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Abstract

This paper describes the concept of mutual knowledge and its potential impact on virtual team performance. Based on an analysis of extant literature, we argue that there is a gap in our understanding of what is known about mutual knowledge as it impacts team dynamics and virtual team performance. Supporting literature, anecdotes, and case studies are used to discuss the importance of mutual knowledge for virtual team performance and the research issues that need to be addressed in the future.

Introduction

Decision makers today are faced with exceedingly complex problems that generally require the collaborative efforts of individuals from many different areas of expertise. The challenges of teamwork and collaboration are further exacerbated by the increasingly dispersed nature of teams today, particularly in terms of geography, time, and culture. One approach to facilitating collaboration is the use of computer-mediated communication (CMC) technologies to support virtual teams. Virtual teams have been described as teams whose members are separated by time and space and who have been brought together to accomplish a goal by conducting communication predominately through technology (Lipnack and Stamps 1997, ibid. 7). Further, virtual team members interact through independent tasks guided by a common purpose.

The ability to effectively communicate and then share knowledge can become a daunting task in virtual settings because of the complex nature of both the virtual context and the technology used to support them. Developing a shared understanding is critical for ensuring that any semantic differences caused by the inherent characteristics of virtuality are minimized. Furthermore, given the enormous challenges of managing a virtual project, it becomes even more important that virtual team communications are noise-free or free of distraction. In view of this, some authors have argued that common knowledge or mutual knowledge is an important factor in engendering effective virtual team interactions and ultimately team performance (Tan et al 2000; Warkentin, Sayeed, and Hightower 1997). However, mutual knowledge researchers have debated the efficacy of mutual knowledge for the last three decades, particularly with regard to whether some form of mutual knowledge is necessary for effective communication (Brown 1995).

Based on an analysis of the mutual knowledge and virtual team literature, in our research we are interested in addressing the following question: *Can (Does) mutual knowledge among virtual team members improve the performance of the team?* Specifically in this paper, we explore this question by conducting a theoretical analysis, developing some initial propositions with evidentiary support in the form of anecdotal evidence and case study data.

The rest of the paper is organized as follows. In the next section, we discuss and analyze relevant literature relating to the effectiveness of mutual knowledge and its potential to impact virtual team performance. Subsequently, the next section proposes a

conceptual model of how mutual knowledge might impact virtual team performance. This is followed by the development of a set of propositions based on the model and we analyze these propositions using *a priori* literature, anecdotal evidence, and some qualitative case study data. The paper concludes with a summary and brief discussion of future research implications.

Background

Mutual knowledge has been described in many different ways in extant literature. For example, Clark (1992, 16) claims that "mutual knowledge is the same as shared knowledge." Additionally, Barr (2004, 939) claims that "common ground and common knowledge are both forms of mutual knowledge: knowledge that is shared and known to be shared." For the purpose of this paper, we will assume common ground, common knowledge, and shared knowledge to be equivalent descriptors of mutual knowledge.

Originally the term mutual knowledge was introduced by both Karttunen and Peters (1975) and Stalnaker (1978). Karttunen and Peters (1975, 13) introduced mutual knowledge with a description of group communication. They wrote:

> "Imagine a group of people engaged in an exchange of talk. At each point in their conversation there is a set of propositions that any participant is rationally justified in taking for granted, for example, by virtue of what has been said in the conversation up to that point, what all the participants are in a position to perceive as true, whatever else they mutually know, assume, and so on. This set of propositions is what we call the common ground or the common set of propositions."

A few years later, Stalnaker (1978, 321) used the term to describe speaker propositions.

> "Roughly speaking, the presuppositions of a speaker are the propositions whose truth he takes for granted as part of the background of the conversation. A proposition is presupposed if the speaker is disposed to act as if he assumes or believes that the proposition is true, and as if he assumes or believes that his audience assumes or believes that it is true as well. Presuppositions are what is taken by the speaker to be the common ground of the participants in the conversation, what is treated as their common knowledge or mutual knowledge. The propositions presupposed in the intended sense need not really be common or mutual knowledge; the speaker need not even believe them. He may presuppose any proposition that he finds convenient to assume for the purpose of the conversation, provided he is prepared to assume that his audience will assume it along with him."

