums. These e-mails and messages constitute our main data and were completed by other sources. Indeed, after task completion, the team members were asked to fill in a questionnaire including qualitative questions about team members, communication tools they used, and some of the team processes.

The latest data source consisted of interviews conducted after task completion. The total number of interviews is twenty. Following the recommendations of Huberman and Miles (1994), all the interviews were recorded and transcribed. Interviewees were asked about their experience of virtual work, their perceptions of team effectiveness (work, attitudes, and behaviours) and their ICT use.

3.3 Data analysis

All the qualitative data gathered from the e-mails, questionnaires and interviews were coded and analysed after task completion. We developed a coding scheme to analyse the dimensions of virtuality and effectiveness variables. The codes are grounded in the literature and take the characteristics of the study context into account. For content analyses purposes, we adopted a double coding method to ensure the reliability of the analyses. Inter-rater reliability reached 92% which is considered a satisfactory rate according to Huberman and Miles (1994). In addition to content analyses, other measures were used to evaluate some of the variables in our conceptual framework. Table 1 presents the analyses method used for each variable in the conceptual framework.

Variables	Analyses methods	Sources
Media combination	Number of media used	Questionnaire
Informational value	Characteristics of media used	Questionnaire
Communication	Number of e-mails exchanged and frequency	E-mails

frequency	of media used	
Interaction rhythm	Evolution of e-mails exchanges	E-mails
Communication nature	Content analyses	E-mails
Interaction style	Content analyses	E-mails
Communication norms	Content analyses	E-mails
Work performance	Marks obtained	-
Work processes	Content analyses	Interviews
Satisfaction	Content analyses	Interviews
Participation	Content analyses	E-mails and interviews
Motivation	Content analyses	Interviews
Commitment	Content analyses	E-mails and interviews

Table 1. *Analyses methods*

4 RESULTS

4.1 Virtuality evaluation

To evaluate the virtuality of the teams observed, we first evaluated the effects of variables influencing the technological and social dimensions. After that, we aggregated these two measures to obtain a global team virtuality level. Three levels were used to describe team virtuality: low, moderate, and high. Table 2 presents the results of the virtuality evaluation for each team.

Teams	Media combination	Informational value	Communication frequency	Interaction rhythm	Technological virtuality	Communication nature	Interaction style	Communication norms	Social virtuality	Team Virtuality level
Team 1	2 media, repetitive use	Moderate	High	Regular	Low	Task-related	Constructive	Built	Low	Low
Team 2	3 media, repetitive use	High	Low	Irregular	High	Task-related	Passive and aggressive	No existing norms	High	High
Team 3	2 media, repetitive use	Moderate	Low	Regular	Moderate	Task-related	Constructive	Built	Moderate	Moderate
Team 4	4 media, repetitive and sequential use	High	High	Regular	Low	Social and task-related	Constructive	Existing	Low	Low
Team 5	5 media, sequential and repetitive use	High	High	Regular	Low	Social and task-related	Constructive and aggressive	Built	Moderate	Moderate
Team 6	1 media, repetitive use	Low	High	Irregular	High	Task-related	Aggressive and passive	No existing norms	High	High
Team 7	3 media, repetitive and sequential use	High	High	Irregular	Moderate	Task-related	Aggressive and passive	No existing norms	High	High
Team 8	1 media	Low	Low	Irregular	High	Task-related	Passive	No existing norms	High	High
Team 9	4 media, simultaneous and repetitive use	High	High	Regular	Low	Social and task-related	Constructive	Existing and built norms	Low	Low
Team 10	4 media, simultaneous and repetitive use	High	High	Regular	Low	Social and task-related	Constructive	Built	Low	Low

