Virtual Workspace Technology Use and Knowledge-Sharing Effectiveness in Distributed Teams: The Influence of a Team's Transactive Memory

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Abstract

Firms are increasingly leveraging their globally distributed knowledge resources through deployment of distributed teams. Since face-to-face meetings are increasingly less common among distributed teams, team members are more frequently sharing their knowledge through the use of "virtual workspaces" – an integrated set of tools that offer a variety of communication support capabilities including a common team repository organized for easy search and retrieval, application sharing, electronic whiteboards and group discussion forums. Current literature suggests that group and contextual factors in general and a group's transactive memory in particular may shape how virtual workspaces are used to enhance the effectiveness of knowledge sharing within distributed teams. However, no empirical study has demonstrated the influence of transactive memory in shaping the relationship between virtual workspace usage and knowledge sharing effectiveness. Moreover, research on information technology support for distributed teams has not proposed theoretically-derived dimensions of communication support that can be provided by virtual workspaces. Based on common ground theory (Clark and Brennan 1991), we identify two dimensions of communication support required to create common ground among team members, as well as the role of transactive memory in influencing the value of each dimension in making knowledge sharing more effective. We studied 53 distributed teams and found that teams with low transactive memory reported higher satisfaction with the effectiveness of knowledge sharing in their teams when they used virtual workspace functionalities that facilitated multi-channel synchronous communication. Email and audio-conferencing were adequate for knowledge sharing in teams with highly developed transactive memory. For teams with moderate transactive memory, the two support dimensions appear to be complementary, such that using one dimension offers the same value as using both. Implications for theory and future research are discussed.

INTRODUCTION

Successful organizations treat knowledge as the key resource of production (Drucker 1992; Grant 1996; Nonaka & Teakeuchi 1995). However, the global marketplace has resulted in dispersed knowledge resources, requiring firms to develop the ability to identify, integrate, and deploy these knowledge resources without limits to geographical or organizational boundaries. In such environments, distributed teams (DTs) are deployed for knowledge sharing (Malhotra & Majchrzak 2004). DTs are defined as *groups of people who interact through interdependent tasks guided by common purpose, and work across space, time, and organizational boundaries primarily through electronic means* (Lipnack & Stamps 1997, Maznevski & Chudoba 2000).

As individuals work within a DT, they must be able to utilize others' knowledge as well as develop their own (Bhappu et al. 2001, Griffith et al. 2003, Raven 2003). The more effective the knowledge sharing in DTs, the better they are able to perform their tasks (Malhotra et al. 2001). We define knowledge sharing effectiveness (KSE) in DTs as member satisfaction with both the practices used by the members to share knowledge as well as the capacity of the members to absorb the shared knowledge. Effective knowledge sharing practices are needed to make the knowledge available between members (Beccera-Fernandez & Sabherwal 2001) while members' capacity to absorb knowledge is required for the knowledge to be understood, interpreted, and exploited (Griffith et al. 2003, Zahra & George 2002).

Knowledge sharing in DTs is difficult because members often do not have a common ground - the set of common beliefs and attitudes that guide the communication process (Clark 1985, Cramton 2001). Face-to-face interactions can assist in building such

common ground and alleviate factors that impede knowledge sharing (Maznevski & Chudoba 2000). However, increasingly, DTs do not have the luxury of meeting face-to-face, even for short periods of time, which increases their reliance on a variety of technologies, including email, audio-conferencing, and "virtual workspace" (Majchrzak et al. 2004). Virtual workspaces (an integrated set of tools that offer a variety of communication support capabilities including a well-organized and searchable common team repository and group discussion forums) provide historical referents, enhance situational awareness, and facilitate multi-channel interactions (e.g. Hinds & Bailey 2003, Greenberg & Roseman 2003, Malhotra et al. 2001).

The value of virtual workspaces for KSE in DTs has been under-researched (Hinds & Bailey 2003). Although studies exist on virtual workspaces such as Lotus Notes (e.g., DeSanctis & Jackson 1994, Montoya-Weiss et al 2001, Schultze & Vandenbosch 1998), these studies have not distinguished theoretically derived dimensions of technology support or examined the relationship between the use of these dimensions and KSE. These studies have also not considered the role of contextual factors such as a team's transactive memory - the shared memory structure that groups use to encode, store and retrieve the available knowledge in the team (Wegner 1987) - in influencing the relationship between the use of virtual workspaces and KSE. In sum, our study seeks to answer the following research questions:

> ***What is the relationship between a DT's knowledge sharing effectiveness and the team's use of virtual workspaces to support their communication needs? How is this relationship influenced by the teams' transactive memory?***

CONCEPTUAL DEVELOPMENT

In this section, we make two arguments: that virtual workspaces can be differentiated along two dimensions critical to facilitating KSE in DTs, and transactive memory shapes the relationship between the two technology dimensions and KSE.

Dimensions of Virtual Workspace Support for KSE in DTs

Communication between individuals requires 'common ground' (Clark 1985); all collective actions are built on common ground (Krauss & Fussell 1991). In DTs, lack of physical collocation, member diversity, and complex tasks with changing knowledge needs make grounding difficult (Clark & Brennan 1991, Cramton 2001, Malhotra et al. 2001).

Clark and Brennan (1991) argue that the key to the process of grounding communications is provision of immediate feedback, requests for clarification, positive acknowledgements, appropriate turn-taking, and continued attention. They further argue that media can constrain or enable grounding of communications in six ways: see and hear what others are doing and looking at (copresence), see other's reactions (visibility), take note of intonation in others' voices (audibility), receive others' utterances without delays (cotemporality), use multiple cues to simultaneously send and receive messages (simultaneity), and ensure utterances stay in intended sequence (sequentiality). Applying Clark and Brennan's theory to distributed groups, Kraut et al. (2002b), Hinds & Kiesler (1995), Greenberg & Roseman (2003) and Owens et al. (2000) suggest that virtual workspaces can support these six grounding needs by facilitating synchronous communication among all members, and promoting immediate clarification and intense back-and-forth interaction.