More recently, Krauss and Fussell (1990) have defined mutual knowledge as "the knowledge that is shared and that is known to be shared."

Based on the previous definitions, we define mutual knowledge as *knowledge that communicating parties share and that each party knows that they both possess*.

Effectiveness of Mutual Knowledge in Group Communications

In research regarding group communication, Cramton (2001) argues that mutual knowledge is necessary for group communication. Based on her research, she reports

several reasons for a failure in communication due to a breakdown in mutual knowledge. These reasons include: 1) failure for one party to perceive the context and situation the other party had intended, 2) failure to distribute information to all team members, 3) failure in communication media, such as undelivered or undeliverable e-mail messages, 4) difficulty in communicating and understanding the salience of information, 5) time lag caused by access and transport speeds, and 6) misinterpretation of the meaning of silence. In conclusion, these breakdowns in mutual knowledge result in a number of communication problems. Specifically these problems can include poor decision quality (Dennis 1996) and extra time spent correcting failures of mutual knowledge (Krauss and Fussell 1990). The processes involved in the breakdown of mutual knowledge and its subsequent consequences studied by Cramton (2001) are shown in Figure 1.

Structural Factors:

Group structure, including geographic dispersion

Available communication media

Task Characteristics (interdependence, information load, time pressure)

Processes:

[2] Use of communication media

The mutual knowledge problem (points 1-5)

[3] Information exchange

[1] Degree of integration required

[5] Feedback

[4] Interpretation of message

Outcomes:

Viability

Performance

[7] Cohesion

[6] Casual attribution
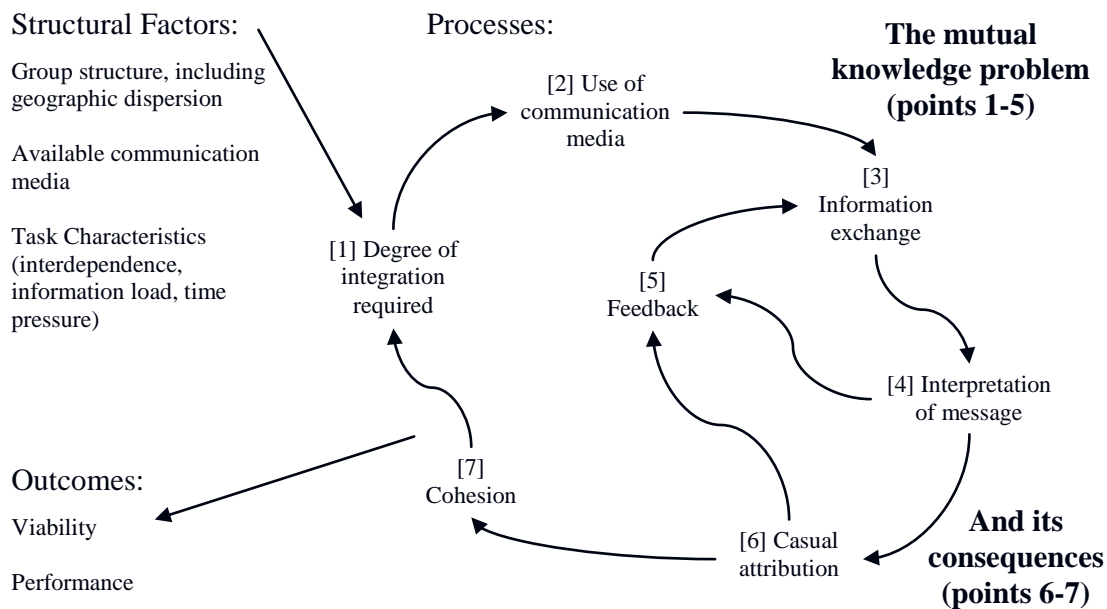
And its consequences (points 6-7)

Figure 1. The Mutual Knowledge Problem and its Consequences for Dispersed Collaboration (Excerpted from Cramton 2001)

