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125. Searching Unanswered Questions
A Review of Knowledge Management Processes in Virtual Teams

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Abstract

This article provides a review of the empirical literature on knowledge management processes in virtual teams in an effort to keep the stock of the current state of knowledge. The review is organized according to the four basic knowledge management processes outlined by Alavi and Leidner (2001) (i.e., creation/acquisition, sharing/transferring, storage/retrieval and application). Factors influencing the effectiveness of knowledge management processes studied in the existing literature are examined and discussed. Building on this review, we critically evaluate this stream of research and propose avenues for future work on knowledge management in virtual teams.

Keywords: Knowledge management processes, virtual teams, dispersed teams

Introduction

Virtual teams are geographically and/or temporally separated, who collectively work on interdependent organizational task by using information and communication technologies (Townsend 1998). One of the primary purposes of forming a virtual team is to synthesize dispersed knowledge and expertise (Alavi et al. 2002b; Boutellier 1998; Penrose 1959). Some extant literature has argued that virtual teams by nature hinder knowledge from being acquired, transferred, stored and applied within teams due to team members' geographic dispersion and reliance on information technologies (Alavi et al. 2002b; Cramton 2001; Griffith et al. 2003). Studies in innovation management (Ahuja 2000) and organizational learning (Walsh 1995) have suggested that the distributed nature of cognition and the diversity of knowledge in team settings create challenges to team learning and knowledge management. These challenges may become even more pronounced when teams are more virtual (Alavi et al. 2002b).

Virtual teams have found themselves in a "catch-22" situation: on the one hand, dispersed knowledge exchange and utilization promote the emergence of virtual teams; on the other hand, virtual teams are arguably less capable of dealing with the knowledge management process. It is an important paradox because effective dispersed knowledge exchange and utilization would not be achieved in virtual teams until the team has figured out the way in which to address their weakness in dealing with knowledge management processes. Hence, it is imperative for business researchers to explore and identify factors that facilitate knowledge management processes within virtual teams and to develop an understanding of how these processes influence virtual team performance. However, a brief review of the literature shows that although literature reviews on virtual teams have been done (Hertel et al. 2005; Martins et al. 2004; Powell et al. 2004; Saunders 2000), no major review of knowledge management processes (KM) within virtual teams has been published to date. This motivates our study to explore such a research question as: What factors influence the effectiveness of knowledge management processes in virtual teams?

A Framework of Knowledge Management Process

Knowledge management refers to the process of identifying and leveraging the collective knowledge in an organization to help it compete (Von Krogh 1998). We build our review on the basis of a framework of four knowledge management processes identified by Alavi and Leidner (2001). According to this framework, organizations as knowledge systems consist of four sets of socially enacted knowledge processes: (1) creation (also referred to as acquisition); (2) storage/retrieval; (3) transfer (4) application (Holzner and Marx 1979; Pentland 1995). This framework is grounded in the sociology of knowledge (Berger and Luckman 1967; Gurvitch 1971; Holzner and Marx 1979) and is based on the view of organizations as social collectives and knowledge systems.

Knowledge creation (i.e., learning) is defined as "changes in an individual's mental models or knowledge representations (Shuell 1986). According to this definition, learning involves acquisition of knowledge and change in knowledge structures rather than a behavior (performance) per se (Greeno 1974; Kwok et al. 2002). Thus knowledge creation is essentially a process of acquiring knowledge in order to create new knowledge. Knowledge storage/retrieval refers to storage, organization and retrieval of knowledge, often seen in the literature on organizational memory (Augenstein 1995; Walsh et al. 1991). Knowledge sharing/transferring refers to sharing and/or transferring knowledge to locations where it is needed and can be used (Alavi et al. 2001). Finally, knowledge application in the form of task teams refers to the application of individual/team's knowledge for problem solving (Grant 1996). Given this framework is to our best knowledge the first and the most comprehensive review work on knowledge management in the field of IS, we decided to use it to structure our assessment of the literature on KM processes in virtual teams.

