



Virtual team collaboration and innovation in organizations

Leif Jarle Gressgård

International Research Institute of Stavanger, Bergen, Norway

Received February 2010
Revised September 2010
Accepted September 2010

Abstract

Purpose – Virtual teams, understood as teams with geographically dispersed members communicating primarily by use of information and communication technologies (ICT), have become a viable form for work in innovation projects involving one or several organizations. Knowledge development and creation of a shared understanding among team members are often stressed as fundamental to successful innovation processes. This paper aims to address how use of ICT in team collaboration impacts on the creation of a shared understanding and knowledge development within the teams, and how these factors are important for organizations' innovation capabilities.

Design/methodology/approach – Based on a review of the literature, the paper discusses how modern ICT may impact on the organization of innovative activities and organizations' innovation capabilities.

Findings – Several important factors related to the use of ICT in teams working on innovation projects are highlighted. A conceptual model and directions for future research based on a literature review are proposed.

Practical implications – Based on the discussion, a conceptual model is presented which highlights the need for well-functioning computer-mediated team interaction in order to realize the innovation potential of organizations.

Originality/value – The paper emphasizes the reciprocal significance of knowledge access and knowledge exploitation for organizations' innovation capabilities, and discusses how ICT impacts on both aspects.

Keywords Team working, Innovation, Knowledge management, Knowledge sharing, Virtual organizations

Paper type Conceptual paper

1. Introduction

Information and communication technologies (ICT) are increasingly being used to support collaborative work in a variety of organizational settings, and as a consequence, new organizational forms and work arrangements are emerging (Peters and Manz, 2007; de Jong *et al.*, 2007). The impacts of ICT become apparent in changes of work patterns and decision-making procedures, both within and between organizations. In this respect, the notion of virtual teams, understood as teams with geographically dispersed members who predominantly communicate by use of ICT (Hertel *et al.*, 2005), has been given substantial attention in recent years (see, e.g. Townsend *et al.*, 1998; Martins *et al.*, 2004; Powell *et al.*, 2004; Hertel *et al.*, 2005; Ebrahim *et al.*, 2009).

Virtual teamwork is regarded as an important form of work in modern organizations as it is capable of complying with the demands of the new business environments characterized by international competition, fragmented and demanding markets, and diverse and rapidly changing technologies. This environment is placing intense pressure on companies to adopt flexible approaches to development of



products and services (Townsend *et al.*, 1998), shorten innovation processes (Kessler, 1996), and speed up time to market (Iansiti and MacCormack, 1997). Superior performance in product/service development and innovation is therefore believed to be one of the main sources of competitive advantage in the modern market place. However, innovation occurs in a social setting, and computer-mediated communication (CMC) imposes certain qualities on the social interaction and group processes of teams working on innovation projects. It is therefore important to investigate how these changes of communication and human interaction influence processes regarded as instrumental to organizations' innovation capabilities and organization of innovative activities.

A considerable amount of literature exists focusing on structural conditions for innovation enabled by ICT (e.g. the role of interfirm networks and access to diverse sets of competencies) (see, e.g. Pittaway *et al.*, 2004), but research on how the characteristics of CMC influence the process of knowledge exploitation is in comparison scarce. This paper argues that an emphasis on the interrelationship between the structural (knowledge access) and behavioral (knowledge exploitation) aspects is crucial for organizations' innovation capabilities, and that realization of the potential for innovation brought about by ICT is dependent on well-functioning CMC processes (Figure 1). In this respect, the processes of knowledge development and creation of a shared understanding among the collaborators are central.

The discussion is based on a review of literature focusing on communication characteristics of virtual teams involved with innovative work. As the focus of the paper first and foremost is on behavioral aspects of CMC with reference to innovation capabilities, particular emphasis has been given to studies concerning social psychological aspects of electronically mediated interaction. Thus, when conducting the review, relevant literature had to meet the criteria of involving electronically mediated interaction (virtuality), team work, knowledge development or creation of a shared understanding, and innovation. Based on these search criteria, several keywords were identified and applied in an open search for literature on the internet using Google Scholar, Academic Search Elite, and Business Source Premier from EBSCO.

The paper begins with a description of the most important aspects of the development of modern ICT, which constitute the basis for the new communication processes in organizations. This is followed by a discussion of the ways in which this new environment of interaction may influence organization of innovative activities and innovation capabilities of organizations. The paper is ended with some concluding remarks and suggestions for future research.

