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COMMUNICATION CONTEXT-DEPENDENT TECHNOLOGY USE IN VIRTUAL TEAMS

Completed Research Paper

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Abstract

Global virtual teams (GVT) are increasingly using virtual workspace technology (VWT) which allow for multiple forms of interaction between team members. However, there is limited empirical and theoretical research on how the use of these technologies depends on the communication context of the teams. We extend recent theorizing about technology support for virtual communication to suggest that VWTs afford team members different forms of interaction. Further, we suggest that, to achieve better performance, teams choose interaction forms (using VWT) that match their communication context. More specifically, we propose that GVTs vary particularly along two dimensions of communication contexts: diversity and task innovativeness, and that VWTs can be used for two forms of interaction: virtual co-presence and knowledge evolution. We hypothesize that higher performing GVTs with high diversity use VWT for virtual co-presence and higher performing GVTs with high innovativeness of task use VWT for knowledge evolution. Data from 54 GVTs provide empirical support for our hypotheses.

Keywords: *Computer-mediated communication and collaboration, Virtual teams, IT and new organizational forms, Competitive impacts of IS, Questionnaire surveys.*

Introduction

Global virtual teams (GVTs) - workgroups of interdependent cross-organizational, cross-functional members drawn from different geographic regions and representing different nationalities that rarely meet face-to-face - are an increasingly popular organizational form for engaging diverse expertise without collocation (Majchrzak et al. 2005; Montoya et al. 2009). Simultaneously, in recent years, the virtual workspace technologies (VWTs) to support these teams are becoming increasingly sophisticated and widely available in commercial software applications (such as Microsoft Sharepoint and IBM Lotus products). Although the technology tools that are emerging are powerful and ubiquitous, leaders of virtual teams have expressed frustration at the lack of guidance about how to use these tools to support their performance (Malhotra and Majchrzak 2005). The research presented in this paper specifically seeks to address this practical problem – what forms of technology use are useful in which GVT contexts.

In the vast array of research on virtual teams (e.g., Cramton 2001; Cummings 2004; Dube and Robey 2009; Fuller et al. 2006/2007; Gibson and Gibbs 2006; Griffith and Neale 2001; Griffith et al. 2003, Hinds and Mortensen 2005; Jarvenpaa and Leidner 1999; Kanawattanchai and Yoo 2007; Kayworth and Leidner 2001/2002; Kirkman et al. 2004; Majchrzak et al. 2000; Malhotra et al. 2007; Massey et al. 2003; Montoya-Weiss et al. 2001; Paul 2006; Piccoli and Ives 2003; Robert Jr. et al. 2008; Rosen et al. 2007; Saunders et al. 2004; Townsend et al. 1998), there has been little theorizing and empirical research pertaining to how VWTs present alternative ways for team members to interact. Moreover, given the wide variety of contexts of GVTs, there is little theorizing and research about how these different contexts may create the need for team members to use the VWTs in different ways to achieve higher team performance

While some researchers have suggested the importance of synchronous and asynchronous support for virtual teams (Baker 2002; Greenberg and Roseman 2003; Heninger et al. 2006; Malhotra and Majchrzak 2004; Rutkowski et al. 2007), this research is often based on notions pertaining to less sophisticated VWTs, i.e., that the primary use of technology is exclusively for information exchange through email, telephone or videoconferencing (Hollingshead and McGrath 1993; Jarvenpaa et al. 1998; Schmidt et al., 2001). Other researchers have investigated the potency of technology support for virtual teams but have failed to take into account the "team context" in which communication and collaboration occurs, such as the type of task, composition of team, and other contextual factors (Dabbish and Kraut 2008; Hambley et al. 2007; Huang et al. 2003; Saunders and Ahuja 2006; Warkentin et al. 1997). Researchers have suggested looking at the fit between different types of technology used and the context of teams as the driver of team performance (Bradner et al. 2005; Kankanhalli et al. 2006/2007; Maruping and Agarwal 2004; Zigurs and Buckland 1998); however, research in this arena is still in its early stages.

In this paper, we build on recent theorizing about technology use by GVTS to suggest that VWTs support not simply information exchange but at least two forms of interactions: spontaneous communication and knowledge evolution. We propose that these two types of technology uses apply differently for different GVT contexts. We provide empirical support to show that team performance is higher when the GVT's use of technology matched to the GVT context.

Conceptual Development

Global virtual teams are internationally distributed groups of people representing different organizations and functions who are with an organizational mandate to make or implement decisions with international components and implications (Maznevksi and Chudoba 2000). They rarely meet in person, conducting almost all of their interaction and decision-making using communications technology (Majchrzak et al. 2005). Two aspects of a GVT's context that can hinder the ability of team members to communicate and collaborate, and consequently impact the performance of the team, are the team's diversity and the challenging nature of the task (Earley and Gibson 2002; Montoya et al. 2009; Harvey and Griffith 2007). Global virtual teams may be assigned a variety of tasks, from relatively mundane help-desk support to innovative new product development and process improvements. GVTs may also vary in the degree of structural, functional, and organizational diversity represented in the team (Kankanhalli et al 2006/2007). Below, we argue that these variations in GVTs create different interaction requirements for team members. These different requirements create need for different uses of the VWTs. If the teams are to perform well, we argue that the uses of the VWT match the interaction requirements.