Table 2. *Virtuality evaluation*

According to this classification and the analyses conducted, we found four low virtuality teams: team 1, 4, 9 and 10, two moderate virtuality teams: team 3 and 5, and four high virtuality teams: 2, 6, 7, and 8. It should be noted that all the teams (except team 6 and 8) developed a media portfolio that included at least two ICTs (e-mails for all teams and one other media form). ICTs are used in different ways (repetitively, sequentially or simultaneously) depending on the team characteristics. However, technological virtuality did not have the same level for all the teams. This result partially validates proposition P1.a concerning the impact of the combination of a set of media on technological virtuality. Indeed, in some cases, using multiple media is not enough to reduce the level of technological virtuality (team 2). Our results also show that a set of communication media with varying characteristics leads to high informational value of media portfolio. However, high informational value not only results from the media combination but also from the compatibility between work characteristics and the media used, mainly e-mail. The level of technological virtuality does not correlate with the level of informational value, leading to a partial validation of proposition P1.b. Indeed, for team 2, although the media portfolio is characterised by high informational value, the level of its technological virtuality was also high. Team 7 registered a moderate level of technological virtuality while its informational value was high.

The results concerning communication frequency were also mitigated. Team 1, 4, 5, 9, and 10 had a high communication frequency associated with low technological virtuality. However, team 3 had low communication frequency with a moderate level of technological virtuality and team 6 and 7 had a high communication frequency with respectively high and moderate levels of technological virtuality. On the other hand, team 2 and 8 had low communication frequency associated with high technological virtuality. These results also partially validate proposition P1.c concerning the effects of communication frequency on the level of technological virtuality.

The last proposition concerning the rhythm of interaction and the evaluation of technological virtuality is confirmed. Our findings show that a regular rhythm of interaction leads to low technological virtuality and, *vice versa*, teams who developed an irregular rhythm of interaction had either a high or a moderate level of technological virtuality. Social virtuality was measured through the nature of communication, style of interaction, and building of communication norms. We first posit that social messages, in comparison with task-related messages, lead to lower social virtuality. The findings confirm this proposition given that low and moderate social virtuality teams (team 1, 3, 4, 5, 9 and 10) were characterised either by task-related or a similar proportion of task-related and social communications. However, high social virtuality teams exchanged high proportions of task-related messages compared to social ones.

Concerning the effects of the style of interaction on the level of social virtuality, our results show that low social virtuality is associated with a constructive style of interaction and high social virtuality derives from either aggressive or passive styles. We also note that in moderate social virtuality teams, the interaction styles were either constructive (team 3) or both constructive and aggressive (team 5). These findings enable us to validate proposition P2.b. Existing communication norms which regulate and guide communication behaviours were the last measures we retained to assess social virtuality. In this regard, we posit that existing or built communication norms resulting from repetitive interaction and experience of ICT use with partners contribute to reducing social virtuality. Our results confirm this proposition (P2.c) and show that low and moderate social virtuality teams had already existing communication norms as their members had worked together in the past (teams 4, 5 and 9) or had developed communication norms through regular communication and constructive feedback (teams 1 and 10). However, high social virtuality teams failed to build communication norms, their interactions were irregular and in some cases communication processes were interrupted (teams 2 and 8).

4.2 Evaluation of effectiveness

Team effectiveness was measured through work performance, attitudes, and behaviours. These measures were then aggregated to obtain a global team effectiveness evaluation. Table 3 presents the results of this stage.

work planning, effective coordination mechanisms, respect for deadlines						
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Table 3. Effectiveness evaluation

According to this evaluation, the teams observed can be classified into three categories: high effectiveness teams: team 1, 3, 4, 9, and 10, low effectiveness teams: team 2, 6, 7, and 8, and a moderate effectiveness team: team 5. Although all the teams had a good mark (apart from team 8), other variables may distinguish teams in the three categories. Effective teams developed work processes based on clear and early task repartition, drawing up of schedules, respect for deadlines and effective coordination mechanisms. The members of these teams were highly satisfied with the virtual work experience, with output quality and with their teammates' behaviour. They also actively participated completing the work by doing their part and helping members in difficulty. Motivation and commitment reached a high level and contributed to establishing a positive work climate and an enthusiastic team spirit. Participation in work activities and satisfaction (as mentioned by one team member) influenced considerably motivation and commitment.