In Figure 1 the first point shows the degree of integration required due to task requirements, context, and group composition. The characteristics of the available communication technologies and how the team decides to use them are shown at point 2. The actual exchange in information is shown at point 3 and then interpreted by the receiver at point 4. Also at point 4, tension can develop due to a breakdown of mutual knowledge. The result from this is either to request more information in the form of feedback (i.e. point 5) or to attribute the breakdown in communication to a particular cause such as failure in technology or the ineptitude of the sender (i.e., point 6). Regarding point 6, Cramton (2001, ibid. 362) asserts that "the available information and how it is processed affects attributions." Again at point 6, feedback (i.e. point 5) may be requested. The alternative is to set into motion the incoming group factors and outgoing group dynamics shown by point 7. The final outcome of this process will be reflected in the subsequent viability and performance of the group. It can also lead the group to re-address the structure of the group and use of communication media.

Based on our analysis of the literature regarding mutual knowledge it is clear that there are two opposing views regarding the efficacy of mutual knowledge in group communication. The first view is based on work of researchers who argue that mutual knowledge does affect group communication (Cramton 2001; Dennis 1996; Krauss and Fussell 1990; Frey and Sunwolf 2005), whereas, the second view is based on researchers who argue that mutual knowledge is not needed for effective communication (Oakhill and Garnham 1996; Barr 2004; Holgraves 2002; Sperber and Wilson 1986). Thus, for example, in contrast to Cramton's conclusion that mutual knowledge is necessary for communication, Oakhill and Garnham (1996, ibid. 37) contend that a lack of mutual knowledge is necessary for communication. In particular, they state that "it is a lack of mutual knowledge, and hence an asymmetry between speaker/writer and listener/reader, that typically prompts a linguistic interchange. Thus, both the speaker/writer's and the hearer/reader's knowledge (and their knowledge of each other's knowledge) determine how individuals ought to be described, and how descriptions will be understood." The authors imply here that mutual knowledge is not needed for effective communication; in fact in their opinion communication is increased when there is a lack of mutual knowledge.

Virtual Team Performance

In order to identify the current state of virtual team research, Powell, Piccoli, and Ives (2004) reviewed 43 papers regarding past virtual team research based on a life cycle model shown in Figure 2.
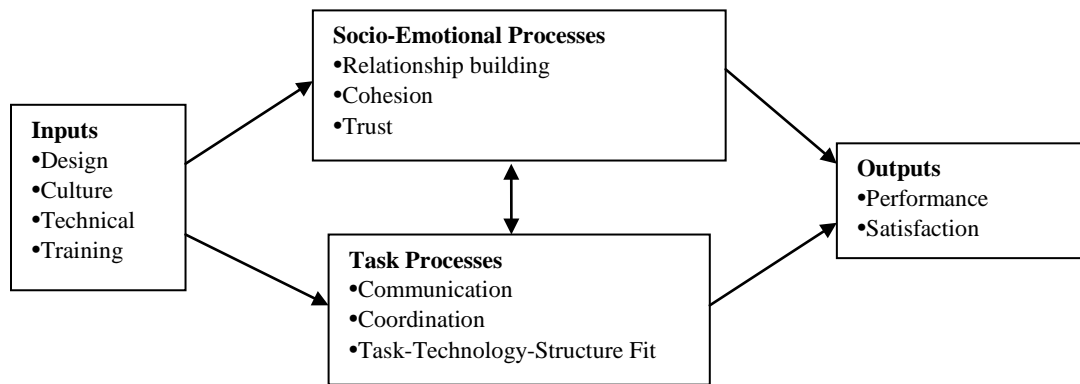

Figure 2. Focus of Early Virtual Team Research (Excerpted from Powell, Piccoli, and Ives 2004)

In Figure 2, according to Powell, Piccoli, and Ives (2004), the input category of the life cycle includes: 1) design, which refers to the identification of both strengths and weaknesses of team members as well as a shared understanding (or mutual knowledge) of the team task, 2) culture, which refers to the environmental influences each team member may have, 3) technical, which refers to the level of knowledge of the technology used by the team, and 4) training, which refers to the instruction that is provided in order to help the team members understand their virtual interactions. Next, the process category is broken into two sections; socio-emotional and task. Socio-emotional process refers to relations, trust and cohesion, which are necessary for the relationship building within virtual teams. Task process then refers to communication, coordination, and the task-

technology fit. Lastly, the output category refers to the team member satisfaction and overall performance.