Key Contexts of Global Virtual Teams

Virtual teams, regardless of context, suffer from misattributions and conflicts, due to the lack of physical cues, different physical contexts, and general lack of awareness of other's context (Bjorn and Ngwenyama 2009; Cramton 2001; Espinosa et al. 2007a; Hinds and Mortensen 2005; Wakefield et al. 2009). These differences make it difficult to develop a shared understanding (Espinosa et al. 2007b; Hinds and Bailey 2003). Moreover, the differences create the need for constant mutual adjustment, surfacing assumptions, disagreeing, and negotiating to evolve the shared knowledge and understanding, all while being physically separated (Kankanhalli 2006/2007; Vlaar et al. 2008). The lack of face-to-face opportunities for these teams places them at the extreme of *virtuality* (Griffith et al. 2003), creating an almost exclusive reliance on VWTs. Because each team member is physically located closer to his or her local constituency than to other team members, each member's knowledge is highly contextualized; as such, there is likely to be less shared contextual knowledge, less awareness of what is unique knowledge relevant to a problem and less ability to articulate aspects of localized work conditions (Sole and Edmondson 2002).

While research on virtual teams has focused on a number of variations between teams, in GVTs, many of these variations are reduced. GVTs generally do not vary on the dimension of virtuality and geographic dispersion as proposed by Griffith et al. (2003), given that they rarely meet face-to-face. GVTs generally do not vary on their electronic dependence (Gibson and Gibbs 2006) since they rely on a VWT to perform their work. GVTs generally do not vary on their interdependence since they are working on tasks that inherently require interdependence. However, there are two context conditions under which these teams do vary: diversity of team members (Cramton and Hinds 2005; Cummings and Haas 2008; Dongsong et al. 2007; Gibson and Gibbs 2006; Haas 2006; Hardin et al. 2007; Jarvenpaa and Leidner 1999; Kirkman et al. 2009; Maznevski and Chudoba 2000) and the innovative nature of the task, i.e. novelty or lack of clarity in the processes and/or outcomes (Gibson and Gibbs 2006; Majchrzak et al. 2005; Malhotra et al. 2000).

According to Kankanhalli et al. (2006/7), while there is a range of dimensions for assessing a team's diversity, two aspects of diversity that are particularly critical for understanding how GVTs perform are: functional diversity and social category (more specifically cultural) diversity. Functional diversity arises from the difference in expertise and experiences of team members that can be attributable to differences in organizational settings, previous work experiences, disciplinary training, functional orientation, industry focus, etc. (Bunderson and Sutcliffe 2002; Cronin and Weingart 2007). In contrast to functional diversity, cultural diversity is characterized by national and linguistic differences between team members. Cultural diversity may arise from differences in members' country of origin (i.e., nationality), and differences in time zones (Cummings 2004; Massey e al. 2003; Montoya-Weiss et al. 2001). GVTs are likely to vary in both functional and cultural diversity (Dube and Pare 2001, Majchrzak et al. 2005).

In addition to differences in functional and cultural diversity, GVTs will also vary in the type of tasks that they are assigned. One task type on which GVTs vary is whether the task is one that requires innovation or not. Innovation is defined as a process or solution to a problem that is novel for the organization and implementable (Amabile 1988). An example innovative task is the development of products, processes or services that are "new to the organization and to the relevant environment" (Knight 1967). A GVT with an innovative task, for example, may be required to formulate a new global strategic policy, a merger of two companies, evaluate the global potential value of a new technology for the firm, develop software in ways that require new processes and relationships with outsourcers, or develop new processes for global virtual teaming itself. In contrast, non-innovative GVTs may be asked to perform tasks that the organization has engaged in previously such as global help desk support or global enhancements to a pre-existing software product. We treat innovation as organization-dependent, e. g., a merger by a company that has rarely previously engaged in mergers is innovative for that company, while is non-innovative to a company that regularly acquires companies.

Context Driven Communication Processes in Global Virtual Teams

Media Synchronicity Theory (MST) is a theory of virtual communication performance (Dennis et al 2008). In MST, communication is the process in which participants engage in order to reach shared understanding. MST argues that communication performance requires two communication processes: *conveyance* and *convergence*. Conveyance communication processes involve the continuous stream and analysis of large amounts of diverse new information to enable the receiver to create and continually update a mental model of the situation. Individuals participating in conveyance processes engage in substantial information processing activities so that potentially large, diverse sets of information can be repeatedly exchanged in a variety of information formats. Individuals

participating in conveyance processes will often require time to analyze the information, make sense of it, and build their mental models.