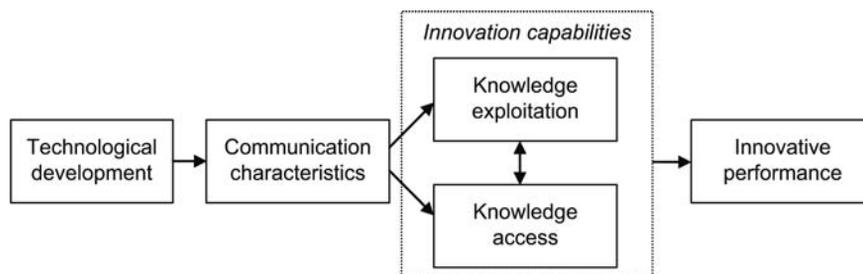


Figure 1.
Conceptual model

2. Development of modern ICT

ICT refers to technologies applied to gather, share and distribute information, and communicate by use of computers and networks (Antonelli *et al.*, 2000). ICT thus represents a collection of technologies related to information management, information sharing, and communication. The ICT-field has gone through a wide-ranging development, from a pure focus on IT, to include digital communication technologies and new digital multimedia (Schmid, 2000). This means that the character of ICT has changed from being a tool for computation of defined tasks, to become a medium for communication and interaction during recent years. The internet is central in this respect, as internet-based technologies have revolutionized the access to information both for individuals and organizations (Evans and Wurster, 1997). This development will continue to impose major consequences for the arrangement of information sharing and transactions between organizations, and support of global cooperation between individuals and organizations.

Historically, the sectors of IT, telecom, and broadcasting have had separate and autonomous systems for application, production, and distribution. Telecommunications and broadcasting have traditionally applied different types of analogous technologies, while the IT-sector has been based on digital technology. Digital representation is now replacing the former analogous methods for production, distribution and receipt of information and communication services. The development and application of the digital technology entail a fundamental change as the three sectors get a common technological basis, and the disconnection between the sectors is thus principally being erased. In other words, the sectors are converging, and it is in this respect common to distinguish between four different types of convergence.

The first is service convergence, which refers to the combination of elements from newspapers, radio and television, making it increasingly difficult to draw clear-cut distinctions between these traditional media (e.g. an online newspaper contains articles published in the paper-based version, and it may also be possible to watch video clips by clicking on the pictures). Network convergence means that content of all media is transferred in the same manner (because of digitalization), and that the traditional idiosyncratic communication nets and infrastructures of various media (e.g. separate infrastructures for cable-TV and telecommunications) no longer represent a technological constraint for content distribution. Consequently, the cable-TV network may become a broadband for internet connection and telephone use in addition to traditional telecasting. Terminal convergence is the third convergence type, and implies that the same end-user equipment can be applied to all media. For example, it is possible to watch television on the computer monitor, and the mobile phone may be a device for internet browsing. Finally, market convergence implies that different operators in the market are joining forces in new ways because of synergies and new market opportunities. The merger between American Online (network provider) and Time Warner (content developer) in 2000, and the collaboration between Nike and Apple (introduction of running shoes interacting with iPod), are examples of market convergence.

The most important convergence types regarding the opportunities for cooperation and communication within and between organizations are network convergence and terminal convergence. Accompanied by new ways of coding and compression of data,

and new techniques for upgrading the capacity of existing infrastructures (and development of new infrastructures), the digital technology is conducive to a major increase of the distribution capacity of the infrastructures. In addition, terminal convergence increases the opportunities for mobile communication and thus alters the scopes and premises for communication between people. ICT is therefore not only a tool for solving defined tasks, but PCs, mobile phones, and palmtops are devices for social and cultural communication. Consequently, new forms of expressions and ways of interaction evolve. Innovative work in modern organizations thus occurs in new and changing social contexts, which implies that the opportunities for communication and cooperation may have consequences for organizations' innovation capabilities and organization of innovative activities.