In the second category, effectiveness was low as the teams failed to establish task repartition or to develop coordination mechanisms. For these reasons, schedules were not respected and two teams (2 and 8) submitted case studies after the deadline. Concerning evaluation of attitude, the members of these teams were less satisfied with their experience and stated that would not be able to work with the same people in the future.

The same perceptions were also noted concerning the evaluation of participation. All of these teams registered at least one 'absent' member who did not take part in the group work. Negative behaviours in this category of teams are closely related to motivation issues. According to the members interviewed, problems of lack of participation or unsatisfactory output quality contributed to a demotivating work climate and increasingly difficult relations between the members. Thus, motivation may be considered an important variable that influences team dynamics and its effectiveness.

The last category, including team 5, registered moderate effectiveness due to lack of satisfaction and participation. The decreased rhythm of work influenced considerably the members' motivation and satisfaction, and the whole team experienced serious difficulty to submit the requisite work on time. For these reasons, the global effectiveness of this team is considered as moderate even though it was high at the beginning of the study.

4.3 Level of virtuality and team effectiveness

We drew up the following table to better visualise the links between levels of virtuality and effectiveness for each team.

Team	Work performance	Attitudes	Behaviours	Team effectiveness	Virtuality level
Team 1	High	High	High	High	Low
Team 2	Low	Low	Low	Low	High
Team 3	Moderate	High	High	High	Moderate
Team 4	High	High	High	High	Low
Team 5	Moderate	Moderate	Moderate	Moderate	Moderate
Team 6	Moderate	Low	Low	Low	High
Team 7	Low	Low	Low	Low	High
Team 8	Low	Low	Low	Low	High
Team 9	High	High	High	High	Low
Team 10	High	High	High	High	Low

Table 4. Association between level of virtuality and team effectiveness

To explain these results, we divided our sample into three categories according to their level of virtuality. We then analysed effectiveness in each category and arrived at the following conclusions.

First, in teams 2, 6, 7, and 8, characterised by a high level of virtuality, team effectiveness registered low levels. Indeed, high virtuality teams were less effective than low and moderate virtuality teams in several ways. This could be seen through their work processes, and the attitudes and behaviours of members. On the one hand, these teams failed to develop and maintain fluid workflow activities due to unequal participation of all the team members. As a result their work lacked coherence, richness and organization. In addition, team 2 and 8 did not respect the fixed deadline and sent their work respectively one month and two weeks later. In terms of satisfaction with the virtual experience, the interviews revealed that the members were satisfied with the quality of the work done but not with their relations with some members or with some members' behaviour. The members interviewed in these teams believed that they would not be willing to work with the same people in the future.

Second, all of the low virtual teams (teams 1, 4, 9 and 10) reached a high level of effectiveness and got a good evaluation mark. They had developed effective processes and achieved a high degree of satisfaction among their members. This level was reached through early task repartition and through the clarification of each member's role. The members of these teams also developed a task progression schedule and respected the deadlines. This also resulted from the active participation of all the team members who had actively taken part in completing the work. All these team members were satisfied with the virtual work experience and said they would be happy and willing to collaborate again in the future.

Finally, in the moderate teams, effectiveness was high in team 3 and moderate in team 5. Team 3 developed an effective work rhythm with regular interaction and immediate or rapid feedback. All the team members were involved in completing the task effectively and participated actively to produce consistent and coherent case studies. The team leader gave constructive comments about the work done and helped other members to solve any work-related problems they encountered. In addition, he maintained a positive and collaborative relationship through his encouraging and motivating messages.

However, effectiveness was moderate in team 5 due to delays in finishing tasks and to problems related to members' satisfaction and motivation. Indeed, we noted that the messages exchanged during the second case study were less frequent. The leader of this team was relatively absent during this stage, which was not the case for the first one.

We summarize our results in table 5.