Convergence communication processes, in contrast, are the "*discussion* of preprocessed information about each individual's interpretation of a situation, not the raw information itself" (Dennis et al. 2008 p.580). Convergence presupposes that individuals have different interpretations of a situation that are not well-understood by other members. Convergent communication occurs through rapid back and forth sharing of small amounts of information, eliciting rapid feedback to correct misunderstandings.

MST argues that most activities that individuals engage in, such as decision-making and negotiation, require both conveyance and convergence processes. However, the relative proportion of convergence and conveyance will vary, depending on what MST refers to as the *communication context*. MST offers a single dimension of communication context – degree of familiarity with the task, technology and other members. MST proposes that less familiar contexts require the participants to spend more time in convergence-oriented communication. This is because, while individuals in less familiar contexts will spend some time in conveyance processes to share ideas and experiences, the lack of a shared understanding about others' interpretations of information will cause the participants to spend a greater portion of their time in developing that understanding through a *convergence* process. In contrast, communication contexts that are more familiar to the participants allow the participants to spend less time communicating to converge because they already have a shared understanding of each other's interpretations. Therefore, team members can spend more time proportionately communicating to *convey* as they execute their tasks.

We propose a modification of MST by suggesting that, while degree of familiarity may be an important context dimension, when applied to GVTs, different context dimensions may create different communication needs. To summarize our arguments below, we suggest that, in teams with high cultural and functional diversity, members will engage in both convergence and conveyance, but do so in ways that require what Hinds and Mortensen (2005) refer to as spontaneous communication - an informal mode of interaction for understanding each others' activities and perspectives. In contrast, in teams with innovative tasks, members will engage in both convergence and conveyance, but do so in ways that require what we call "knowledge evolution capture". Evolution of knowledge is central to radically innovative task settings (Brusoni and Prencipe 2006). Knowledge evolution capture allows members to not only share their perspectives in more detail, but allows members to understand how their perspectives fit each others' to foster emergence of new perspectives.

Cultural differences in a GVT affect team members' perspectives, communication capabilities, cognitive schemas, preferences and attitudes about interpersonal leadership, definitions of time, and values (Hambrick et al. 1998; Saunders et al. 2004). Greater diversity creates different expectations for communication practices and decreased identification with the team, leading to the possibility of increased misunderstanding, and a reduced ability to reach agreement, make decisions and take action (Earley and Mosakowski 2000; Gibson and Gibbs 2006). Time zone differences create fewer overlapping hours and more coordination delays (Cummings 2004) creating the need for more careful temporal coordination requirements which can impact team performance (Montoya-Weiss et al. 2001). Therefore, a key challenge among team members is timely coordination of work style preferences and expectations. Hinds and Mortensen (2005) propose and find that culturally heterogeneous distributed teams in which members engage in spontaneous communication are better able to identify and quickly resolve conflicts. Spontaneous communication allows for enhanced awareness of each others' concerns, motives and progress.

GVTs engaged in innovation tasks face a different set of communication challenges than those created by diversity inherent in the team. Gibson and Gibbs (2006), in their review of research pertinent to innovative virtual teams, describe the challenges of communication associated with such teams. Team members must exchange "ever evolving" information relevant to each of them, and at the same time process the information to gain awareness of other members' task progress (especially how it relates to the overall objective of the team). Further, this complex information processing is a continual process of sharing evolving ideas, interactive idea modification, idea analysis, idea dissemination to local constituencies for feedback, and then reporting feedback from external constituencies to the team for further discussion. In virtual teams faced with an innovative task, there exists a potential of "discrepant events" (Majchrzak et al. 2000) as ideas diverge and expectations are not met, causing members to reconsider goals and their own technical assumptions as well as the assumptions of others. Further, unpredictability in evolution of perspectives – as different attempts at combining and recombining perspectives are tried - can be misinterpreted by the lack of nonverbal cues that aid improvisation and subtle control (Gibson and Gibbs 2006, Rico et al. 2008). The fluidity of the communication context then creates the need to keep each member updated as individuals' thoughts about the task evolve.

Given the differences in communication requirements for the two different contexts, the MST perspective of technologies supporting conveyance and convergence may need to be expanded to include use of technologies to

support spontaneous communication and knowledge evolution capture. Below, we elaborate on how these two forms of interactions in GVTs are supported by the use of virtual workspace technologies.

Use of Virtual Workspace Technology in GVTs

VWTs are portals that are assigned to a team with a range of functionalities (Malhotra and Majchrzak 2005). VWTs typically include the capability of being a repository for team documents, as well as a range of additional features, including notification alerts sent to the email when changes are made to the repository, electronic whiteboards, chat/instant messaging, the ability to simultaneously share software applications such as Excel or Computer-Aided Design tools, the ability to tag entries made to the repository for easy search and retrieval, and the ability to comment and amend others' documents (Greenberg and Roseman 2003).