3. Innovation capabilities and organization of innovative activities

The field of innovation is very diverse; innovation research has emanated from many academic disciplines including management, psychology, economics, and sociology, among others. Within these and other disciplines, researchers tend to conceptualize innovation in different ways (Read, 2000). For the purpose of this paper, a broad understanding of the concept is suitable, and innovation can thus be understood as a process of creating or modifying an idea, and develop and implement it in an organization (Zhuang, 1995; Nohria and Gulati, 1996). The output of the process can be products, services, processes, or strategies, and the fundamental parts are in any case the aspects of novelty and usefulness with reference to the adopting organization (Read, 2000). It is further common to make a distinction between incremental innovations and radical or disruptive innovations. The former innovation type refers to adaptations and improvements of existing products/services/processes, while the latter represents novel developments that are not built on existing products/services or ways of doing things (processes) in the organization. On this basis, it can be argued that the fundamental aspect of an organization's innovation capability is the extent to which it is able to discover business opportunities, and thereafter effectuate the innovation process in an efficient manner. Common for all innovation processes is the fundamental role of possession and utilization of knowledge in the development process. The innovation capability of an organization is therefore generally perceived as its ability to access and use internal and external knowledge in developing and introducing new products, services or processes (Hagedoorn and Duysters, 1999).

When it comes to organization of innovative activities, the work is often carried out in small teams focusing on development of products or services (Keller, 1986; Gibson and Gibbs, 2006). The reasons for this are that small teams are assumed to result in higher individual commitment and performance, and that they are more efficient regarding market introduction of new products and services (Townsend *et al.*, 1998). Use of virtual teams, where the members use technology as means of communication and interaction across geographical and organizational boundaries, has therefore become customary (Boutellier *et al.*, 1998; Townsend *et al.*, 1998). This development has resulted in two distinct yet interconnected types of changes related to communication, which again have consequences for the innovation capabilities and organization of innovative activities in organizations. First, the development has resulted in changes of the communication patterns in organizations and thus altered the information flow.

Second, the technological development has also affected the nature of the communication processes (i.e. characteristics of human interaction) in organizations. Related to the former type of changes, empirical studies have shown a positive relationship between use of ICT and functional flexibility (e.g. Bresnahan *et al.*, 2002; Hempell, 2005), which means that organizational members are able to interact and make decentralized decisions to a larger extent than before. Studies have further shown that organizations with a greater extent of functional flexibility are both more productive (Black and Lynch, 2004; Zwick, 2004) and innovative (Hujer and Radić, 2003) than less flexible organizations. In order for organizations to increase their innovative capabilities, it is therefore argued that organizations have to arrange for their members to react quickly and independently to new information, and communicate in unrestricted ways both internally and externally (Batt, 1999; Hempell and Zwick, 2008). Studies have also shown that members of functional flexible organizations to a larger extent than others are aware of the necessity of innovation (Batt, 1999), and that they are able to intercept necessary information and obtain knowledge of customer needs that can create the basis for innovation processes (Lindbeck and Snower, 2000). In this way, easily accessible communication networks in organizations can increase the communication rate and intensity, and also promote interaction across organizational levels and organizational boundaries. This is important as the sources of innovation often are located at the lower levels of the organizational structures, or outside the boundaries of organizations (Van den Bosch *et al.*, 1999). This acknowledgement further represents the basic premise of the concept of open innovation, which proposes that companies should use both external and internal competencies in innovation processes (e.g. Chesbrough, 2003; Chesbrough and Crowther, 2006). Abilities to recognize and exploit information from external sources are also fundamental to the concept of absorptive capacity introduced by Cohen and Levinthal (1990), which is considered to be decisive for organizations to be innovative. Terms like user innovation and customer-centric innovation are also based on the same line of reasoning, implying that efficient means for exploitation of customer input in corporate innovation processes are crucial for the success of new product development (von Hippel, 1986; Brem and Voigt, 2007; Bilgram *et al.*, 2008).

This focus on customer input and exploitation of external sources of knowledge underscores the assertion of Powell *et al.* (1996) that the *locus* of innovation is no longer the individual or the firm, but increasingly the network in which the firm is embedded. Accordingly, recent work on organizational innovation has emphasized the importance of business networking for innovativeness (see, e.g. Pittaway *et al.*, 2004, for a review). Tether (2002) for example, has shown that firms that have introduced innovations with higher degrees of novelty are more likely to rely on external sources of knowledge in their development processes. Ritter and Gemünden (2003) have further shown that network competencies (determined by firms' access to resources, network orientation of human resource management, integration of intraorganizational communication, and openness of corporate culture), have a positive influence on product and process innovation success. This shows that the innovation capability of an organization to some extent is dependent on its communication structures, as innovation processes often are initiated by information concerning new business opportunities seized through interaction with external relations.