3. Literature Selection Method

Three means were used to identify relevant articles concerning KM processes in virtual teams. First, and consistent with prior formal reviews published in the field of IS (Powell et al., 2003; Martins et al., 2004), a computer search using ABI/INFORM was conducted, and search results were manually screened to eliminate irrelevant hits. We used "virtual/dispersed/non-collocated/computer-mediated/IT-mediated" as keywords search through abstracts to possible hits on virtual teams. In the same logic, we used "team/group" to capture the notion of team. While acknowledging that teams and groups are different in terms of task interdependence, the two terms are often used interchangeably in traditional and virtual team research (Cohen et al. 1997; Langfred 1998; Sundararajan 1990). To capture knowledge issues in virtual teams, "learning/knowledge/innovation/ problem solving" were used as keywords to search in article abstracts for hits on knowledge management. Another major source is recent literature review articles, such as Powell, Piccoli et all (2004), Martins et al. (2004) and (Hertel et al. 2005). We examined the reviews and identified 11 papers dealing with knowledge processes and learning issues in virtual teams. Thirdly, we referred to resources on virtual teams located at ISWORLD website, and identified 4 papers concerning knowledge processes in virtual teams. All articles identified were read to determine if the issue and the unit of analysis met our search criteria (i.e., knowledge sharing, knowledge application, knowledge acquisition/creation, and knowledge storage/retrieval in geographically dispersed teams). 25 papers were ultimately identified as meeting the criteria for inclusion and were analyzed in the literature review.

Review of Knowledge Management Processes in Virtual Teams

In the current section, we first explore what knowledge management processes have been studied by categorizing the 25 papers according to Alavi and Leinder's (2001) framework. This framework is grounded in the sociology of knowledge and is based on the view of organization

as "knowledge systems" (Alavi and Leinder 2001). This framework suggests that organizational knowledge processes consist of creation, storage/retrieval, transfer, and application. We manually screened all the 25 papers to examine what KM processes each paper focuses on. For each KM process, we adopted the input-process-output model to identify factors that influence team outputs at various stages of the virtual teamwork. This model is the dominant framework used in the study of teams and provides a sound basis for organizing and integrating the literature on VTs (Martins et al. 2004; Powell et al. 2004). According to the model, we identify two broad categories of potential factors involving KM processes- input factors and process factors, which are the primary focuses of this review. Input factors refer to *a priori* factors that a team has upon formation of the team, such as design, structure, and composition characteristics of the virtual team and the endowment of resources, skills and abilities with which the team proceeds with its work. Process factors refer to *emerging* factors influencing teamwork process among team members. Both input and process factors are instrumental to knowledge management because it largely facilitates communication processes and information flows that are central of the idea of knowledge management in organizations (Alavi et al. 2001). Furthermore, in addition to direct effects, input factors may influence KM processes through processes factors (Powell et al. 2004). We discuss organize the review for each KM process by the two categories and the team outputs as presented below.

Overall, all the four KM processes have been more or less studied in the existing literature. In the context of virtual teams, the most studied is knowledge transferring/sharing (13 articles), while the least studied is knowledge storage/retrieving (2 articles). Knowledge acquisition (9 articles) and knowledge application (9 articles) in virtual teams have been moderately studied. Most of the papers (i.e., 19 papers) focus on only one KM process except that five of them cover two KM processes (Haas 2006; Majchrzak et al. 2000a; Majchrzak et al. 2000b; Malhotra et al. 2004; Malhotra et al. 2001), and one covers three KM processes (Paul 2006). The next section discusses in details the influencing factors for each knowledge management process.

Knowledge Creation/Acquisition

Knowledge creation/acquisition is the process of learning that changes team members' mental models or knowledge representations so as to produce new knowledge (Shuell 1986). Research to date has touched upon the effect of using information technology on team knowledge acquisition (Alavi 1994; Alavi et al. 2002a; Ocker et al. 1999) and collaborative know-how development (Majchrzak et al. 2005), situated learning in a virtual environment (Robey et al. 2000), factors that enable acquisition processes in virtual teams (Vogel et al. 2001), and benefits of acquiring knowledge in virtual teams (Saunders 2000).