In the above section, we have identified two forms of interaction that may be particularly needed for the different contexts that GVTs may face: spontaneous communication and knowledge evolution capture. Spontaneous communication involves a form of interaction in which members use the VWT to (relatively) instantaneously reach out to other team members to share their ideas. While many VWTs might be used as a repository, in which case members are not logged in all the time to the portal, other VWTs might have features that allow members to be notified instantly when changes are made to the portal in which case they can turn their attention to the portal. Moreover, with VWTs that have chat functionalities, members within the portal can instant message each other. Finally, when coupled with electronic whiteboards and application sharing, members can not only text each other, but also work on documents together in real-time. Technology use that can enhance interactivity and speed of interaction has been referred to as "virtual co-presence" (Ma and Agarwal 2007; Slater et al. 2000; Zhao 2003). In facilitating virtual co-presence, technology use "*produces a subjective feeling of being together with others in a virtual environment, i.e., the feeling that others can readily see and hear what each other is doing and looking at*" (Ma and Agarwal 2007, p. 48-49). Previous researchers have pointed out that functionality may not be indicative of how technology is actually used by GVTs (Majchrzak et al. 2005). Therefore, we focus on usage of the VWT to support virtual co-presence, regardless of the specific functionalities that made that usage possible.

In addition to virtual co-presence, VWTs can be used for what we call "knowledge evolution capture". Knowledge evolution capture allows team members to annotate each others' entries in the portal, annotations which can then be identified with the annotation's author to help team members see the evolving perspectives of other members as problem definitions and solution generation proceeds (Bieber et al. 2002). Knowledge evolution capture also involves members contributing early ideas that are relatively ill-formed so that others can see and comment on early ideas, as well as observe the trajectory of the individual as he or she progresses toward acceptance of a solution (Majchrzak et al. 2000). Knowledge evolution capture also involves allowing members to link their entries to other entries so that the logical chain of thought that the individual had in mind when posting that entries can be understood by others. Finally, use of VWTs for knowledge evolution capture involves opening multiple windows simultaneously so that different perspectives can be compared simultaneously to help members not only observe differences between members, but also changes in the members' thinking over time. For example, Majchrzak et al. (2000) demonstrated that a VWT that fostered knowledge evolution capture helped team members move toward a creative solution, as members commented on each others' entries in the portal, they observed new and unexpected similarities and differences.

VWT use types - virtual co-presence and knowledge evolution capture - are not entirely orthogonal to the traditional distinction between synchronous and asynchronous. Virtual co-presence is clearly more synchronous than knowledge evolution capture. However, in addition, another dimension differentiates the two ways in which GVTs use VWTs: how shared understanding is created. With virtual co-presence, shared understanding comes from the ability to be spontaneous when sharing with others. Thus, when using VWTs, spontaneous communication is not the same as having face-to-face meetings or teleconferences or video-conferences which are the typical media channel for synchronicity. Spontaneous communication using VWTs refers to the ability to engage other GVT members in quick feedback sessions, when and if the need arises, in an unplanned manner. Similarly, knowledge evolution capture is not simply asynchronous support – which often refers to time delays in interaction. With knowledge evolution capture, the time delay is not the critical element of interaction; rather it is the "*reviewability and revisability*" (Clark and Brennan 2000) of shared information in order to evolve collective knowledge to spur breakthroughs needed for innovation.

Below, in Figure 1 we depict how the two interactions forms that VWTs can be used for - virtual co-presence and knowledge evolution capture - reflect two dimensions of technology: communication temporality and the manner in which shared understanding is achieved.

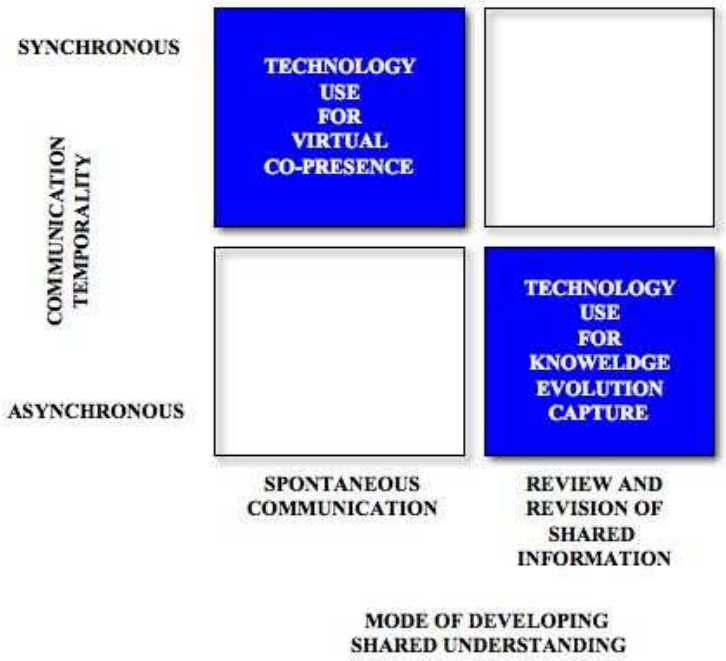

Figure 1: Archetypical Use of Virtual Workspace Technology

Hypotheses

In sum, we have argued that two contexts on which GVTs vary are team (functional and cultural) diversity and task innovativeness. Building on MST, we argue that contexts affect communication requirements which are met through technology usage. Additionally, extending beyond MST, we suggest that higher performing teams will adjust their use of technology to fit different context conditions. Therefore, we hypothesize:

H1: Highly diverse global virtual teams will perform better when they use virtual workspace technology to engender virtual co-presence.

H2: Global virtual teams with innovation as a task objective will perform better when they use virtual workspace technology for knowledge evolution capture.

In summary, our contribution from our theorizing is that virtual team performance will be related to the team's use of technology to match the teams' contextual needs. We expand MST to propose two different uses of virtual workspace technology – for virtual co-presence and for knowledge evolution capture. We also propose two aspects of communication contexts that apply to global virtual teams – team diversity and innovativeness of the team's objective. We suggest that virtual workspace use for virtual co-presence helps create a shared understanding in high diversity contexts by allowing for spontaneous communication. On the other hand, virtual workspace technology use for knowledge evolution highlights change of collective knowledge and emergence of new collective knowledge by allowing for reviewability and revisability.

Research Methodology

We collected data from three different data sources in 54 virtual teams. We obtained post-milestone team performance from the team clients who were not involved in the team's activities, VWT usage from team members, and team context information from the team leader. As such, our methodology reduced common method variance and ensured that we obtained responses from sources most knowledgeable about the measures being collected. We asked a set of questions to ensure that our sample met our criteria of a global virtual team: all teams included only members that were geographically dispersed (i.e., were located in different cities): on the average, members met in person less than 3% of their time together as a team, and on the average, members met in person less than 15% of their time with any other single member of the team. All the teams used a virtual workspace, plus email and telephone conferences as their method of coordination and communication. Our questions about technology usage are focused only on their use of their virtual workspace.

The 54 teams came from 33 companies in fifteen different industries (e.g., printing, financial services, health care, high-tech, automotive, chemical, consulting, consumer products, etc.) participated in this study[1]. Some teams came from multinational companies while other teams came from small firms. Example objectives of the teams included: new product development, developing new supplier networks, global demand and supply planning, developing new business processes, strategic planning, creation of new human resource policies, and developing new software applications based on a global platform customizable for local markets.

A total of 263 individuals completed a survey on virtual workspace usage (out of which 258 were usable responses), along with 54 team clients completing an interview on team performance and 54 team leaders completing an interview on team context. The team performance data was obtained from a short standardized interview with the internal clients of the team once the team completed its work.

Measures

The measures for the three sources of data are presented in Table 1 and briefly explained below.

Team Performance. Team performance was assessed using the Ancona and Caldwell (1992) measure. Executives to whom the team had recently delivered a milestone were asked to rate the team on a six-item scale. A composite reliability coefficient of .88 was obtained at the team level.

Innovative Objective of Virtual Team. We interviewed the team leaders and asked them to describe the objectives of the team. After obtaining a several sentence description of the objective, we asked the team leader a series of follow-up questions: has the company done something like this before? Does this objective require significant changes to existing work practices? Would you consider this objective to be innovative for the company, defined as a novel product or process? (based on the work by Amabile 1988). The authors then independently coded the verbatim comments of the team leader as indicating an innovative objective or a non-innovative objective. Differences in coding between the two raters were resolved through an iterative process.

Diversity. Both functional and cultural diversity were obtained from the team leader. For cultural diversity, we followed Cummings and Haas (2008), obtaining, data on crossing of nationality boundaries as well as crossing of time zones. In addition, Staples and Zhao (2006) suggest measuring culturally diverse teams based not only on differences in nationality, but differences in language. Therefore, we asked team leaders a third question about differences in language. Similar to the work of Haon et al. (2009) we measured functional diversity so as to capture differences in training, fields of expertise, functional departments and professional experiences. We asked the team leader if different functions were represented on the team, if different organizations were represented on the team, and if team members hailed from different companies. Our measure of diversity was a summation of these six items (three for cultural and three for functional diversity).