Email and audio-conferencing, support technologies that have received the most research attention in the extant literature on DTs, have been shown to provide only limited support for KSE (Hinds & Bailey 2003). Such technologies often fail to include all team members all the time, violating the precept of synchronicity among all members. Exclusion of even a few members within a DT yields an uneven distribution of information and the lack of sharing of unique information (Cramton 2001; Hinds & Bailey 2003). Moreover, grounding requires referential integrity, the mutual belief that the addressee has correctly identified the communicator's referent (Kraut et al. 2002b). When communicating using audio channels only, such as with audio-conferences, the speakers and listeners may not be using the same reference. Even asking all team members to look at the same document during the audio-conference may not ensure referential integrity with documents having multiple possible reference points. Thus, virtual workspaces can overcome these limitations by ensuring that everyone is involved in a discussion (through access to the same workspace) and referential integrity by providing additional channels that can be used synchronously to confirm references. For example, Walther (2002) suggests that instant messaging integrated into a workspace, when used in conjunction with other synchronous communication such as audio-conferencing, allows members clarification about references. Kraut et al. (2002a) argue that the provision of manipulatable visual displays (e.g. collaborative application sharing or electronic whiteboards) in a shared workspace allow partners to visually monitor the references made during synchronous discussions and to assess each other's comprehension in real-time. Therefore, these functionalities of a virtual workspace can make it easier to recognize when an individual is performing an incorrect action and

allow others to intervene with immediate actionable feedback.

Thus, we suggest that a first dimension supporting communication needs of distributed teams is multi-channel synchronous communication technology support, defined as *technology that enables intensive interaction, immediate clarification, and discussion amongst all team members at the same time.* Functionalities such as manipulatable visual displays - electronic whiteboards and synchronous application sharing - and instant messaging integrated into a shared workspace, in addition to audio-conferencing, are exemplars of this dimension. By enabling immediate clarification and the back-and-forth interaction needs of distributed teams, technology support for multi-channel synchronous communication helps members maintain their common ground and enhance their ability to effectively share knowledge. Since current theory refers only to the presence or absence of multi-channel synchronous technology support for common ground, rather than degree (e.g., Greenberg & Roseman 2003, Walther 2002), we treat this dimension as a dichotomous construct.

Clark and Brennan (1991) admit that synchronous communication alone does not solve all the difficulties associated with the grounding of communications. Grounding done exclusively through synchronous communication modes tends to fade quickly. It also fails to allow for revisabilty of utterances before the communication is sent and for later reviewability and revision of the utterance by either communicating parties or others who were not engaged in the communication. For DTs performing interdependent tasks, Kraut et al. (2002b) suggest that members particularly need the ability to review and revise utterances about the task. Task information can be more easily reviewed and revised when the information can be found in a centralized location accessible to all

members at any time, when the information includes not simply current but also historical team activities, when both detailed and summary information on team activities can be retrieved, and when there is some indication in this information of the progress of team activities over time (Dourish & Bellotti 1992). Others (Greenberg & Roseman 2003, Sproull & Kiesler 1991, Abbot & Sarin 1994) have similarly suggested the value of such virtual workspace functionalities for maintaining a common ground that are not provided by email and audio-conferencing alone. Kraut et al. (2002b) refer to these functionalities as offering support for persistent communication across time. Thus, we propose that a second dimension of virtual workspaces that support communication needs of distributed teams is persistent communication support, defined as *the support that allows members access to task information any time anywhere - information that includes current progress, past activities, and summary as well as detailed information.* Persistent communication support requires first that a team-based repository exists, and second that the repository is reviewability and revisable, such as through the use of keywords, link, threads, etc. (Bordetsky & Mark 2000). Keywords could be provided for easy search and keywords could be allowed to change over time. Links between entries and tools to visualize the patterns among links could be provided to promote an understanding of both summaries and details and changes that have transpired over time. Author-identified annotations could be provided so that individual contributions could be identified, reviewed, and revised if necessary. On-line schedulers can be included to allow quick review of a team's progress. Discussion threads with links to documents can be provided to allow for easily reviewing how the discussion has evolved. Since each of these functionalities has been promoted as increasing the ease of reviewability and revisability

(Bordetsky & Mark 2000), we treat the degree of persistent support by the virtual workspace as a continuum of the number of functionalities provided.

In sum, we agree with the current state of the literature on distributed teams that the common ground needed for KSE is not sufficiently facilitated by non-virtual workspace technologies such as audio-conferencing and email (e.g., Hinds & Bailey 2003). We disagree, though, with the current literature that argues that the limitations of audio-conferencing and email require that these technologies be supplemented with face-to-face meetings to share knowledge effectively (e.g., Maznevski & Chudoba 2000). Face-to-face meetings are increasingly less common among DTs (Majchrzak et al. 2004) and thus the face-to-face solution is not often feasible. Instead, we suggest that common ground and knowledge-sharing effectiveness can be enhanced in distributed teams that don't meet face-to-face when their use of audio-conferencing and email technologies is supplemented with virtual workspaces that support a) multi-channel synchronous and b) persistent communication. The two dimensions of virtual workspaces contribute to KSE differently: 1) support for multi-channel synchronous communication allows all-member synchronicity, immediate clarification with referential integrity, and intense back-and-forth discussions, while 2) support for persistent communication promotes reviewability and revisability of task information over space and time by providing information about past activities and current progress, easy retrieval of summary and detailed information, and access to information as needed. We believe that these two dimensions encompass the specific functionalities provided by a range of virtual workspaces being used by DTs currently. In theorizing the functionalities of workspace along these two dimensions, we have responded to Clark and Brennan's (1991) call to generate theory-based dimensions

that establish a framework for examining the impact of different media on communications.

The Influence of Team's Transactive Memory

Not all researchers of DTs have argued for the positive benefit of these virtual workspaces. Some have suggested that, despite the added functionalities provided by virtual workspaces, they will continue to have limited value unless supplemented with face-to-face interactions (Cramton 2001, Hinds & Bailey 2003, Maznevski & Chudoba 2000). It has also be argued that even though the use of the virtual workspaces will lead to sharing information equally among all DT members, exclusive reliance on these technologies can lead to misattributions and the sharing of less unique knowledge, resulting in unresolved conflict and lower KSE (Hinds & Bailey 2003).

One factor explaining why researchers differ on their assessment of the value of virtual workspaces for KSE may be the transactive memory of the team. Transactive memory (TM) is the group's memory of "who knows what" and leads to a clear division of labor which in turn enables group members to build expertise in their own areas while being aware of the expertise of others (Lewis 2003; Wegner 1987). A well-developed TM has been found to lead to a more efficient coordination of expertise in teams (Faraj & Sproull 2000).

Teams with well-developed TM are better able to locate and share their expertise more effectively than teams with less developed TM (Faraj & Sproull 2000, Hollingshead 1998a, 1998b, Lewis 2003, Moreland & Argote 2004), a finding empirically demonstrated for distributed teams as well (Yoo & Kanawattanchai 2001). Teams with well-developed TM have similar labels and categories for encoding and retrieving

information, as well as a recognized division of labor so no one individual needs to remember or understand everything the team does (Hollingshead 1998a).