Propositions	Results
P1.a: Using a set of communication media in a simultaneous, sequential or repetitive fashion reduces the level of technological virtuality.	Partially validated
P1.b: Using a set of communication media with high informational value reduces the levels of technological virtuality.	Partially validated
P1.c: Frequent communication through ICT enables virtual team members to reduce the level of their technological virtuality.	Partially validated
P1.d: A regular communication rhythm through different ICT tools reduces technological team virtuality.	Validated
P2.a: Socially focused communication enables virtual team members to cope with the limits related to their virtuality and hence reduces the level of their social virtuality.	Invalidated
P2.b: Social virtuality is reduced through constructive interaction styles while it	Validated

increases with passive and aggressive styles.	
P2.c: Existing communication norms shared by virtual teams concerning media use reduces their level of social virtuality.	Validated
P3.a: High work performance is associated with a low level of virtuality.	Validated
P3.b: Effective and positive attitudes result from a low level of virtuality.	Validated
P3.c: Effective and positive behaviours result from a low level of virtuality.	Validated

Table 5. *Results of the propositions*

5 DISCUSSION

Different levels of virtuality. In this paper, we recommended going beyond the dichotomy of pure virtual teams and traditional ones and thus considering virtuality as a continuous concept. Along with Bell and Kozlowski (2002), Dubé and Paré (2002) and Kirkman and Mathieu (2005), we posit that there are different levels of virtuality. However, our main contribution is the conceptual framework we present in this paper to assess virtuality. We emphasized the relevance of considering the reliance on ICT tools as a key component to evaluate virtuality and thus contrary to what it was argued by (Scheitzer and Duxubury, 2009). In this sense, Dennis et al. (2008) posit that in virtual settings media must be considered in terms of the capabilities they afford. However, virtual teams have different requirements of media capabilities over time depending on their context (Dennis et al., 2008). Thus, they argue that the set of media initially used by the virtual team may evolve over time. It turns out that while it is essential to take into account the characteristics of media used, it is not enough to understand team's virtuality. We also need to consider how the members of virtual teams interact through these media and appropriate them over time as they developed common norms of communication. We thus put forward two different constructs involved in technological and social virtuality. While technological virtuality refers to the objective features of the different ICTs used and how they are combined and used, social virtuality is related more to the way virtual team members communicate through ICTs and adapt their use to build parameters for face-to-face contexts.

Technological virtuality: a step towards understanding virtuality but not enough. Our results show that it is not only the combination of different media that matters but how the different media are combined and used in order to overcome problems of understanding and communication due to the reliance of team members on ICTs. We retained the information value of the ICTs as a relevant feature to consider when examining virtuality. Contrary to Mathieu and Kirkman (2005) who consider the extent of use of ICTs and the information value of ICT use separately, we propose examining them jointly. Our proposition suggested that the combination of different ICTs with higher information value reduces technological virtuality. Nevertheless, our results partially validated propositions P1.a and P.1.b. We thus argue that while the use of a set of communication media with high informational value is essential to reducing virtuality, it is not always enough.

In addition, our results indicated that frequent communication between virtual team members is not sufficient to overcome the limitations of virtuality. Proposition P1.c was not validated. However, our results validated the proposition P1.d which stipulates that a regular communication rhythm through different ICT tools reduces technological team virtuality. We argue that virtual team members need to maintain frequent interaction which guarantees synchronous and regular communication. While Maznevski and Chudoba (2000) emphasized the need for regular face-to-face communication in virtual settings, our analysis demonstrated that by maintaining regular communication through a set of ICTs, virtual team members can overcome constraints related to their dispersion. This is contrary to generally accepted thinking, and we argue that virtuality is not assessed uniquely by comparing the extent of ICT use with face-to-face.

Social virtuality: the missing brick. Our results invalidated the proposition P2.a which stipulates that socially focused communication enables virtual team members to cope with the limitations related to their virtuality and hence reduce the level of their social virtuality. This result can be explained by the inherent characteristics of our sample, and in particular the lifespan of the teams observed. All the teams had just three months to complete two case studies. Apart from teams 4 and 10, all the remaining teams were composed of members who were working together for the first time. The short duration of team tasks in addition to the lack of past shared work experience generated communication that concentrated on completing work to respect deadlines and work performance evaluation and left little or no time for social and personal exchanges.