These described changes induced by increasing use of ICT in business life are mainly of a structural character. As use of ICT may increase access to both external and internal knowledge, it influences the innovation potential of organizations. However, in order to realize this innovation potential, organizations must focus on conditions for exploitation of the structural changes. That is, in order to take full advantage of the knowledge resources made available through ICT, mastering the behavioral aspects of CMC is fundamental. Research focusing on ICT and innovation has so far been mostly concerned with the structural aspects. This paper will therefore highlight the reciprocal dependency between structure and process, and focus on fundamental aspects of behavioral processes which are important for organizations' innovative capabilities. The discussion will more specifically focus on two interrelated aspects: first, the extent to which electronically mediated communication is able to create a social context supportive of innovation is discussed. Social interconnectedness and mutual understanding among members of virtual teams are important in this respect. The focus is thereafter directed at the importance of knowledge sharing and knowledge development in virtual teams working on innovation projects.

4. Shared understanding

Multinational and interdisciplinary virtual teams are frequently assembled with the intention of developing new products and services (Sethi *et al.*, 2001). The cultural diversity this entails is assumed to increase the degree of innovation and creativity in problem solving, and thereby also promote the development of new and radical solutions. An increase in "scope" of expertise, knowledge sharing, and the potential for different combinations of skills constitute the basis for this assumption (Nakata and Im, 2010). However, efficient cooperation by use of electronic media depends on the existence of a shared understanding among the group members regarding the problem at hand. This includes mutual understanding of norms for collection, sharing and use of information, division of work and roles/responsibilities, and the social context for interpretation of information (Scott and Lane, 2000; Peters and Manz, 2007). As virtual teams often are assembled on a project basis and consist of geographically dispersed participants from different organizations, a shared understanding may not exist at the time of establishment. The creation of a common social platform for interaction and for the work that is to be carried out is thus important, and both means and amount of communication are fundamental for a successful construction of a shared understanding among the team members (Malhotra *et al.*, 2001). This may represent a challenge for virtual teams, as non-verbal behavior (e.g. smiles, headshakes, eye contact, distance) that provide information which is constructive for adjusting, modifying and managing the interaction, is not as available as in face-to-face interaction. This has to be accounted for in the selection of media for communication in various phases of the innovation process, and has to be given particular attention in the initial phases of teamwork. Boutellier *et al.* (1998), for example, found that use of communication media capable of transferring information that represented substantial degrees of social presence (by transferring non-verbal signs like body language, gesticulation, etc.) was of particular importance for the outcomes of the first phases of innovation processes. However, research has also found that a high degree of social presence not necessarily is beneficial in the early faces of teamwork, and that the

outcome of rich interaction may depend on the cultural diversity of the team members (Staples and Zhao, 2006; Carte and Chidambaram, 2004). Culturally heterogeneous teams using rich media or meeting face-to-face may create subgroups, which are detrimental for team processes. Such teams may therefore be better off not meeting face-to-face until relationships have been developed, but rather communicate by use of technologies that can reduce the possibilities for subgroup formations.