While collocated teams are often able to develop a transactive memory through joint training (Moreland & Argote 2004), TM in DTs is difficult to develop and maintain (Griffith et al 2003; Lewis 2003). DTs are often not collocated at their onset for collective training (Malhotra et al. 2001; Majchrzak et al. 2004). DTs often experience changing membership and involve members who have no previous experience working together, factors found to harm TM development (Bresman & Kaeufer 2002, Hollingshead 1998a). When this lack of familiarity is combined with the lack of physical cues to counter-act generalizations and stereotypes, expertise of others on the team as it applies to the task at hand may be difficult to surmise (Walther 2002). In addition, DTs are often initiated in order to conceptualize problems in new ways and flexibly adjust to rapidly changing environmental conditions (Majchrzak et al. 2004), requiring frequent updating of the team's TM. Therefore, many DTs may not have a well-developed TM, which may in turn harm their knowledge sharing effectiveness

Griffith & Neale (2001) and Griffith et al. (2003) suggest that virtual workspaces may offer a dual-edged sword: they may help to compensate for gaps left when teams have an under-developed TM and they may enhance the capabilities for KSE in teams with well-developed TM. For teams with under-developed TM, virtual workspaces may help team members establish a common ground through all-member synchronous interactions and clarifications with referential integrity to ensure that labels are understood and expertise recognized. As such, support for multi-channel synchronous communication may allow teams with poorly developed TM to effectively share knowledge. While support for

persistent communication over time may also be helpful, the team's more pressing need to build a common ground (versus maintaining one over time) may make multi-channel synchronous support particularly useful for KSE in teams with poorly developed TM. Thus, although teams with poorly developed TM may have been shown in previous research to ineffectively share their knowledge, virtual workspaces that supports multi-channel synchronous communication may help to compensate for the gaps in the team's TM, helping the team to more effectively share member knowledge. Thus, we hypothesize:

> ***Hypothesis 1: In distributed teams with low transactive memory, knowledge sharing effectiveness will be positively related to use (vs. non-use) of virtual workspace tools that support for multi-channel synchronous communication.***

For teams with well-developed TM, Griffith & Neale (2001) argue that virtual workspaces can enhance an already well-functioning TM by providing support for persistent communication about changes in the task and individuals' contributions to the task over time, keeping expertise directories updated. By providing support so members can quickly identify changes in expertise over time, quickly review team progress, and easily find information about other members' contributions anytime, anyplace, teams with well-developed TM may be able to experience higher degrees of satisfaction with how knowledge is shared. While providing multi-channel synchronous support may also be helpful to such teams, Kraut et al. (2002b) suggest that visual feedback, such as that conveyed in synchronous application sharing and electronic whiteboards, may be less necessary and provide little new information when there is an efficient, pre-existing understanding of the expertise of other

members of the team, and non-workspace tools such as audio-conferencing and email are available. Thus, we hypothesize:

> ***Hypothesis 2: In distributed teams with high transactive memory, knowledge sharing effectiveness will be positively related to the degree of persistent communication support provided by the virtual workspace.***

We have hypothesized that synchronous support is more valuable to low TM teams while persistent support is more valuable to high TM teams. However, in the case of teams with moderate levels of TM development, the value of each of the two dimensions is not as clear. In such teams, members have some awareness of each other's expertise, but that awareness may be faulty or incomplete. With such teams, either persistent or synchronous support may be helpful for KSE, depending on the precise nature of the gap in the team's TM. Persistent communication support may be particularly helpful for those teams in which their moderate TM is due to frequently changing team membership or evolving tasks. This may be case because the support for persistent communication allows team to maintain a history of how expertise is evolving over time, which in turn helps to involve new members quickly and helps the entire team quickly reconfigure itself to meet the changing task demands. In contrast, multi-channel synchronous support may be particularly helpful for those teams in which their moderate TM is due to the need to share information that is so specific to context, domain, country, time or topic that it is easily misunderstood. In such situations, the referential integrity provided by multi-channel synchronous support may be more helpful. Following Kraut et al. (2002b) -- that providing support when support is not needed is unlikely to lead to new information -- it is unlikely that having support for communication needs that are already well served by the team's TM will help the team's KSE. Thus, a team with moderate TM that needs

support for persistent communication is unlikely to benefit when multi-channel synchronous support is provided, and visa versa, suggesting an interaction effect of the two technology dimensions on KSE in DTs with moderately developed TM:

> ***Hypothesis 3: In distributed teams with moderately developed transactive memory, knowledge sharing effectiveness will be related to the interaction between the degree of use of persistent communication support and use of synchronous communication support.***

In sum, we have proposed that a) virtual workspaces can be theoretically examined along two dimensions that support common ground: multi-channel synchronous communication support and persistent communication support; b) the usage of these two dimensions of technology support affect the satisfaction of members with the team's knowledge-sharing effectiveness; c) that TM influences the relationship between dimensions of technology support and KSE; and d) that the different dimensions affect KSE differently, depending on the team's TM. In the next section, we describe our research design and analysis strategy.

RESEARCH DESIGN

Sample Design

The study involved a cross-sectional survey of individuals working in 53 virtual DTs. We identified the DTs through solicitation by DT consultants, professional organizations, collaboration tool providers, and personal contacts. The solicitation promised a benchmarking report in exchange for participation.

The 53 DTs represented 33 companies across 15 industrial sectors (e.g., printing, financial services, health care, high-tech, automotive, chemical, consulting, consumer products, etc.). Example tasks that teams worked on included: new product development, new supplier network development, global demand and supply planning, new business

processes development, strategic planning, new human resource policies creation, and software applications development.

The 53 teams were generally global: 75% of the teams included members from more than one national culture, with 60% including members who were either at 3 or more time zones apart or had different native languages. 50% included members from more than one company. On average, the teams had been together 21 months. The average team size was 12 with a range from 3 to 50. 31 of the 53 teams were innovation-oriented, with the remaining teams operational or project-based. 33 of the 53 teams were ad-hoc, with the remaining ongoing teams. Our sample consisted exclusively of what Griffith and Neale (2001) refer to as "purely virtual" teams - teams that did their work exclusively through mediated electronic tools.

Data collection involved one-hour phone interviews with the leaders of each of the 53 teams and a web-based survey with the 263 individuals involved in the teams. For smaller teams (6-10 members), all members of the team filled out the survey. For larger teams (>10 member), on average, we received responses from 50% of the team members. The team leader was asked to encourage team members to complete the 35-minute online survey. Team members received a summary report that compared their team (aggregated across the team members) to the aggregate statistics of all teams in our sample. During the interview with the team leader, we confirmed that all the teams used audio-conferencing and email on a regular basis, in addition to the workspace functionalities, and rarely met face-to-face (if at all).