Nevertheless, our results validated the proposition P2.b which stipulated that social virtuality is reduced through constructive interaction styles while it increases with passive and aggressive styles. Indeed, having constructive interaction is essential in order to preserve a positive and enthusiastic team spirit and dynamic, and thus enabling team members to achieve their assigned work.

Moreover, our analysis emphasized the importance of the development of communication norms when assessing virtuality. Indeed, we demonstrated that when virtual team members manage to create communication norms, they can decrease their virtuality. As virtual team members gain experience through their recurrent communication with ICTs, they develop shared expectations on the way these are used. They are then able to transmit complex communication while using so-called lean media (Dubé and Robey 2008).

While researchers highlight the importance of communication norms for face-to-face teams (Markus, 1994; Watson-Manheim and Bélanger, 2007), our study stresses the accuracy of communication norms for virtual teams as well.

To conclude, while we underscored the need to consider the duality linked to technological and social virtuality, our study emphasized the predominance of social virtuality. Indeed, we argue that through the development of shared communication norms, virtual team members can overcome their high technological virtuality. Carlson and Zmud (1999) emphasized the importance of experience with the media and the partner. Through their recurrent use of the media and interaction with each other, virtual team members can create shared communication norms and thus modify their needs of communication capabilities. Dennis et al.(2008) emphasized in this sense the importance of understanding the context of virtual teams as this imply different media requirements.

Levels of virtuality and effectiveness. Unlike other research (Kirkman and Mathieu 2005), we present an assessment of virtuality that transcends the extent of ICT use. We instead propose a multidimensional approach to evaluate virtuality. Our findings reveal that high team effectiveness is associated with either low or moderate levels of virtuality. In contrast, low effectiveness results from a higher level of virtuality. Let's note that Schweitzer and Duxbury (2009) found that the degree of virtuality is associated with a decrease in two key dimensions of team effectiveness which consist on member perception of performance and member satisfaction. However, as we do not refer to the same dimensions of virtuality, our results cannot be compared.

Potter and Balthazard (2002) found that low frequency of interaction is not related to low performance levels. These results confirm our findings concerning the effects of low virtuality on team performance. We found that some teams that exchanged few e-mails managed to develop effective work processes and results (team 3). They compensated for the lack of interaction using other variables such as prior knowledge of members, active participation in the collective task, or the use of a wide panel of ICTs.

Maznevski and Chudoba (2000) found that effective teams develop a regular rhythm of interaction and use more than one means of communication. They also show that high task complexity increases

interaction frequency and ICT use, and that team consensus and decision acceptance contributes to reducing the negative effects of team diversity (cultural, professional and organizational). In this respect, our results concerning the importance of communication frequency on team performance are corroborated.

In another study on the effects of interaction on performance, Geister et al. (2006) found that motivational, work-related and relationship-related feedback are positively related to members' satisfaction and motivation. Along with Geister et al. (2006), we found that frequent, motivating and constructive feedback contributes to building an enthusiastic team spirit and climate and increasing members' satisfaction with the virtual work experience.

Lin et al. (2008) validated an integrative model of virtual team effectiveness. They highlighted the importance of relationship building and group cohesion for effective virtual teams. However, both relationship building and cohesion are directly affected by communication. Nonetheless, the authors do not give any other indication of how the use of ICTs may affect communication. Our research, in contrast, opened the black box of ICT use in virtual settings. We proposed a conceptual framework which takes into account both IT artifact and ICT use when assessing virtuality and its impact on effectiveness.

6 CONCLUSION

This paper analysed the effects of team virtuality on its effectiveness. We developed a multidimensional approach to assess team virtuality through different variables grouped into two dimensions: technological and social virtuality. Team effectiveness was evaluated through work performance, members' attitudes and their behaviours. We tested our propositions on ten virtual teams of graduate students involved in online Master degree programmes. Our results highlighted the need to go beyond the extent of ICT use to evaluate team virtuality. We argue that team members can deal with the constraining objective features of ICTs through their interpretation and negotiation of the media used. Our results indicate that team members can develop a low level of virtuality while communicating exclusively through ICTs. Our results also show that low virtuality teams developed either high or moderate effectiveness whereas high virtuality teams achieved low or moderate effectiveness. Effective teams developed positive processes, attitudes and behaviours. However, high virtuality teams had lower member satisfaction and ineffective team processes. Our findings consequently enabled us to formulate relevant implications for the literature and management of virtual teams.