Input factors: First, the existing studies have examined how team dispersion facilitates the acquisition effectiveness by comparing dispersed teams and face-to-face teams. The findings suggest that computer-mediated learning can be as effective as face-to-face learning (Ocker et al. 1999). Second, early studies found that findings concerning the effect of using advanced information systems on knowledge acquisition are mixed. On the one hand, it is found that the learning outcome of GSS supported virtual teams is superior to non-supported virtual teams (Alavi 1994). On the other hand, it was found that virtual teams using email perform better than advanced IT-supported (i.e., GDSS) teams in a learning environment (Alavi et al. 2002a). The reason might be that cognitive load required for mastering advanced information systems is much higher than that for Email; therefore members' remaining cognitive resources to learn are reduced in virtual teams with advanced IT (Alavi et al. 2002a). Third, recent literature looked at how virtual team composition (e.g., locals versus cosmopolitans) influences knowledge acquisition (Haas 2006).

Process factors: (Vogel et al. 2001) identify nine enabling process factors using case study on seven virtual teams (e.g., assisted learning, cognitive apprenticeship). Communities of practice and situated learning are regarded as important means to facilitate knowledge acquisition and hence leads to positive learning outcomes (Robey et al. 2000). Recently, Majchrzak et al. (2005) found that collaboration know-how development as an instrumental process to facilitate knowledge creation.

Knowledge Sharing/Transferring

Input factors: A few structural factors have been identified to influence communication processes within virtual teams. Virtualness, defined as time that team members spend apart on tasks, is suggested to negatively influence collective knowledge and shared understanding (Griffith et al. 2003), and to negatively influence development of transactive memory (Griffith et al. 2001). Training is suggested to be useful in enhancing coherence within virtual teams (Cornelius et al. 2003). For highly innovative virtual teams that are innovating in both process and team task, keeping a malleable structure that can evolve over time is important for completion of the innovative task (Majchrzak et al. 2000b; Malhotra et al. 2001). Another structural factor is use of information technologies. Use of collaborative technology has been suggested to moderate the effect between team virtualness and shared understanding (Griffith et al. 2003) and to moderate the effect between virtualness and transactive memory. (Majchrzak et al. 2000a) suggest that task complexity and experience with a particular technology does not determine use of the technology. Recent research has suggested that not all types of information technologies are suitable to knowledge transfer: paradoxically, overly rich media such as video conference facilities are not perceived as effective in transferring knowledge (Paul 2006).

Process factors: The existing literature has achieved the consensus that effective communication process within virtual teams is essential to knowledge sharing/transfer and subsequently to team performance (Cornelius et al. 2003; Cramton 2001; Griffith et al. 2001; Griffith et al. 2003; Sole et al. 2000). A number of factors facilitating effective communication have been identified, including shared understanding/mutual understanding/mutual knowledge (Cornelius et al. 2003; Cramton 2001; Griffith et al. 2003), collective knowledge/collective mind (Griffith et al. 2003; Yoo 2001), transactive memory (Griffith et al. 2001; Griffith et al. 2003; Yoo 2001), conversational coherence (Cornelius et al. 2003) and technology use norms (Sole et al. 2000).

Shared understanding, mutual knowledge and mutual understanding all refer to a similar notion –knowledge that the communicating parties share in common and know they share (Krauss et al. 1990), or more broadly as "common ground" (Clark et al. 1982), which are similar to episodic memory in Alavi and Leinder's (2001b) framework. Research has suggested that this kind of tacit team-level knowledge is essential to team performance, such as satisfaction (Cornelius et al. 2003), viability and decision making quality (Cramton 2001) by facilitating effective communication among VT members.

Collective knowledge (or collective mind) refers to explicit knowledge that has been internalized by the team members, such as teamwork procedures (Griffith et al. 2003). It is different from shared understanding in the sense that shared understanding is more implicit (Griffith et al. 2003). Collective knowledge has been suggested to have positive influence on team performance (Yoo 2001). Technology use norms can be considered a particular instance of collective knowledge (Sole et al. 2000), referring to shared knowledge of using a particular technology used in the team. Technology use norms positively influence knowledge sharing practice and subsequently influence team performance (Sole et al. 2000).

Transactive memory is a shared system for encoding, storing, and retrieving knowledge available to the group (Griffith et al. 2003), is the team members' meta-knowledge about who knows what in the team (Yoo 2001). Transactive memory have been suggested to moderate the relationship between communication volume and team performance (Yoo 2001) and influence teams' utilization of potential knowledge (Griffith et al. 2003).