Measures

Knowledge Sharing Effectiveness (KSE). As defined earlier, KSE is the satisfaction of DT members with both the knowledge-sharing practices of the team and the ability of other members to absorb the shared knowledge. To measure satisfaction with knowledge-sharing practices, we used an 8-item scale: "In terms of knowledge-sharing practices of my team, I am satisfied with 1) the knowledge that is available to me from other members to help me perform my activities, 2) with the way the knowledge is managed within the team, 3) the degree of knowledge-sharing among team members, [and] 4) the knowledge that team members are able to provide from their external contacts." and "I am satisfied that the team members in my team 5) clearly understand the processes used to accomplish the team's activities, 6) have enough technical competence to understand and use the knowledge shared by the team, 7) have enough competence in knowing how the organization works to understand and use the knowledge shared by the team, [and] 8) are generally able to exploit new knowledge created within the team." The first four items were adapted to the DT context from the Beccera-Fernandez and Sabherwal (2001) scale measuring satisfaction with knowledge sharing practices of organizations. The remaining four items measured the ability of the DT members to absorb the shared knowledge and were adapted for the DT context from Szulanski's (2001) measure of absorptive capacity, as recommended by Griffith et al. (2003).

A confirmatory factor analysis of the eight items indicated that they constituted a single factor (Fit Indices > .95). A reliability coefficient of .88 was obtained at the individual level. To ensure that we could aggregate to the team level, the James' index of inter-rater agreement was used (James et al. 1984). Janz et al. (1997) suggested a median

of .70 or above as a guideline justifying aggregation of individual's responses into a group. We obtained an inter-rater agreement with a median of .89. Upon aggregation, we validated the measure by correlating it with team performance. Team performance was measured by asking executives to whom each team reported (not team leaders) to complete a performance assessment scale developed by Ancona and Caldwell (1992). The correlation between our 8-item KSE measure and team performance was significant ($p < .05$) indicating that KSE, as we measured it, is related to an external managers' view of the team's performance.

Virtual Workspace Support. Our development of the two dimensions of virtual workspaces was grounded in an initial set of functionalities associated with each dimension: 1) multi-channel synchronous communication support included electronic whiteboards, synchronous application sharing, and instant messaging and 2) persistent communication support included indexing, version history, links, keyword searching, annotations, and status/progress indicators to organize and retrieve task information. We expanded on this initial list by examining and including functionalities used by the major workspace platform providers (Groove, Eroom, Livelink, Webex, Lotus Notes, and netMeeting). We then identified an expert panel of 16 practitioners using or selling workspace technologies and researchers studying workspace technologies. We asked the expert panelists to confirm that our list comprehensively described workspace technology functionalities. This yielded a list of 21 functionalities across the two dimensions.

To confirm that our list of functionalities corresponded to our two theoretical dimensions of multi-channel synchronous and persistent communication support, we asked the expert panelists to assess (on a 7-point scale) the extent to which each of the 21

functionalities enabled each of the seven communication needs (the three synchronous communication needs – immediate clarification, intense interaction, and all-member synchronous discussion; and the four persistent communication needs – information about past activities, easy retrieval, access to information, and progress over time). The panelists' assessment (shown in Appendix A) confirmed that the three functionalities of instant messaging, electronic whiteboard, and synchronous application sharing offer support for synchronous communication needs, while the remaining 18 functionalities provide support for persistent communication needs.

We then presented the list of 21 workspace functionalities to the team leaders and asked each, in an hour-long interview, to answer the question: "which of these functionalities is your team using to support your work processes". We asked the question in this way because we wanted to identify functionalities that the team relied on for their work, not extraneous functionalities tangential to the team's work. Team leaders were asked, instead of individual team members, because the team leaders were responsible for selecting the workspace technologies used by the team and ensuring that the functionalities were used by the team (i.e., team leaders confirmed during the interviews that they either organized the repositories or allocated responsibility for organization, ensured that the tools were made available to the team, trained team members in their use or allocated responsibility for training, and opened and closed discussion threads). In addition, in the hour-long interview, we were able to ensure that the respondent understood each functionality in the context of the IT platform they were using, a process that could not ensue with 293 individual team members. Table 1 presents

the list of functionalities and the number of teams using each, divided into those supporting each dimension.

Table 1: List of Workspace Tools and Number of Teams Using Each Tool

Workspace Tool	**No. Using (Max = 53)**
Functionalities for Multi-Channel Synchronous Communication Support	
1. Instant messaging (without file sharing)	25
2. Electronic whiteboard capabilities	23
3. Synchronous application sharing between team members	24
Functionalities for Persistent Communication Support	
4. Automatic notification to team members of any need addition to team repository	18
5. Threaded discussion database	21
6. Team's knowledge repository integrated with corporate databases	18
7. Intelligent search (key-word, context-sensitive search) capabilities for team repository	20
8. Online (electronic) team virtual meeting scheduler	35
9. Online (electronic) capture of team's progress towards milestone	33
10. Field identifying authorship of all entries in team repository	39
11. Electronic annotation capabilities for entries in team repository	30
12. Identification of authors of electronic annotations made on entries in team repository	28
13. Visualization tools (e.g., hyperbolic trees) to exhibit links between entries in repository	3
14. Links associated with entries categorized by types (e.g., antecedent, analogous)	10
15. Entries have subjects, keywords, and dates fields to make them searchable	24
16. View multiple entries simultaneously on screen for comparison and contrast	20
17. Team repository query for patterns via fused, indexed, & summarized multimedia data	7
18. Automatically generated revision history for all revisions made to entries in repository	22
19. Easy changing of keywords (& other important identifier fields) associated with entries	18
20. Automatic suggestion of keywords for entries being made to team repository	6
21. Text mining tools to identify related concepts across entries in the team repository	4

As called for in our hypotheses, multi-channel synchronous communication support was computed as a dichotomous variable with 36 teams having any of the 3 synchronous functionalities. Calculating the index in this fashion assumes that the three functionalities provide equivalent and overlapping support for synchronous communication needs such that the use of each functionality does not necessarily increase the level of synchronous communication support. In contrast, degree of persistent support was measured as a count of the number of persistent support functionalities used, embedding the assumption that each functionality offers additional support not provided by other functionalities associated with persistent communication. The expert panel ratings (Appendix A)

provided some evidence for these assumptions: there was significant variation across the 18 persistent functionalities in the rated level of support each provided the four persistent communication needs. On the other hand, the three synchronous functionalities contributed about equally to all three synchronous communication needs. This suggests that, as theoretically argued, each persistent functionality made a separate contribution to facilitating communication, thus warranting a count, while synchronous functionalities could be treated dichotomously (use of one or more of the functionalities is counted as supporting synchronous communication).