6.1 Research contributions

Theoretical contributions. Our main contribution is to go beyond the dichotomy between using more or less ICTs and its effect on virtuality. Instead, we put forward a conceptual framework to assess virtuality which takes into account the IT artefact used and the ability of users to adapt and reinvent the media. While researchers acknowledge the need to consider virtuality as a continuum (Kirkman et al. 2004; Fiol and O'Connor 2005), Lu et al. (2006) pointed out the lack of accurate measurement regarding team virtuality. To fill this gap, our study proposes an integrative conceptual framework to assess virtuality, enabling us to distinguish between technological and social virtuality. Based on our theoretical contributions, we distinguished three level of virtuality (high, moderate and low). Although we considered two dimensions of the virtuality concept, our conceptual framework is multidimensional as it includes several variables identified in virtual team literature. In this regard, the proposed approach constitutes a rich attempt to uncover all virtuality variables.

In addition, our research provides further insights into how team effectiveness varies depending on the level of virtuality, which few studies have explored to date (Chudoba et al. 2005, Gibson and Gibbs 2006). By providing an extended conceptualization of virtuality, on the one hand, and several measures of team effectiveness, on the other, our study constitutes, to our knowledge, a first attempt to integrate this large number of variables concerning both virtuality and effectiveness. We may conclude that high effectiveness is reached through either moderate or low virtual teams but never through high virtual teams.

Methodological contributions. Our methodological contributions concern two aspects. On the one hand, we conducted a longitudinal qualitative study which may be considered as an innovation in this field. The qualitative approach enabled us to achieve our exploratory purpose of analysing the recent concept of virtuality and to discover its effects on team effectiveness. The longitudinal approach enabled us to examine how virtual team dynamics and its members' perceptions evolve over time. At the same time, we adopted multiple data sources that enabled us to gather a large amount of information. We used e-mails, qualitative questionnaire and interviews to test our research propositions and to analyse virtuality and team effectiveness. We believe that this pluralist approach enriched our database and contributed to the validity of our results.

Managerial contributions. From a managerial point of view, our results focused on the role of ICTs in virtual teams. Virtual team managers have to pay particular attention to issues related to ICTs. As high effectiveness teams have low virtuality levels, managers have to ensure ICT availability and facilitate their access to team members. They also need to check that team members are using them effectively. These ICTs must also be compatible with the work to be done. It is not enough to provide team members with rich media; it is also important to ensure that this media provides high informational value for the work to hand and enhances performance.

In addition, as team virtuality is reduced through low technological and social virtuality, virtual team managers need to establish regular and frequent communication, constructive comments and feedback and a well-adapted ratio of social and task-related exchanges. This can be achieved through building communication norms and routines, encouraging team members to actively participate in the work to be done, and enhancing their knowledge of one another. These norms also have to be accepted and adopted by all the team members.

6.2 Limitations and future extensions

We also need to indicate some of the limitations related to this study. From a methodological point of view, we conducted a qualitative study with ten virtual teams, which is suitable for the exploratory purposes of our research. However, for future extensions, a study including a larger sample of virtual team members may contribute to validating and generalizing our virtuality evaluation results and its impact on team effectiveness.

In addition, some variables, which were not included in our study may very well be significant variables with regard to effectiveness. For example, cultural diversity may considerably influence performance outcomes, yet this was not analysed because of its irrelevance to our context. In addition, as our propositions were tested in an educational context, the results may differ in a professional context. Consequently, validation in a professional context is required if our results are to be generalized.

Regarding the virtuality and effectiveness variables analysed, only their single effects were taken into consideration. Thus, we did not consider the possible interactions between virtuality variables on the one hand (i.e. media combination and nature of communication) and effectiveness variables on the

other (i.e. participation and members' motivation). Future work may usefully include these possible links and how they shape team virtuality and effectiveness.

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