It is apparent from the figure that communication is an element of the task process phase in virtual team interactions. Powell, Piccoli, and Ives (2004) go even further and argue that communication is at the core of any virtual team process. Khazanchi and Zigurs (2006, 19) agree, stating that "communication is fundamental to teamwork." They define communication as "the process by which people convey meaning to one another via some medium through which they exchange messages and information in order to carry out project activities." The researchers identify culture, trust, and leadership as the three main issues that affect virtual team projects. As a sub-level of trust, Khazanchi and Zigurs (2006) mention common ground, or mutual knowledge as an important component for building trust.

In their review of past research, both Powell, Piccoli, and Ives (2004) and Khazanchi and Zigurs (2006) cite a number of research studies that impress the importance of team member communication in the virtual context. For example, Suchan and Hayzak (2001) conducted an in-depth analysis of virtual teams in a large consulting firm. The teams developed knowledge repositories as a way to deal with the need for information sharing. The development of a common language for the repositories was a challenging database problem; but, via the process of resolving those issues, the teams ended up with a shared communication language. Their repositories became a common ground—a shared understanding of their domain. Similarly, in their research on quick-response teams, McKinney, Barker, Smith, and Davis (2004) found that even though team members were not geographically dispersed, that the members who do not know one another can get up to speed very quickly—a phenomenon that is common in virtual projects. Explicit sharing of communication values was the key factor in the success of these teams. These studies reinforce the idea that values have to be communicated and shared in order to build the common ground required for effective teams.

Balthazard, Potter, and Warren (2004) found that communication is one determinant of virtual team performance. Similarly, Hightower and Sayeed (1996), Tan et al. (2000), and Warkentin, Sayeed, and Hightower (1997) found evidence linking information exchange on a given task and shared norms/expectations of task processes with distributed team performance.

On the other hand, researchers have also found that virtual teams communicate less effectively than traditional teams (Burke and Chidambaram 1996; Galegher and Kraut 1994; McDonough, Kahn, and Barczak 2001) and face greater obstacles in conducting orderly and efficiently exchange information (Hightower, Sayeed, Warkentin, and McHaney 1997; McDonough, Kahn, and Barczak 2001). However, virtual teams have been shown to communicate more frequently than traditional teams (Eveland and Bikson 1988; Galegher and Kraut 1994). Other studies, such as that by Sarker, Sarker, Nicholson, and Joshi (2005, ibid 205), have found a correlation between the level of virtual team capability, credibility, communication volume, and culture of knowledge sharing. They argue that a virtual team member who is more communicative (i.e. has a high level of participation in chat sessions and posts a higher volume of text as e-mail or threaded messages visible to remote members) will end up transferring more knowledge to his or her virtual team members.

Mutual Knowledge and Virtual Team Performance

        To address our research question we propose that mutual knowledge can improve communication throughout the life cycle of virtual teams and moderate the relationship between virtual team inputs, processes (both socio-emotional and task), and outputs (as displayed in Figure 3).
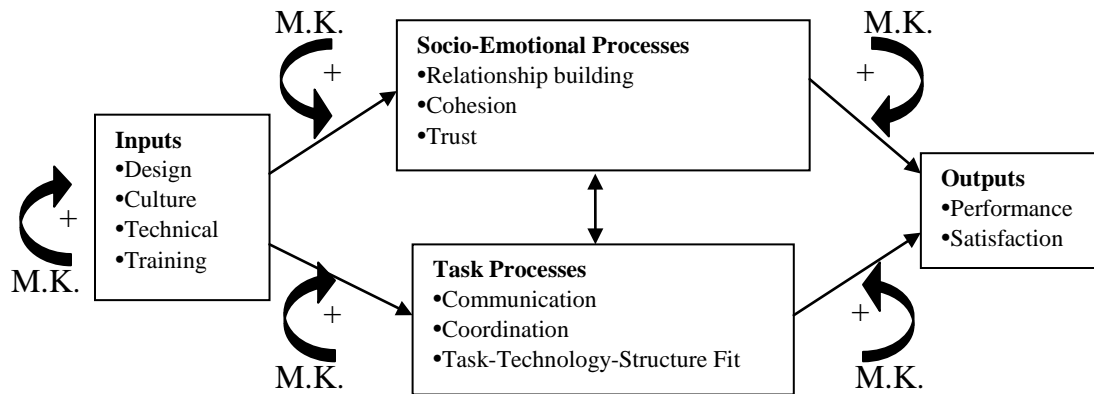