Conversational coherence refers to communicating parties' ability and motivation to refer to each other and to develop topics (Cornelius et al. 2003). Different from previously discussed communication factors, conversational coherence is at the individual level concerning individual ability and motivation. Conversational coherence is suggested to positively influence shared understanding (Cornelius et al. 2003). Similarly, Ba et al. (2004) examined the effect of emergence of cognitive convergence (i.e., the evolving similarity of cognition structure among team members) on knowledge sharing, suggesting that both cognitive convergence and shared cognition are important factors influencing team effectiveness.

Knowledge Storage and Retrieving
Limited research to date (i.e., only two studies) has looked at knowledge storage and retrieving in virtual teams. One study has found that codified knowledge saved in the knowledge repository is unlikely to be appropriately referenced for later search and retrieval (Majchrzak et al. 2000a). Storing too much knowledge items within team's electronic knowledge repository can also make the knowledge retrieval difficult due to information overload (Malhotra et al., 2001). To avoid such problem, virtual team members and managers can rely on norms for knowledge storage and codification, thereby allowing for valuable information to be archived, and for more efficient usage of embedded search tools over knowledge repository (Malhotra et al. 2001).

Knowledge Application
Research to date on knowledge application has looked at structural factors and communication factors that influence team knowledge application in the form of problem solving. The structural factors include leadership effect (Krumpel 2000), use of IT (Archer 1990; Boutellier 1998; Chidambaram et al. 1993; Sharda et al. 1988) and team structure (Clear et al. 2000; Majchrzak et al. 2000b).

Input factors: Krumpel (2000) suggests that virtual teams with an effective leader are more capable of applying knowledge in a way that helps them solve organizational problems. Concerning computer mediation, Boutellier (1998) suggests that intensive use of information technology enables virtual R&D teams to work more efficiently and effectively. Majchrzak et al. (2000) suggest that a malleable structure for highly innovative teams is important to successful completion of innovative tasks. Not surprisingly, research has also revealed that teams of high degrees of virtuality (e.g., geographical dispersion, temporal difference, dynamic structure, national diversity) may encounter difficulties in applying knowledge for innovation (Gibson et al. 2006). Also, the nature of the task has influence on the effectiveness of knowledge application and integration. If a task is perceived as intellectually challenging and is highly contextualized, knowledge integration among team members are the most effective (Paul 2006).

Process factors: (Alavi et al. 2002b) suggest that transactive memory, mutual understanding, contextual knowledge and flexibility of organizational ties are all important factors to knowledge application within virtual teams, and knowledge management systems (KMS) should be designed to address these factors. Psychological safety communication climate, defined as an environment in which communication is characterized by openness, trust, support,

respect, and risk taking, is found to be an important factor moderating the effectiveness of knowledge application for innovation (Gibson et al. 2006).

The existing literature has compared the quality of problem solving between traditional teams and virtual teams, and found that virtual teams end up with higher performance (Sharda et al. 1988), or at least not worse (Archer 1990; Chidambaram et al. 1993), but take longer to accomplish tasks (Archer 1990; Sharda et al. 1988).

Future Research Direction
We evaluate the body of research on KM processes in virtual teams in an effort to identify areas of research that hold significant promise and those that appear to have been overlooked.

Knowledge Creation/Acquisition
Early virtual team research on knowledge acquisition/creation has paid significant attention to knowledge acquisition as the final objective of team activities. Most of the studies examine learning processes by taking learning as a team task (Alavi 1994; Alavi et al. 2002a; Ocker et al. 1999; Qureshi et al. 2001). However, such a team task setting seldom happens to virtual teams in real organizations. Instead, virtual teams are formed to solve a practical problem by integrating team members' current knowledge, skills and ability (KSA) (Powell et. al 2004). In most cases, learning as part of the well-being for team members is a by-product of teamwork. That is, teams themselves often become the "training grounds for the acquisition of new skills and knowledge areas" (Cianni et al. 1977). Along the same line, we propose that the issue of on-job learning and/or on-job training may be an interesting issue to look at in the area of knowledge creation and acquisition. On-job learning/training is closely related to the notion of team member viability – defined as individual's KSA development and ability to perform effectively in virtual teams in the future (Powell et al. 2004). Therefore, it is very important to facilitate team members' on-job learning when the team is focused on completing a task. The skills, abilities, and knowledge acquired as team members get jobs done are particularly relevant, context-specific, thus possessing high value for the team. One of the future research directions for knowledge acquisition in virtual teams can be concerning *influencing factors of effective on-job learning/training within virtual teams*.