TM Development. The level of TM development was measured using the Faraj and Sproull (2000) measure of the degree to which members know how knowledge is distributed among the members. As recently reviewed by Lewis (2003), the Faraj and Sproull operationalization is consistent with the idea that TM develops from an understanding of what another person knows. Moreover, Lewis argues that the scale measures manifestation of TM in a task-independent form, a form that may be the most feasible way to measure TM "in the field". The scale used 5-point Likert responses of extent of disagreement/agreement to the following statements: "Team members in my distributed team: 1) have a good "map" of each team member's talents and skills; 2) work on tasks appropriate with their task-relevant knowledge and skills, 3) know their own skills and how they relate to the team's work, [and] 4) know who on the team has specialized skills and knowledge that is relevant to the teams' work". A reliability coefficient of .79 was obtained at the individual level. To ensure that we could aggregate to the team level, the James' index of inter-rater agreement yielded a median of .93,

which is above the guideline (.70) justifying aggregation of individuals' responses into a group score.

Control Variables. We included two control variables in our analysis: team size and heterogeneity of the team. We controlled for team size, following other large-sample studies on individuals in virtual teams (Cummings 2004; Jarvenpaa & Leidner 1999). Group size has the potential to affect the ability of group members to recognize members' expertise (Littlepage & Silbiger 1992). It has been argued that although individuals in larger groups have access to a larger pool of cognitive or experiential resources (Bunderson 2003), larger groups become increasingly less able to draw on these resources as size increases beyond a certain level (Steiner 1972). This may be the case because members of larger groups feel that they lack effective communication mechanisms (Slater 1958, Zenger & Lawrence 1989). Team size, obtained from the team leader, varied from 6 to 50 members (with a median of 10 and mean of 13).

Heterogeneity was included as a control variable because previous research on DT and transactive memory have suggested that heterogeneity will affect the ability of a DT to develop, maintain, and effectively use its transactive memory (Griffith & Neale 2001). To measure heterogeneity, we gave each team leader the list of boundaries developed by Duarte and Snyder (1999) and asked them to indicate which boundaries were crossed. The number of teams (out of 53) crossing each boundary is shown in Table 2.

Table 2: Boundaries Crossed by Teams

Boundary	# of teams
Members from more than one company	26
Members from more than one organization within the same company	24
Members from more than one function	31
Members that transition on and off the team as needed	24
Members from more than one national culture	41
Members that are geographically distributed over three or more time zones	35
Members whose native language is different from majority of the team	33
Members from more than one management level	41

Analysis Strategy

The three hypotheses suggested an interaction effect of TM and use of the two dimensions of virtual workspaces on KSE. Thus, we conducted a single hierarchical moderated regression. Hypothesis 3 proposed that KSE is affected by the interaction of the two dimensions of technology specifically for teams with moderate TM. Therefore, a test of the interaction effect for all 3 hypotheses required that a three-way interaction of TM and the two technology dimensions be significant.

We followed suggestions by Aiken and West (1991) for conducting the hierarchical moderated regression: 1) the two controls were entered in the first step, 2) the three independent variables - TM, Synchronous support, and Persistent support – were entered in the second step, 3) the two 2-way interaction effects of TM by each technology dimension, and the 2-way interaction among the two technology dimensions were entered in the third step as controls for the 3-way interaction, and 4) the predicted 3-way interaction effect among all three independent variables was entered in the fourth step. Interaction effects were computed by first centering the variables. Following Care and Russell (2003), indication of a significant interaction effect should be determined based on both a significant beta coefficient as well as a significant change in R^2.

The correlations among the nine predictor variables and the dependent variable of KSE are shown in Table 3. The high correlation between KSE and TM (before subgroups of TM were created) is consistent with the literature that has shown that TM development is related to knowledge sharing (Yoo & Kanawattanchai 2001). Nevertheless, it was important to ascertain the discriminant validity between the two constructs of TM and KSE. Following Sirdeshmukh et al. (2002), we ran two models

using AMOS 4.0: in model 1, we let the correlation between the two constructs be a free parameter to be estimated, while in Model 2, we constrained the correlation between the two constructs to be 1, i.e. perfectly correlated. The statistics associated with Model 1 ($\chi 2$=175.09, $p < 0.001$, NNFI = 0.90, CFI = 0.91) were significantly better than the ones for Model 2 ($\chi 2$=261.88, $p < 0.001$, NNFI = 0.81, CFI = 0.85). The difference in $\chi 2$ between the two models was statistically significant ($p < 0.05$) supporting the discriminant validity between the two constructs.

Table 3: Correlations Table

	KSE	SIZE	HET	TM	PS	SYN	PS X TM	SYN X PS	SYN X TM
Dependent Variable									
Knowledge-sharing effectiveness (KSE)	1.0								
Control Variables									
Team size (SIZE)	-.02	1.0							
Team Heterogeneity (HET)	.03	.31*	1.0						
Independent Variables									
TM Development (TM)	.72**	-.15	.-.10	1.0					
Persistent Support (PS)	0	.23*	.32*	-.10	1.0				
Synchronous Support (SYN)	.13	.15	.17	-.05	.54**	1.0			
Interaction Effects									
PS X TM	.04	.07	-.04	-.04	-.09	0	1.0		
SYN X PS	-.21	.07	.08	0	-.04	-.47**	-.10	1.0	
SYN X TM	-.28*	.17	.07	-.45**	.06	.04	.65**	.03	1.0
SYN X PS X TM	.55**	-.07	-.13	.47**	-.19	.03	.23*	.02	-.10

*: p<.05; **: p<.001

If the 3-way interaction effect is found to be significant, Aiken and West (1991) suggest that the full-sample moderated regression be supplemented with separate analyses at each level of the moderator (in our case, three levels of TM development). We followed their guidelines of subdividing the sample into thirds based on equal standard deviation splits (yielding 17 low teams, 20 moderate teams, and 16 high teams) and then conducting individual regressions to determine if the slopes for the simple regression lines for each subgroup differed significantly from 0 in the hypothesized direction. Due to the small sample sizes for each of the TM level groups, we only

included the two technology variables (synchronous and persistent support) and their interaction when conducting the sub-group regression analysis (Jaccard et al 1990). Finally, Carte and Russell (2003) suggest that quantitative analysis of moderation effects alone are rarely insightful: "Insight into underlying processes behind moderation is most likely to result from qualitative research efforts aimed at adding meaning to abstract relationships found in quantitative research" (p. 481). Therefore, we provide some illustrative comments from team leaders to add meaning to the abstract relationships found in the regressions.