Research concerning distributed cognition supports the notion that the outcome of team interaction is a construction of a shared understanding of the situation among the team members. Lee-Kelley and Blackman (2005) use the concept of “mental models” to describe how organizations and individuals create and share views of opinions, and by this arrange for shared understanding and knowledge development. In other words, mental models constitute the link between the collective and the individual as they create a context for interpretation and understanding of new information. The abilities of different communication media to create and develop shared mental models are thus fundamental to the construction of settings suitable for effective teamwork and innovation processes. However, research has also shown that shared mental models can be negative as similarities in experiences and practices above a certain level may reduce the efficiency of a team (Lee-Kelley and Blackman, 2005), and the effects of shared mental models among team members are therefore also important regarding the organization of innovative activities. In cases where shared experiences result in limited repertoire and poor conditions for improvement, the innovation capabilities of the teams will be reduced. As a consequence, external relations may be important for teams involved with development of products and services. This is supported by research concerning the efficiency of product development teams, which indicates that a focus on external relations represented by a strong customer focus and relations with numerous other companies is associated with high efficiency (Svetina and Prodan, 2008). Especially the first phases of development processes, like idea generation or testing of prototypes, are likely to improve if relations with potential customers in order to reveal customer needs and opportunities in the market are emphasized (Boutellier *et al.*, 1998). For this reason, it is common that certain individuals in networks of product development teams hold gatekeeping functions (i.e. strong connection to both internal colleagues and external contacts) (Tushman, 1977; Tushman and Katz, 1980; Tushman and Scanlan, 1981), and this has proved to be important for the innovation capabilities as it creates opportunities for information flow improvements between teams and team members (Tushman, 1977). Persons in control of the information flow between the external environment and internal team members in a network have access to numerous (and sometimes rare) information sources, and by using these sources the knowledge base is expanded. Persons having gatekeeping functions make a team involved with product development able to challenge its views, reconsider its work conditions, and adopt and exploit new information from the external environment.

A large number of external contacts may also increase the social capital of the team, and by this positively influence the performance. In this respect, Newell *et al.* (2004) emphasize the importance of external relations, and argue that team members should access distributed knowledge by mobilizing their social capital. However, they also claim that this has to be combined with a focus on internal interaction, and that team

members have to build strong social bonds with each other as knowledge development is a process of social construction of a shared understanding through interaction. In other words, strong social bonds between team members are a prerequisite for exploitation of external knowledge. It is further argued that high associability and trust among team members are important aspects of strong team bonds (Leana and Van Buren, 1999). However, research has also shown that team longevity and trust among team members beyond a certain level can have negative effects on their performance (Katz, 1982). Edelman *et al.* (2004) argue that strong social bonds may act as barriers to new ideas and knowledge, and according to Sethi *et al.* (2001), the degree of innovation might decrease when the social ties between the members of a cross-functional team increase above a certain level. Other studies have also shown that lack of modification of team composition has resulted in aimlessness and entropy in the teams, and also that routines creating work flow and progress can be dysfunctional by generating misinterpretations of information and reduce the possibilities for innovation (e.g. Gersick and Hackman, 1990). These findings support the notion that socialization effects and group thinking reduce innovation capabilities, and according to Madhavan and Grover (1998), a consequence of this is that organizational members involved in innovation activities should participate in several innovation teams. Further, Kratzer (2001) has shown that the ties between the members of innovation teams are weaker when electronic means of communication are applied. This means that electronic communication media can be used actively in creating an optimal level of social connection between members of new product development teams, based on the objective of increasing the teams' innovation capabilities.

Research has also shown that the performance of new product development teams with few but important relations with individuals within their own organization, is better than for teams with numerous and strong ties (Hansen, 1999). It is further argued that the means of communication should be different for external and internal relations (Büchel, 2005). New product development teams with extensive one-way internal communication (e.g. one-way report of work status/progress by use of e-mail) will be less influenced by internal procedures and work processes of the organization. This may be of particular importance for development of disruptive innovations, as these processes require new mindsets that break with existing work procedures, and thus also depart from a focus on standardization of business activities often sought after in order to increase efficiency. Electronically mediated communication may in these situations be suitable for controlling the extent of interaction, and thus be preferable in many situations even when non-mediated communication is an option.

As mentioned earlier, a factor often emphasized in discussions concerning the innovation potential of virtual teams, is the diversity of team composition (Malhotra *et al.*, 2001; Sethi *et al.*, 2001). It is a common understanding that within-team competence heterogeneity will result in variation of perspectives and ideas, which is important for creative thinking and innovation (Nakata and Im, 2010). Research has also shown that multicultural teams achieve higher levels of creativity and produce more and better alternative solutions to problems than teams characterized by less cultural diversity (Brown and Eisenhardt, 1995; Sole and Edmondson, 2002). However, the results are not unambiguous. For example, Sethi *et al.* (2002) found no relationship between cross-functionality of team composition and degree of innovation of the