Technology Use for Knowledge Evolution Capture. Adapting elements from MST, our five-item measure asked team members to indicate the extent to which the virtual workspace technology used by the team supported their ability to review and revise the information posted to the repository. In particular, we asked about technology support for specific ways to revise and review, including making annotations, creating drafts that could be later modified, tracking changes, and linking entries. To ensure that we could aggregate to the team level, the James' index of inter-rater agreement was used (James 1982). Janz et al. (1997) suggested a median of .70 or above

[1] *The teams were obtained in three ways: 1) through a solicitation sponsored by the Society for Information Management to its members, 2) through a solicitation sent out by Groove Inc. to its customers, and 3) through a solicitation sent out by Netage to its 7000-member distribution list of individuals interested in virtual teams.*

as a guideline justifying aggregation of individual's responses into a group. The James index was found to be greater than .70 for the 5 items, indicating that the items could be aggregated to the team level.

Technology Use for Virtual Co-Presence. We adapted of the Slater et al.'s (2000) measure of virtual co-presence. Team members were asked the extent to which the virtual workspace technology they used helped them to feel as if they were present in the same location with other members, engage in synchronous interactions mirroring the way they would have interacted face-to-face, and easily call for impromptu communication between team members. The James index obtained for our sample was greater than .70 justifying aggregation of individual's responses into a group.

Control variable. We controlled for team familiarity because it has been argued that team familiarity influences information sharing in groups and group performance (Gruenfeld et al. 1996). It is possible that global virtual team members, even though are working virtually, may have worked with other on the team in the past, which can have an influence on team performance.

Table 1: Measures

RES-PONDENT	SCALE (and ITEMS)
Team Executive Sponsor	**TEAM PERFORMANCE** The questions that follow are related to your assessment of the distributed team that provided you with a recent deliverable. Please rate the success of this team in the following areas: 1. Efficiency 2. Adherence to budget 3. Quality of work 4. Work Excellence 5. Meeting or exceeding expectations 6. Doing superb work (Scale: 1 = Not at all successful; 5 = Extremely successful)
Team Members	**TECHNOLOGY USE FOR VIRTUAL CO-PRESENCE** The virtual workspace technology used by the team has enabled me to: 1.…feel as if I were present in the same location as the other members (even when I wasn't) 2.… engage in synchronous interactions with other team members mirroring the way I would have interacted if I were face-to-face 3,… easily call for impromptu communication between team members. (Scale: 1 = Strongly Disagree; 5 = Strongly Agree) **TECHNOLOGY USE FOR KNOWLEDGE EVOLUTION CAPTURE** The virtual workspace technology used by the team has enabled me to easily: 1.…make and save author-identified annotations on the knowledge in the team repository 2…contribute knowledge to the team repository in a draft-like form 3… keep track of the changes over time in any document in the repository 4… link different entries because they share a similar subject or purpose 5…compare different pieces of knowledge in the repository. (Scale: 1 = Strongly Disagree; 5 = Strongly Agree)
Team Leader	**INNOVATION OBJECTIVE OF THE VIRTUAL TEAM TASK (SCALE: No/Yes)** 1. Is your team characterized as 'operational' (defined as problem-solving tasks carried out repeatedly for customers such as customer support) or 'project' based (defined as "one-off" problems a team is attempting to solve such as a merger or a new product development)? 2. "Is the task being conducted by the team innovation oriented?" **EXTENT OF DIVERSITY IN THE VIRTUAL TEAM** On your team, are there members … (SCALE: No/Yes) 1. … from more than one national culture. 2. … who are geographically dispersed over three or more time zones. 3. … whose native language is different from majority of the team members. 4. … from more than one company. 5. … from more than one function. 6. …. from more than one organization in the same company. ***TEAM FAMILIARITY*** (Control Variable) How many members of this distributed team have you worked with on other teams in the past?

Results

We used Partial Least Squares (PLS Graph Version 3.0) to test our hypotheses. We followed Hulland's (1999) prescription for PLS analysis to assess the test for reliability of constructs used in the measurement model. The results of the assessment, along with all manifest variable means and standard deviations, are shown in Table 2. Individual item reliability was measured as the degree to which an item loaded on its intended construct (Hulland, 1999). All the items in our study loaded on their hypothesized constructs with loadings greater than 0.7 (Hulland, 1999).

The composite reliability of constructs was used as an indicator of internal consistency (Grey and Meister 2004, Werts et al. 1974). The results are all above the 0.7 threshold that is suggested by Nunnally and Bernstein (1994). Finally, AVE (average variance extracted) for each of the constructs exceeds the thresholds of 0.5, i.e. 50% of variance in indicators of a construct has been accounted for (Chin 1998).

The discriminant validity among the constructs in the model can be assessed by comparing the square root of average variance extracted (AVE) for each of the constructs with the inter-correlations between constructs (Hulland 1999). For our latent constructs, the square root of average variance extracted for each of the constructs is higher than the inter-correlations among constructs in the model.