FINDINGS

Full-Sample Moderated Regression Results

The results of the moderated regression on the entire sample are shown in Table 4. The results indicate that neither of the control variables entered in Step 1 are significantly related to KSE. Also, as expected, neither of the two virtual workspace dimensions entered in at Step 2 was significant. In Step 3, the direct moderation effect of TM on the relationship of each technology dimension to KSE was assessed and found not to be significant, thus ruling out simple 2-way interaction effects. Finally, the moderation effect of TM on the relationship of both technology dimensions considered together was entered at Step 4 and found to be significant. As hypothesized, TM has a significant moderation effect on the relationship between use of virtual workspaces and KSE, based both on the significant 3-way interaction effect and a significant change in R^2.

Table 4: Regression on Knowledge Sharing Effectiveness for Full Sample

Dependent Variable: Knowledge Sharing Effectiveness	**Model 1** β	**Model 2** β	**Model 3** β	**Model 4** β
Control Variables				
Team Size (Size)	-.03	.06	.07	.07
Team Heterogeneity (Heter)	.04	.08	.09	.11
Independent Variables				
TM Development (TM)		.74***	.77***	.64***
Persistent Support (PS)		-.06	-.01	.07
Synchronous Support (SYN)		.18	.05	-.03
2-way Interactions				
PS X TM			.01	-.09
SYN X PS			-.20	-.26*
SYN X TM			.04	.08
3-way Interaction				
SYN X PS X TM				.31**
Adjusted R^2	-.04	.52	.52	.59
F	.03	12.17***	8.10***	9.22***
$F(\Delta R^2)$		20.24***	1.1	7.94**

***p <. 001 **p < .01 *p<.05

To rule out alternative plausible interpretations for the results, we examined whether teams with varying levels of TM had different levels of workspace support. We found that they did not, nor did they have different degrees of face-to-face time. We looked for differences in the control variables of size and heterogeneity across the three groups and found no differences. We also measured familiarity with other members on the team and aggregated that to the team level. The aggregated measure did not show significant correlation with TM (r=.06). The measure was also not significant when used as a control variable in regression analyses. In addition, we also explored differences across the three groups in terms of complexity of task being performed using the three-item scale developed by Goodhue & Thompson (1995). We found no statistical differences across the groups, nor was this measure a significant control variable in regression analyses.

Sub-Sample Analyses

Table 5 shows the results of the regressions for teams at each level of TM development separately. In the discussion below, we describe the results for each level including illustrative comments.

TABLE 5: Regression Results for Different TM Development Groups

Dependent Variable: Knowledge Sharing Effectiveness	Low TM Development (n=17)		High TM Development (n=16)		Moderate TM Development (n=20)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Independent Variables						
Persistent Support (PS)	-.63	-.71	-.15	-.63	.01	.27
Synchronous Support (SYN)	.98*	1.12*	.24	1.13	.08	-.06
2-way Interaction						
SYN X PS		.11		.73		-.48*
Adjusted R^2	.36	.32	-.12	-.06	-.06	.13
F	5.48**	3.47*	.20	.71	.42	1.9
$F(\Delta R^2)$		.13		1.71		4.8*

$p \leq .05$ ** $p \leq .01$ *** $p \leq .001$

Teams with Poorly Developed TM

As hypothesized, for teams with poorly developed TM, the regression results indicate that in groups with low TM development, KSE was related to virtual workspace support for multi-channel synchronous communication support. Also, as expected, providing increased persistent communication support for teams with low level of TM was unrelated to KSE. The comments of one team leader help to illustrate the value of multi-channel synchronous support provided by the virtual workspace: "*These visuals [enabled by the electronic whiteboard] made clear where disagreements remained, and which areas needed to be clarified during meetings without delays. I'm a new leader to the team and many members are new so we need this help*".

Teams with Highly Developed TM

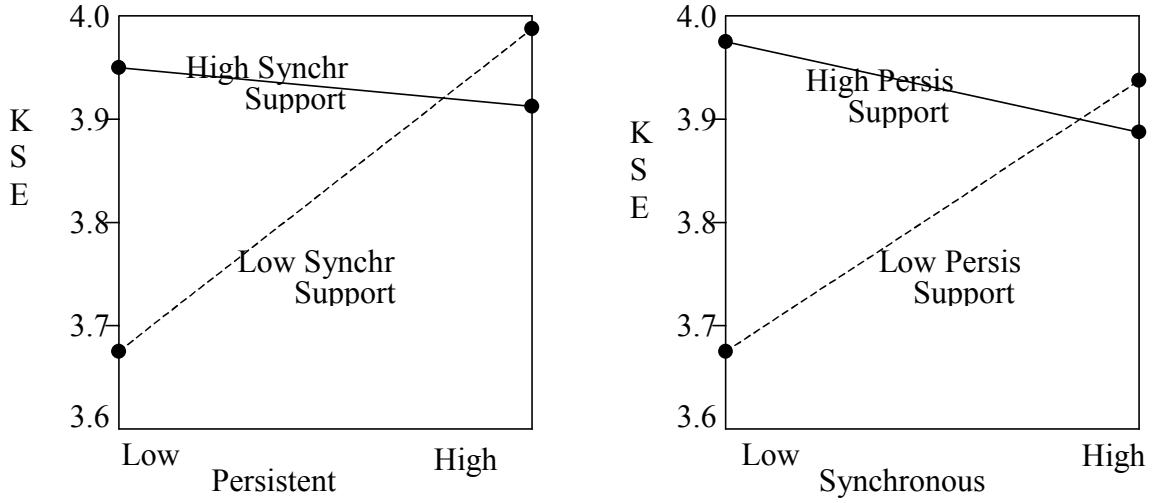
In teams with highly developed TM, regression results in Table 5 indicate that the second hypothesis was not supported. Although we had hypothesized that such teams

would benefit from use of virtual workspace support for persistent communication, the results indicated that email and audio conferencing were sufficient to meet their communication needs. As the leader of one team with high TM and high KSE commented: "*We used teleconferencing to express emotions and consolidate our work, using email in between the teleconferences*."