product that was developed. The explanation of this finding could be that while both the number and variation of new ideas put forth by teams consisting of members with different backgrounds and competencies may be larger than for more homogeneous teams, the integration processes and problem solving processes can be more challenging. Further, Gibson and Gibbs (2006) found that national diversity regarding team composition was detrimental to innovation outcomes, and that a psychologically safe communication climate might help mitigate the challenges caused by team diversity. In this respect, electronically mediated communication can have both positive and negative effects. On the one hand, conflicts may escalate as people communicating by use of electronic media are less critical in message framing, and also focus less on social norms for behavior and custom interaction (Siegel *et al.*, 1986; Sproull and Kiesler, 1986). On the other hand, research has also found that CMC to a larger extent than face-to-face communication makes the interaction more focused on the message content, and that the interaction in this way becomes more oriented towards the problem the team is about to solve (Lebie *et al.*, 1996). Regardless of communication form, researchers focusing on the performance of multicultural teams have found that teams, whose members communicate efficiently and handle conflicts and other behavioral challenges in constructive manners, will outperform homogeneous teams (e.g. Watson *et al.*, 1993). The main reason for this is that innovative products/services often are results of new linkages between different ideas and perspectives. The role of development and sharing of knowledge is in other words fundamental.

5. Knowledge development

As stated earlier, innovation capability can be understood as the ability to develop and apply internal and external knowledge in development processes (Hagedoorn and Duysters, 1999). The assumption that creativity and new ideas are results of the interaction between different areas of knowledge has been supported in various fields of research, e.g. knowledge literature (e.g. Simon, 1985), social networks (e.g. Granovetter, 1973), and complexity research (e.g. Kaufman, 1995). According to Madhavan and Grover (1998), one implication of this has been that planned idea-conflicts, or “creative abrasion” (Leonard-Barton, 1995), may be positive for the performance of innovation teams. Whether such conflicts turn out to be creative and not destructive, however, depend on the team members’ abilities to sustain a meaningful and including interaction. In this respect, several studies have shown that the extent of participation is more equally distributed among team members in virtual teams compared to face-to-face teams (Weisband *et al.*, 1995). This finding is generally explained by the effects of reduction of status differences caused by the lower amount of social cues in computer-mediated interaction. Communication by use of electronic media does to a lesser extent than face-to-face communication reflect status or hierarchical relations, thus as organizational members use electronic media for communication, their power or status positions will not be reflected (to the same extent as for face-to-face communication) contextually (e.g. through clothing) or dynamically (e.g. through facial expressions and gesticulations). For this reason, electronically mediated communication is often perceived as more impersonal and social anonymous (Kiesler *et al.*, 1984). Lack of social feedback and norms for social interaction direct the

attention to the content of the message, and electronically mediated interaction may by this arrange for aspects that are important for de-individualization (anonymity, reduced self regulation and reduced self consciousness) (Diener, 1980; Festinger *et al.*, 1952; Forsyth, 1983). As the transmitted information is not linked to the sender, the social constraints are reduced. One implication of this is that CMC is more open than face-to-face communication, and may therefore support the utterance of points-of-view that would otherwise be detained. This again may be useful in order to increase the number and diversity of ideas put forth in innovation work (e.g. brainstorming sessions).

Madhavan and Grover (1998) also focus on dissemination and utilization of knowledge in teams involved with product development, and claim that the potential for development and utilization of new knowledge is embedded in the team itself and the nature of the interaction between the members. These authors distinguish between “embedded knowledge” and “embodied knowledge”, where the former refers to the knowledge potential of a team and is a result of the combination or integration of the tacit knowledge of the team members. Embodied knowledge refers to the new product or service that the team has developed. In an innovation context, a team is thus assembled based on its knowledge potential, but the realization of this potential (i.e. whether it is reflected in the products/services developed, which refers to a transition from embedded knowledge to embodied knowledge) is dependent on the interaction between the team members. This is also in line with the view of Newell *et al.* (2004), who argue that effective knowledge integration in a team involves well-functioning dialogue and negotiation. In other words, communication processes in a team will be influential for the team’s innovation potential. Madhavan and Grover (1998) also claim that the degree of innovation of the product/service being developed may be important for team composition, and that the characteristics or qualities that the team members must possess depend on the inherent innovativeness of the product/service that is to be developed. That is, an increase in innovativeness has to be followed by an increase in expertise. Teams involved with development of products/services with a high degree of innovation must therefore consist of members with top competence within different fields and across organizational borders, and may thus lack a social platform for interaction (Malhotra *et al.*, 2001). One of the main challenges in these cases is to create well functioning relations based on trust between group members (Peters and Manz, 2007), which again may be difficult as electronically mediated interaction may weaken the social ties between the team members (Kratzer, 2001).