Table 2: Correlations, Composite Reliabilities and Discriminant Validity

	Mean (S.D.)	Composite Reliability	1	2	3	4	5	6
1. Team Performance	3.98 (0.53)	0.88	0.74					
2. Tech. Use for Virtual Co-Presence	3.29 (0.66)	0.9	0.21	0.80				
3. Tech. Use for Knowledge Evolution Capture	3.46 (0.47)	0.8	0.19	0.53	0.77			
4. Innovation Objective of Team Task	-	-	-0.01	0.18	0.20	-		
5. Team Diversity	3.51 (1.71)	-	0.04	-0.11	0.12	-0.09	-	
6. Team Familiarity	2.24 (0.72)	-	0.15	0.06	0.25	-0.03	-0.09	-

The hypotheses predicted that interaction effects of context of virtual teams with technology support would affect performance, above and beyond any main effects. Therefore, first we ran a PLS model that only included main effects and control variable (Figure 2). Next, to investigate the interaction effect, we followed the suggestion of Goodhue et al. (2007) to use product of sums of constructs when using PLS when sample size is a concern for testing interaction effects. We then entered all 8 variables (4 main effects, 2 interaction effects, 1 control, 1 dependent variable) in the equation simultaneously. The results are shown in Figure 3. As can be seen, after controlling for team familiarity and main effects, the path coefficient between Team Performance and the interaction of Technology Use for Knowledge Evolution Capture with Innovation Objective of the Team ($\beta = .24$, $p < .05$) is positive and statistically significant. Additionally, the path coefficient between Team Performance and the interaction between Technology Use for Virtual Co-Presence and Diversity of the Team ($\beta = .29$, $p < .05$) is positive and statistically significant. Further, the difference in R^2 between the model with main effects only and the full model (including interaction terms) is .12. Together the two interaction terms explain 36% variance in performance of global virtual teams (i.e. $R^2 = .36$). Therefore, Hypotheses 1 and 2 were supported.