Teams with Moderately Developed TM

For teams with moderately developed TM, we hypothesized a significant interaction of persistent technology support and synchronous support on KSE. Table 5 presents support for this hypothesis. Following Aiken and West (1991), we plotted the two-way interaction (see Figure 1 below)

Figure 1: Effect of Persistent and Synchronous Communication Technology Support on Knowledge Sharing Effectiveness



The regression results and the plots in Figure 1 indicate that teams with moderate TM need some form of technology support. Without any support (low on both synchronous

and persistent), their KSE suffers. However, as expected, the two technology dimensions appear to be complementary, such that using one technology dimension offers the same value as using both technology dimensions. In one team with moderate TM and high KSE, the leader explained his team's use of persistent communication support provided by the virtual workspace: "*We had an agreement that anything that needed to be shared with members would be shared not by email but by putting it in the Team Room. The fact that we were writing everything helped a lot. We could use words for our discussion; we didn't need to draw. We also didn't need IM since we checked the Team Room everyday and picked up the phone anytime we had a question*." In contrast, the leader of another team with moderate TM and high KSE commented on her team's use of the synchronous support provided by the virtual workspace: "*With email, there is distortion. We don't write English so well [the formal written language of company] so we are starting to speak more often by phone and using IM to get feedback. The Lotus Notes database is a fine place to put formal documents and check for information, but the team doesn't need it for their daily work*." Apparent from these quotes is that, as found in our regression analysis, while each team relied heavily on one technology dimension or the other, neither team felt the need to use both technology dimensions.

DISCUSSION

Our findings suggest that the use of virtual workspaces is related to KSE in DTs, and that this relationship depends on the team's TM. Teams with low TM achieve a greater level of member satisfaction in KSE when those functionalities of the virtual workspace that facilitate multi-channel synchronous communication are used. In teams with highly developed TM, however, use of email and audio-conferencing facilities are seemingly

adequate for knowledge sharing in the team. Finally, in teams with moderate TM, members are more satisfied with the team's KSE when they use those functionalities of the virtual workspace that either facilitate multi-channel synchronous communication or persistent communication.

We recognize that our study has several limitations. While the full sample of 53 is sufficiently powerful to detect the 3-way interaction, the sample sizes in our sub-group analyses were small. Consequently, it is possible that some of effects were not discovered. Future research should use larger sample sizes to validate our findings, particularly for the sub-samples.

Our measure of technology support was specifically derived for this study. Thus, research is needed to confirm that the way in which technology support was measured, and the calculation of the indices (dichotomous for synchronous, and continuous for persistent) can be replicated and applied with similar results across samples.

Finally, the study is cross-sectional; consequently, we cannot determine the causality between technology dimensions and KSE. It may be that a team's KSE is not ***influenced by*** technology use, but instead ***affects*** technology use. While previous longitudinal case studies (e.g., Malhotra et al. 2001) suggest that technology use can help KSE, future studies need to examine multiple teams as they progress through their life cycle to systematically investigate types of workspace functionalities used and the consequent impact on KSE. Moreover, since our study is cross-sectional, it is difficult to disentangle if TM moderates the effect of virtual workspace use on KSE or if virtual workspace use moderates the effect of TM on KSE (Carte & Russell 2003). We examined correlations between TM and KSE for high and low levels of virtual workspace support (for each

dimension together and separately), and found that TM and KSE were consistently and highly correlated regardless of level of support, suggesting that technology does not moderate the effect of TM on KSE. Nevertheless, it could be the case that over time, as suggested by adaptive structuration theory, TM and the use of virtual workspaces influence each other (DeSanctis & Poole 1994). Thus, longitudinal research is needed to help disentangle the process by which TM and virtual workspace use interactively facilitate KSE.

The findings encourage researchers to: a) consider the role of TM in understanding how technologies are used by distributed teams to achieve desired team outcomes, b) examine virtual workspaces not by their individual functionalities (such as instant messaging or discussion threads), but rather based on theoretically-derived and generalizable dimensions, and c) consider the impact that technology dimensions have not just with desired outcome variables, but their interactions with each other in affecting the outcome.

Our findings, that the effect of virtual workspace use on KSE is different for different levels of TM, provide additional support for the growing body of literature suggesting that "social definition" theories (Markus, 1994, Ngwenyama & Lee 1997, Fulk et al. 1990) are more informative about the impact of communication media than perspectives that assume media have invariant objective properties (Daft & Lengel 1986). In our study, we found that teams with different levels of TM development tended to benefit from different dimensions of support provided by the virtual workspaces. This suggests that the value and use of technology should not be examined independent of key "social definition" factors; one of many such factors is the team's TM development. Moreover,

as we suggested at the outset of this paper, consideration of such a contingency variable as TM may help to explain why some researchers have such high hopes for virtual workspaces (e.g, Bordetsky & Mark 2000; Greenberg & Roseman 2003), and others are less sanguine (e.g, Hinds & Bailey 2003). It may be the case that imposing certain virtual workspace functionalities (such as persistent communication support) on certain types of teams (such as ones with poorly developed TM) will not help the team to share its knowledge more effectively. Moreover, in such teams, providing additional functionalities that have limited value may only confuse users so that team conflicts are left unresolved (Hinds & Bailey 2003). In contrast, other virtual workspace functionalities (such as multi-channel synchronous support) may have a benefit for other teams (e.g. teams with poorly developed TM and some teams with moderately developed TM). Thus, the different opinions in the literature about the possible value of virtual workspaces may be resolved in part by examining both the team's TM and the specific dimension of technology being discussed.

In contrast to Hypothesis 2, our results indicated a lack of relationship between use of technology to support persistent communication and KSE in teams with a high level of TM development. Although somewhat surprising, this finding is consistent with Rice's (1992) and Harmon et al.'s (1995) contention that, in teams with well-developed TM, there is an accumulated store of knowledge about each member that can be drawn on to guide interaction and knowledge-sharing even with limited additional technology support. As Harmon et al. (1995) quote one participant: "I could visualize their expressions just by the sound of their voices" (p. 145). The high correlation between TM and KSE lends support to the notion that teams with well-developed TM are able to share

knowledge effectively without the additional functionality provided by virtual workspaces.

Teams are able to achieve high TM because their task, members, or contexts stay relatively stable over the course of the team's activities (Lewis 2003). We have argued that many DTs do not operate in such stable environments. As such, there is a greater likelihood of DTs not having a stable well-developed TM and thus will benefit from virtual workspaces. In such teams, our findings suggest that the extent of TM development will affect the utility of the technology for knowledge sharing. For teams with poorly developed TM, the use of multi-channel synchronous technology support will help team members obtain immediate clarification about the task at hand from other team members. For teams with moderate TM, the picture is more complex: the interaction of the two technology dimensions affects KSE such that teams benefit from the use of either one. We postulated that this was due to the different technology dimensions supporting different gaps in the team's TM: persistent communication support was theorized to overcome gaps in keeping TM updated possibly due to frequently changing membership or an evolving task, while multi-channel synchronous support was theorized to overcome gaps in creating a TM when referential integrity is needed, such as when information being exchanged is highly unique to each member's country, time, domain, or context. Future research should identify ways to determine the nature of gaps in a team's TM and reasons underlying those gaps. Additionally, the degree of match between the type of gap experienced and the technology support used needs to be addressed.