Trust can be defined as a reciprocal belief in the other parties’ intentions and behavior (Kreitner and Kinicki, 1992), and social psychological research has shown that trust-based relations between team members may have a positive influence on the efficiency and performance of teams (Zand, 1972, 1981; Madhavan and Grover, 1998). An atmosphere where this kind of trust is lacking, on the other hand, can result in retention of information, and also attempts of influencing the decisions toward specific interests and by this lead the resources of the team away from its goals (Zand, 1981). According to Madhavan and Grover (1998), trust is especially important in cross-functional and interorganizational teams, as withholding information because of low trust levels is especially unfortunate for processes involving knowledge articulation, internalization, and reflection. Further, they claim that there are two

aspects of the communication between team members that are important for the establishment of trust-based relations. The first concerns the richness of personal interaction. Crucial for this aspect is the extent to which the team members can communicate directly (face-to-face), frequently, and on an informal basis. The other aspect concerns information redundancy, which refers to information sharing exceeding the minimum threshold of what is required for the individual team members to carry out their tasks. As both the richness and redundancy of information are important for establishing trust-based relations in a team, the necessity of these factors will increase as the degrees of innovation in the development projects increase. In this way, innovation degree represents a moderator variable in the relationship between interaction characteristics and the degree to which the knowledge the team possesses is exploited in the product/service being developed. As a consequence, and somewhat paradoxically, communication media incapable of transferring a certain amount of social information (cues) may not be suitable for development projects where the need for electronically mediated communication is greatest because of the geographical and organizational dispersion of the team members. However, research has shown that over time, virtual teams share information important for establishing social relations (Walther, 1995, 1997). But as teams working on development projects with high degrees of innovation to larger extents than other teams are cross-functional and project-based, and thus active in limited time spans, the opportunities for developing social relations are generally limited. In line with the assertion that the degree of innovation will be a deciding factor for the appropriateness of electronically mediated communication in projects involving product/service development, Riggs *et al.* (1992) found that richness of personal interaction and information redundancy do not have to be high in development of products with low degrees of innovation. As a consequence, there are differences between virtual teams working on incremental innovations and virtual teams working on disruptive innovations. The need for communication in these two types of teams is different, and the organization of the teams has to be adapted to this in order for the innovation capability to be optimal. In summary, both team composition and communication processes should be different depending on the degree of innovation of the product development projects. The innovation capability of an organization is thus influenced by the organization's ability to compose teams and adapt the information richness and information redundancy based on the degree of innovation of the products/services being developed.

6. Conclusions and directions for future research

The objective of this paper was to draw attention to how the development within the field of ICT impacts on organizations' innovation capabilities and organization of innovative activities. The reason for addressing this issue is the increasing use of virtual teams in business life, combined with an increasing emphasis on employee creativity and innovation in organizations (Anderson *et al.*, 2004). Innovation capabilities involve strategic organization of innovative activities in terms of identifying and accessing internal and external knowledge (i.e. composition of virtual teams), and exploitation of these knowledge resources. In discussing this latter process, particular emphasis was put on how new forms of human interaction enabled by ICT may influence the process of creating a shared understanding in virtual teams working

on innovative projects, and also how the knowledge development in such teams may depend on qualities or characteristics of the communication processes. This is illustrated in the refined conceptual model shown in Figure 2.

The model underscores the interrelationship between knowledge access and knowledge exploitation for the innovation capabilities of organizations, and several important topics for future research can be derived. The overall research agenda should be to investigate how different modes of interaction and combinations of various electronic communication media can facilitate successful integration and exploitation of external and internal knowledge in innovation processes. Many studies in the CMC literature focus on differences between virtual teams and “traditional” teams working face-to-face (see, e.g. Fjermestad, 2004, for a review). However, as the use of ICT within and between organizations increases, it is common for teams to interact both face-to-face and by use of ICT, and not solely by either communication mode. Research investigating the interplay between various means of communication (from face-to-face interaction on one extreme to text messaging by use of mobile phones on the other) in the various phases of the innovation process is therefore necessary. Innovation type and degree of innovativeness in the product/service being developed may also be relevant for the appropriate combination of communication means, and should therefore be focused in future research. The discussion has further shown that the process of knowledge development (and sharing of knowledge) is fundamental to organizations’ innovation capabilities. In this respect, it is important to gain knowledge of what kind of input (R&D, customer perceptions, etc.) that is important to the various innovation phases and innovation types, and how the means of communication can facilitate the specific combinations of internal and external input.