Figure 3. Mutual Knowledge and Virtual Team Performance (Modified from Powell, Piccoli, and Ives 2004)

Propositions

        Based upon Figure 3, we posit the following set of propositions. We evaluate and support the propositions by using anecdotal evidence from previous literature and case study data.

Proposition 1: Mutual knowledge positively affects virtual team inputs.
        1.1: Mutual knowledge benefits virtual team design.
        1.2: Mutual knowledge benefits virtual team culture.
        1.3: Mutual knowledge has an effect on the technical component of virtual team inputs.
        1.4: Mutual knowledge benefits virtual team training.

        This proposition suggests that mutual knowledge can benefit design, culture, technical, and training dimensions/constructs of virtual team inputs. For example, if the virtual team task is designed with each team member having mutual knowledge, the process of communication will improve in quality and this in turn will improve team performance. Virtual team project managers could establish mutual knowledge among team members through initial introduction and team building activities as well as giving members access to descriptive project documentation, which lists acronyms and other project specifics important for team members to understand. Also, it can be surmised from a priori literature that mutual knowledge breakdowns contribute to a lack of semantic fit in dispersed groups.
        The proposition is supported by studies, such as that by Cramton (2001), that have found that misunderstandings regarding the perceptions of context and salience of information are prime causes of breakdowns in mutual knowledge (Proposition 1.1).

Other studies, such as that by Sarker et al. (2005), have found a correlation between the level of cultural collectivism and knowledge sharing (Proposition 1.2). In other research (Beranek 2000) virtual team participants were given training about the importance of sharing information in order to gain trust among the group participants. It was found that the groups who did receive training developed higher levels of relational links and trust than teams not receiving training (Proposition 1.4).

The following anecdote from Jessup and Robey (2002, ibid 89) further illustrates the proposition that mutual knowledge can benefit design, culture, technical, and training dimensions/constructs of virtual team inputs. In their story, a team of rocket designers from different organizations used technology to coordinate their work. The team members insisted that all voice communications were logged into a discussion databases that could be accessed by portable notebooks. Ultimately, the requirement to write everything into textual databases placed too much pressure on the team members. Not only was the data entry difficult and time consuming, but team members were also unable to relay the complex rationales underlying their design recommendations. As a solution, the team introduced regularly scheduled telephone conferences to add verbal communication to the electronic text. This adjustment helped the team succeed in its design task. This example supports the importance of design, culture, technical, and training dimensions/constructs of virtual team inputs. Their anecdote suggests that virtual teams may need to employ older technologies (i.e. telephones, face-to-face meetings) to complement their dependence on computing technologies. An important point from this anecdote shows that problems occurred when the task was not designed with the right technology component and the right training and support (Proposition 1.1, Proposition 1.3, and Proposition 1.4). The team members were not able to have or share mutual knowledge because the original method and tool did not allow them to express the complex rationales underlying the design recommendations. Therefore, they had to switch to a new tool that did allow everyone to understand and communicate in the best way.

Proposition 2: Mutual knowledge positively affects virtual team socio-emotional processes.

2.1: Mutual knowledge increases virtual team relationship building.

2.2: Mutual knowledge increases virtual team cohesion.

2.3: Mutual knowledge increases virtual team trust.

This proposition and its sub-propositions are supported by previous research that has shown that it is difficult to assess trustworthiness among team members when they have never met one another (McDonough, Kahn, and Barczak 2001) (Proposition 2.1, Proposition 2.2, and Proposition 2.3). Lipnack and Stamps (1997) illustrate a similar form of trusting relationships in many of their anecdotes of effective virtual team work. One of their stories in particular discusses organizational members who did not want to rely on impersonalized trust in their team work, but personalized trust among team members. The team members used face-to-face relationships to establish personalized trust in their online interactions. One of the team members commented:

"to start establishing a [trust] relationship I think you do need to have the physical contact more because you have this indefinable thing about

relationships and body language and you don't get it in the same way… so as you do the team building you need to have some physical contact." Another member reported:

"we are having a global team meeting in two weeks time… the big joke is 'can't you do this virtually?' I say no we can't do it virtually, we can get so far virtually but until we have a real good drink and a good meal and a good social chat at length we are not going to be a 'real team.' We can then use technology to maintain it [relationship] and obviously it's going to slide."