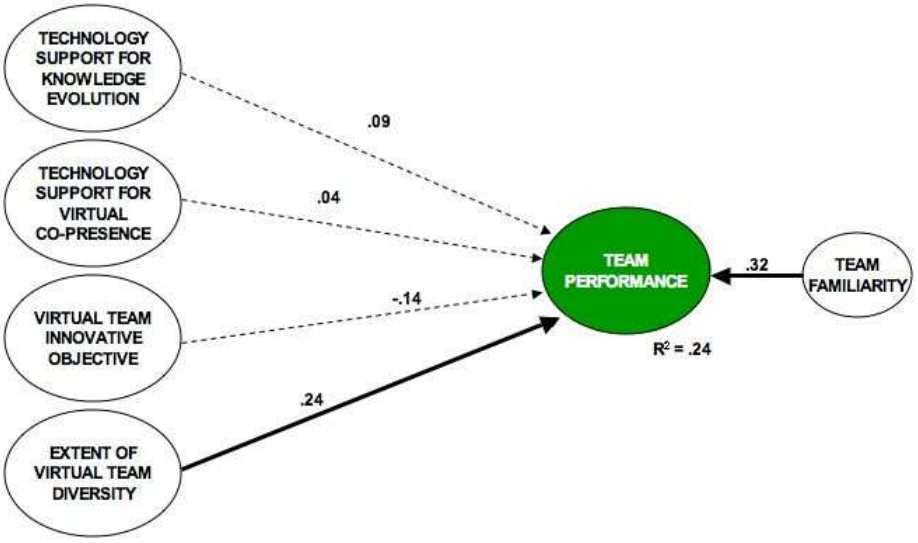

Figure 2: Model with Main Effects Only

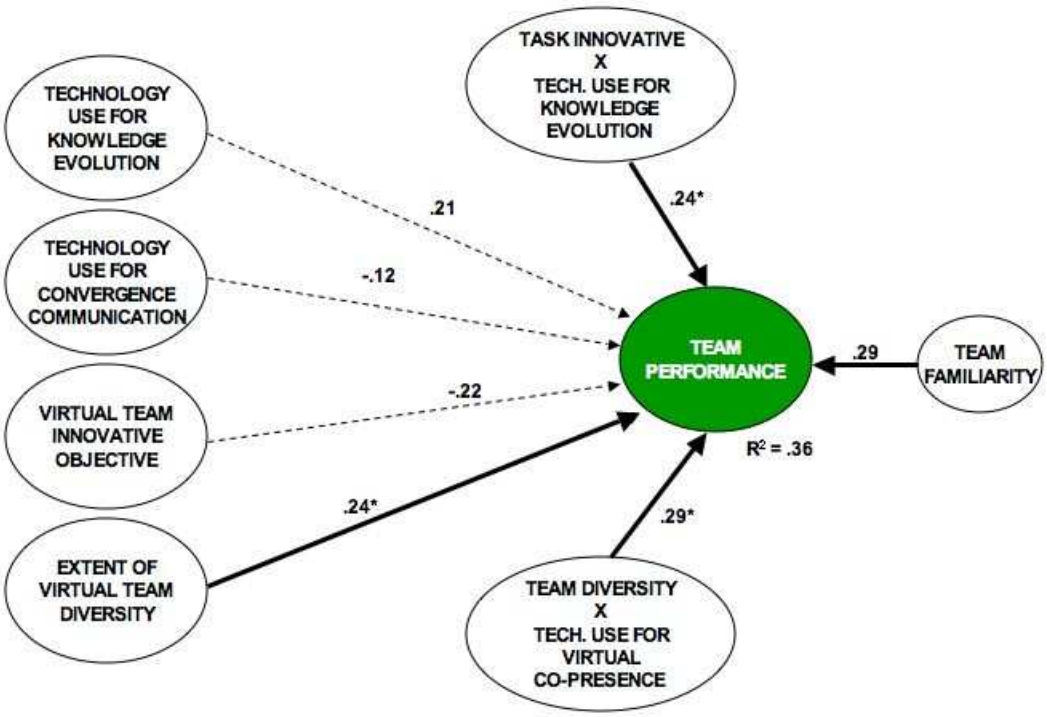

Figure 3: Full Model

In order to confirm the results obtained from PLS, we also conducted an OLS regression. The results from the regression are shown in Table 3. Once again, the two interaction terms were significant providing support for our fit hypotheses 1 and 2.

Table 3: OLS Regression Results

DV = Team Performance	
Control	
Team Familiarity	0.26
	(2.01)
Main Effects	
Team Diversity	-0.12
	(0.83)
Team Innovativeness Objective	-0.19
(1=Innovation, -1= Otherwise)	(1.47)
Tech. Support for Knowledge Evolution	0.31
	(1.63)
Tech. Support for Virtual Co-Presence	-0.12
	(0.65)
Interaction Effects	
Team Diversity	**0.34***
X Tech. Support for Virtual Co-Presence	(2.59)
Team Task (Innovation/Non-Innovation)	**0.29***
X Tech. Support for Knowledge Evolution Capture	(2.24)
R^2	0.31
F	2.96*

Discussion

Based on a multi-method research study of 54 virtual teams that rarely met face-to-face, we found that fit between communication context and type of use of virtual workspace technology impacts team performance. As hypothesized, global virtual teams tasked with innovation objectives performed better when they used technology for knowledge evolution capture. In addition, as predicted, global virtual teams that were highly diverse compared to those that were less diverse performed better when they used technology for engendering virtual co-presence.

There are many limitations of this study. Although our different sources of data helped to overcome common method variance bias, our technology support and context variables are based on a survey of teams at one point in time. Therefore, we are unable to explore a process view as to how the technology use unfolds over time differently. Another limitation is that recent research on global virtual teams is increasingly suggesting the need to examine multiple dimensions of diversity. For example, Chao and Moon (2005) call for research on a "mosaic" of cultures that include demographic, geographic, and associative variations brought to bear in a team. Although we followed existing convention by using a proxy measure of diversity (Gibson and Gibbs 2006), future research should consider more direct measures of the patterns of perceived shared meanings that constitute one's culture, as well as measures of the degree of dispersion in expertise and experiences.

Despite these limitations, we believe this study has several theoretical implications. First, this study found empirical support for the general MST proposition that technology support is related to high task performance moderated by communication context. In addition, we found support for important modifications to MST to account for the fit between different types of use of virtual workspace technologies and GVT context. Our findings differ from MST by suggesting that the different communication context dimensions (rather than a single familiarity dimension) pose different demands for virtual workspace technology use.

Our rationale for innovation objectives requiring technology use for knowledge evolution was unique to the nature of global interdependent virtual teams. Many corporate cross-functional teams tasked with innovation objectives collocate to brainstorm, obtain an agreement on the problem definition, and then develop an initial concept of a proposed solution. Global virtual teams, however, are appointed to engage in innovation without the

benefit of collocation. Corporations which choose to have this innovation done by virtual instead of face-to-face means do so for various reasons (Lipnack and Stamps 1997, Majchrzak et al. 2004). An underlying objective of companies deploying virtual teams is to keep the members physically located with their local constituencies, local analytic tools and local information sources so that decisions made by the team can be shared and analyzed and reflected upon by the individuals' tools, sources, and constituencies (Malhotra et al 2000). These reflections obtained for each individual member of the team are then shared with the other team members for further reflection and decision-making by the team. Thus, while virtual co-presence is clearly important for a virtual team to make clarifications and make accurate attributions to agree on and implement an innovative solution, knowledge evolution capture in such a dynamic context becomes particularly more salient. On the other hand, interacting team members may be less likely to experience the same need for knowledge evolution capture when individuals are not bound by a common innovation objective, are not cross-functional, and do not represent local constituencies in a dynamic and iterative idea generation, evaluation, refinement and implementation process. Thus, our findings of the contextual role of innovation objectives suggest a need to recognize that communication contexts in global virtual team settings may be different than communication contexts among electronically mediated non-team communicating partners. Developing theories of technology use uniquely suited to the virtual team context are needed. This research is a step in that direction.

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