Our study proposed two dimensions of workspace technology: multi-channel synchronous and persistent communication support. These dimensions are akin to

"design principles" called for by Markus et al. (2001). These theoretically derived principles are applicable across a variety of IT platforms provided by multiple workspace vendors. As such these principles should stand the test of time as workspace technologies evolve. Researchers can use these generalizable communication support categories (design principles) to investigate the efficacy of virtual workspace in multiple settings and probe multiple phenomena related to use of technology in distributed teams.

Our findings suggest that the presence or absence of multi-channel synchronous support is related to a DT's KSE. An extension of this finding for future research may be to explore if this theoretical dimension should be postulated as a continuum, i.e., degree of support rather than absence or presence of support. Theory is needed to explore what the concept of more or less support implies. We found no relationship between the number (out of 3) of synchronous functionalities used and KSE, suggesting that having more synchronous functionalities is not necessarily more supportive of KSE. Our findings that support a dichotomous dimension may suggest that some minimum threshold value is needed for teams to have their referential integrity and immediate clarification needs supported, but that more is not necessarily better. Further theory and research is needed in this direction.

The theory base underlying the two dimensions is the concept of a common ground (Clark 1985). An alternative perspective is that synchronous and persistent support influence KSE not because of the *common ground* established between the members; but instead due to the *quality of argument* they facilitate (Sussman & Siegal 2003). Synchronous interaction allows people to quickly assess the quality of an argument while persistent communication support provides the historical and detailed information needed

to evaluate source reliability and alternative interpretations. This alternative explanation suggests that KSE will be affected by the use of technology when technology facilitates more than common ground. It must also more specifically help participants to increase their confidence in quality of arguments generated. Research that allows a test of both explanations simultaneously will help to resolve how workspace technologies need to be deployed to facilitate KSE.

This study was conducted on DTs that were purely virtual (Griffith et al. 2003) and heterogeneous. Future research should address the extent to which the results presented in this paper apply in less extreme contexts. Will teams with more opportunities for face-to-face contact or more homogeneity find persistent communication support more helpful since it will compensate for the tendency of such teams not to write things down (Griffith et al 2003)?

We examined if teams differing in the number of boundaries spanned used workspace functionalities differently. We found no differences; use of technology was not affected by any boundaries spanned nor did number of boundaries spanned moderate the relationship between technology use and KSE. This finding suggests that the decision about what functionalities to provide team members should not be based on the number of boundaries crossed. Number of boundaries may be a poor proxy for the more important concept of a team's TM. Moreover, not every team needs or will benefit from the same set of functionalities. Instead, practitioners should assess the team's TM to help decide on appropriate technology functionalities to deploy. Finally, we have argued that many DTs will never achieve high levels of TM given the challenging and dynamic nature of tasks and settings of distributed teams. With such teams, providing multi-

channel synchronous support (in cases of low TM), and either persistent or synchronous support (in cases of moderate TM) are appropriate. In sum, we have highlighted that virtual workspaces are neither universally useful nor useless. Their utility depends on the distributed team's cognitive fabric.

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Virtual Workspace Technology Functionalities	Synchronous Communication				Persistent Communication				
	Provide immediate clarifications during team virtual meetings	Intensive Interaction among all team members during team virtual meetings	Discussions among all team members at the same time	MEAN	Information about past team activities	Easily retrieve summary or detailed information on a topic	Access information as and when required to perform an activity	Indication of progress of team activities over time	MEAN
Instant messaging (without file sharing)	6.1	5.3	5.6	**5.7**	1.2	1.5	1.8	1.4	1.5
Electronic whiteboard capabilities	6.7	6.5	5.7	**6.3**	1.9	1.7	2.7	1.4	1.9
Synchronous application sharing between team members	6.5	6.2	5.6	**6.1**	2.2	2.0	3.4	1.9	2.4
Online (electronic) capture of teamÕs progress towards milestone	3.1	3.4	1.8	2.8	6.3	4.6	4.2	6.9	**5.5**
Online (electronic) team virtual meeting scheduler	2.4	2.9	2.2	2.5	3.3	3.7	4.0	4.3	**3.8**
Automatic notification (to team members) of any new addition to team repository	2.3	1.7	1.5	1.8	2.2	4.2	4.1	4.4	**3.7**
Field identifying authorship of all entries in team repository	2.4	1.7	1.6	1.9	5.6	5.5	4.7	3.7	**4.9**
Intelligent search (Key-word, Context-sensitive search) capabilities (for team repository)	3.2	1.6	1.3	2.0	4.3	7.0	6.2	3.9	**5.4**
Electronic annotation capabilities (for entries in team repository)	3.8	1.8	1.3	2.3	4.3	4.7	4.6	4.1	**4.4**
Identification of authors of electronic annotations made on entries in team repository	3.9	2.6	2.1	2.9	4.4	4.5	5.0	4.0	**4.5**
Entries have subjects, keywords, and dates fields to make them searchable	3.4	1.7	1.8	2.3	5.6	6.7	5.9	4.6	**5.7**
View multiple entries simultaneously on screen for comparison and contrast	4.0	2.7	2.4	3.0	5.6	5.4	5.4	4.1	**5.1**
Automatically generated revision history for all revisions made to entries in repository	3.2	1.5	1.5	2.1	6.5	5.1	4.0	5.4	**5.3**
Easy changing of keywords (and other important identifier fields) associated with entries	2.1	1.3	1.8	1.7	2.0	4.6	4.5	3.4	**3.6**
Threaded discussion database	3.6	3.6	2.8	3.3	6.4	5.3	5.2	5.4	**5.6**
Team's knowledge repository integrated with corporate databases	2.6	0.7	1.6	1.6	6.4	5.4	5.1	1.7	**4.7**
Visualization tools (e.g., hyperbolic trees) to exhibit links between entries in repository	0.8	0.8	1.8	1.1	4.0	4.0	5.0	5.0	**4.5**
Links associated with entries categorized by types (e.g., antecedent, analogous)	0.6	0.4	0.6	0.5	5.0	5.0	5.0	3.0	**4.5**
Team repository query for patterns via fused, indexed, and summarized multimedia data	2.3	1.9	0.7	1.6	6.3	6.7	6.1	3.8	**5.7**
Automatic suggestion of keywords for entries being made to team repositor	1.8	1.1	2.2	1.7	5.3	6.5	4.8	1.8	**4.6**
Text mining tools to identify related concepts cross entries in the team repository	1.9	0.8	2.3	1.7	6.2	6.8	5.7	4.2	**5.7**

Appendix A: Expert Panel Results