These reflections illustrate that team members perceive trust based on abstract systems as not providing emotional satisfaction. Therefore, they sought to establish trust relationships through face-to-face encounters. For the most part, this story shows how important relationship building, cohesion, and trust in virtual teams can be (Proposition 2.1, Proposition 2.2, and Proposition 2.3). The team members need to have a mutual understanding that everyone is working towards the same goal.

Proposition 3: Mutual knowledge positively affects virtual team task processes.
    3.1: Mutual knowledge increases virtual team communication.
    3.2: Mutual knowledge increases virtual team coordination.
    3.3: Mutual knowledge positively affects the task-technology-structure fit.

This proposition addresses the question of whether mutual knowledge can improve communication. Despite the many challenges of achieving mutual knowledge, there is ample evidence from the virtual team and virtual projects literature to support the notion that mutual knowledge among virtual team members will lead to better communication and consequently enhance virtual team performance.

For example, Ocker (2005) found that a lack of shared understanding among virtual team members presents a significant inhibitor to the creative performance of virtual teams. Ocker (2005) concluded that the inability to reach a common conceptualization prevented any synergy to occur within the team and at some point the divergent concepts needed to converge (Proposition 3.2). In their research on global virtual teams, Qureshi, Liu, and Vogel (2006) concluded that it is important for geographically dispersed team members to have mutual knowledge for effective communication and to build shard understanding (Proposition 3.1). Similarly, Khazanchi and Zigurs (2006) assert that engendering shared understanding is a critical practice for effectively managing the complexity of highly dispersed virtual projects (Proposition 3.1).

Pinsonneault and Caya (2005, 11) suggest that virtual teams experience difficulties in communication and exchanging information and conclude that face-to-face teams have a higher perceived communication and effectiveness of information exchange (Proposition 3.1). They also conclude that "multiple communication media offer more opportunities for exchanging diverse types of information and appear to provide the necessary flexibility for dealing with the various information processing requirements that characterize the virtual work environment."

Additionally, we present below a compilation of raw data collected by one of the authors for a previous research study on virtual project management (Khazanchi and

Zigurs, 2006). In this study, a sample of participants from five global firms who had previous experience with virtual projects and/or were participating in or leading virtual projects were selected to participate in virtual focus groups collected over a week's period.

Some of the comments from the focus group participants highlight and provide supporting anecdotal evidence for our proposition (Proposition 3.1) that mutual knowledge increases virtual team communication (see Table 1).

Mutual Knowledge and Communication	*"I'm not sure of the intent idea #7. The fact that we work in teams would mean there will be sharing since not one single person can do it all. Obviously there needs to be trust developed in team members and this may be more of a challenge when working virtually. I would want some questioning of all information provided by any team member for the simple reason that it would help build understanding, and it would also help build relationships. I believe that ground rules of respect and courtesy would also be in order when forming teams."*
	"Is this formalized or ad hoc? How are problems / issues communicated to the entire team? Are problems/issues assigned in order to maximize effectiveness?"
	"During out communication between vendor, the Offsite person always assumes that we know all the information about the product and expects us to frame the correct question."
	"The project manager and the architecture working secretly and decides that the rest of the team members does not have to know about those architectural or crucial changes to the project immediately."
	"Lack of information sharing."
	"Created culture of willingness to share and to accept all information."
Mutual Knowledge and Coordination	*"Yup. Face-to-face or conference call discussions are necessary to decide the words we'll use for consensus statements. The written word (whether sent via mail or email is necessary for documenting the consensus."*
	"Use of diagrams and process flows to explain business processes to team members."
	"None of the members of my specific team have written any of the code we were testing. When certain issues arise, without contact with the development/architects the project could stall."
	"Associated with lack of consistent vision was having an understanding of what each step/activity was trying to achieve – knowing what we were trying to do for each activity/day would help focus efforts."
	"Lack of understanding common goals."
	"Misunderstanding of words and expressions."
Mutual Knowledge and Task Technology Fit	*"Use of on line sharing tools during conference calls (net meeting) to keep team engaged."*
	"There were situations where we probably should have used Webex or some other visual communication technology to share data/educate others on the team... "let them see what I see." We didn't use it at all, most likely due to inexperience with the available technologies."
	"Without using collaborative document tools, configuration management of documents was troublesome. Changes made to documents often passed each other in the mail so that we never knew what the "official" version was."
	"New technologies/tools. Learn as you go."