Knowledge Sharing/Transferring
The existing literature emphasizes on knowledge transfer processes but has overlooked agents who send or receive knowledge that is transferred. Szulanski (1996) suggests that knowledge flows can be conceptualized as a function of five factors based on the communication theory, including 1) perceived value of the source knowledge; 2) motivational disposition of the source; 3) existence and richness of transmission channels; 4) motivational disposition of the receiver; 5) the absorptive capacity of the receiver. Research to date on knowledge transfer in virtual teams only looked at existence and richness of transmission channels (e.g., IT as a means of communication) and ways to recognize perceived value of the source knowledge (e.g., mutual understanding, transactive memory); it overlooked the other three elements (i.e., motivational dispositions of the receiver and the sender, the absorptive capacity of the receiver), which are all deemed essential in knowledge transfer (Govindarajan 2000). For instance, virtual teams often feature tight timeline and local specialty (Alavi et al. 2002b). Tight timeline may impede team members from performing extra work such as knowledge storage. In addition, information technology (e.g., a knowledge repository) may serve as a "jealous mistress", sucking up team members' tacit knowledge (Griffith et al. 2003). If the individual allows his/her knowledge to be shared by putting them into a knowledge management system, he/she may lose the benefit of retaining that knowledge. Recent research has started looking into factors affecting people

contributing knowledge into knowledge management systems (Kankanhalli et al. 2005). Similarly, future research in the virtual team setting could look at *factors that influence team members' willingness to share knowledge and their ability to absorb transferred/shared knowledge in virtual teams*.

Knowledge Storage/Retrieving

The role of knowledge manager in virtual teams deserves further study on the issue of knowledge storage and retrieval. (Malhotra et al. 2001) suggest that knowledge manager is an important role in virtual teams, who can ensure valuable information to be kept and quick and precise search is handy. Further study should theoretically justify and/or empirically explore *to what extent knowledge manager can facilitate knowledge storage and retrieving in virtual teams*. Furthermore, it is often reported that codified knowledge in knowledge repositories is unlikely to be appropriately referenced for later search and retrieval (Majchrzak et al. 2000a). One explanation might be that knowledge is highly contextual and it cannot be understood properly without capturing its local context. Future research should look at *factors that influence the quality of knowledge repository developed in virtual teams*.

Knowledge Application

Knowledge application is arguably one of the major goals for which teams are formed (Grant 1996). Knowledge application is the end while the other three knowledge processes are means to achieve this end. It seems that there must be close relationships between knowledge application process and the other three KM processes. However, in the current literature only few studies explicitly put knowledge application and knowledge transfer together [e.g., (Haas 2006; Majchrzak et al. 2000a; Malhotra et al. 2001)], or compare the performance complications of multiple knowledge management processes in the same study (Haas 2006; Paul 2006). Future research should explore *the extent to which knowledge application is related to the other three knowledge processes*. Studies on knowledge application mostly focus on the effect of IT use on knowledge application quality by comparing virtual teams with traditional teams (Archer 1990; Chidambaram et al. 1993). Future research can focus on between-*virtual-team comparison by comparing the effect of various levels of IT use* (e.g., basic IT such as email vs. advanced IT such as GDSS) on virtual team performance.

A Holistic Approach to Knowledge Management In Virtual Settings

By examining input factors and process factors identified in the extant literature, it appears apparent that, while factors do differ across KM processes, many factors remain applicable in multiple KM process settings, e.g., team structural factors (e.g., degree of virtualness, degree and types of information technologies, leadership behaviors) are identified as important factors to multiple KM processes. Similarly, process factors such as transitive memory, shared understanding, collective mind appear to be equally important to multiple KM processes. This leads us to a reasonable speculation that these factors may in fact influence the effectiveness of all the KM processes. While it is worthwhile to test how these factors play a role in the KM processes that have been covered, a more pertinent question remains: whether and how do these structural and process factors differ in their effects on different KM processes? Further, there is no virtual team that only uses one KM process throughout its lifecycle. On the contrary, virtual teams concurrently use and integrate multiple KM processes in different situations to accomplish their tasks at hand. Future research could investigate why and how virtual teams use multiple KM practices to accomplish their team goal, and under what conditions one KM process is more effective than another?

References (Available upon request)