Table 1. Focus Group Comments (Excerpted from Khazanchi and Zigurs 2006)

The next group of comments from the focus group participants highlights and supports the proposition relating to mutual knowledge and coordination (Proposition 3.2) and how coordination is very important for virtual team work (see Table 1).

The final group of comments from the focus group participants highlights and supports the proposition relating to mutual knowledge and task-technology-structure fit (Proposition 3.3) and how task-technology-structure fit is very important for virtual team work (see Table 1).

Overall, a majority of the comments excerpted above in Table 1 suggest that information sharing and understanding is a central component to the success of a virtual team, which supports Proposition 3.

Proposition 4: Mutual knowledge leads to higher quality virtual team outputs.
>   *4.1:* Mutual knowledge leads to higher virtual team performance.
>   *4.2:* Mutual knowledge leads to higher virtual team satisfaction.

This proposition suggests that mutual knowledge can benefit virtual team outputs in terms of performance and satisfaction. Currently, there is some evidence to support this proposition and indicate that mutual knowledge can positively impact virtual team outputs. For example, Stasser and Stewart (1992) found that group decisions often reflect the common knowledge shared among the team members. This suggests that the greater the mutual knowledge within a team, the better the team performance and the quality of the final decision (Proposition 4.1). Furthermore, based on a study of four classes Beranek (2000) found that groups are more cohesive also tend to communicate more openly, exert more influences on members to conform to group norms, and display higher task satisfaction (Proposition 4.2). This is supported by the work of Hollenbeck, DeRue and Guzzo (2004) who present findings that face-to-face teams trained together, perform better than individual based learning. The researchers indicate that the shared understanding (mutual knowledge) of the task results in better performance (Proposition 4.1). Additionally, Nelson and Cooprider (1996) tested the relationship of mutual trust, influence, and shared knowledge with performance and a study of 86 IS departments. They found that shared knowledge mediates the relationship between performance, trust, and influence. They also found that by increasing the levels of shared knowledge between groups' leads to increased performance (Proposition 4.1).

Concluding Remarks and Implications

In this paper we have described the concept of mutual knowledge and its potential impact on virtual team processes and performance. Supporting literature and anecdotal evidence were used to substantiate propositions that suggest a relationship between mutual knowledge and virtual team performance. We believe that despite the challenges of achieving mutual knowledge and the variety of research issues addressed in the literature, it is apparent that our understanding of how mutual knowledge can impact virtual team processes and performance needs further investigation.

One of the most important implications for practice is the notion that virtual team project managers need to be aware of the importance and implications of sharing knowledge among their teams. This implies designing virtual team tasks in a way that enable each team member to have mutual knowledge. To reiterate an earlier statement, the enormous challenges of managing a virtual project make it even more important that virtual team communications are noise-free.

The results of our study open various avenues for future research and potentially to expand on this work. We expect to validate our theoretical propositions in the real-world context of organizations, probably with case studies, lab, and field experiments. Future research will need to address issues such as whether mutual knowledge can be enhanced over time and whether it is affected by the increasing familiarity between team members. In the same vein, the question of whether too much mutual knowledge can cause groupthink needs to be addressed. A key area of focus in our future research will be to try to develop an understanding of how or why mutual knowledge works in a virtual team setting. Finally, more research needs to be conducted on questions relating to the role that information technology plays in establishing and sustaining mutual knowledge in virtual teams as well as any cross-cultural and global implications related to mutual knowledge.

Notes

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