As described earlier, the necessity of competence diversity regarding team composition may increase as the degree of innovativeness of the product/service being developed increases. A need for competence diversity implies inclusion of team members from different organizations and with various backgrounds, and it is

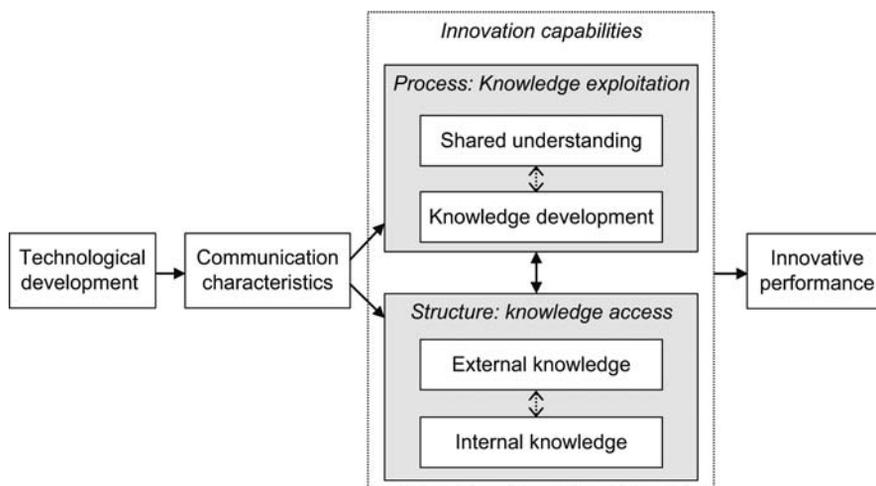


Figure 2.
Refined conceptual model

therefore relevant to consider the social and cultural context of teamwork. Use of virtual teams in global projects thus necessitates research concerning transcultural issues and power relations between organizations, as well as exploration of communication challenges because of different cultural conventions regarding use of technology. Research on effects of cultural diversity on virtual teamwork has largely focused on the early stages of team life (e.g. Staples and Zhao, 2006). However, research on non-virtual teams has shown that the strength of the social ties increases and stereotype perceptions due to use of salient cues decrease over time (McLeod *et al.*, 1996; Watson *et al.*, 1993). Future research on virtual teams should therefore apply more longitudinal approaches in order to capture changes of group processes. The role of ICT in this respect can be related to the importance of selecting and combining communication media based on the degree of social presence considered necessary for the given situation and task at hand. Central factors that may influence the necessity of transferring various types of cues are for example the innovation phase and degree of innovativeness of the teamwork.

Research should also focus on industrial differences in virtual teamwork. In their studies of challenges related to knowledge management in product development teams with cross-functional participants, Ramesh and Tiwana (1999) found that problems related to knowledge development and knowledge sharing were of particular significance in high-tech industries. Providing knowledge of industry characteristics that are important for successful innovation processes is of particular importance considering the increasing market convergence and cross-industry collaboration.

In sum, the model and issues addressed in this paper have important consequences for both practitioners and researchers involved with the functioning of virtual teams. First and foremost, it is important to consider the antecedent conditions for achieving innovative outcomes of virtual teamwork, and by this be able to configure the technologies based on the most relevant factors. In other words, the technology has to be adapted to the situation at hand and the objectives of the teamwork. As use of virtual teams focusing on development of products and services is becoming a viable form for organizational work in modern business life, factors important to the efficiency and effectiveness of such teams should be emphasized in organizational work and future research.

References

- Anderson, N., De Dreu, C.K.W. and Nijstad, B.A. (2004), "The routinization of innovation research: a constructively critical review of the state-of-the-science", *Journal of Organizational Behavior*, Vol. 25 No. 2, pp. 147-73.
- Antonelli, C., Geuna, A. and Steinmueller, W.E. (2000), "Information and communication technologies and the production, distribution and use of knowledge", *International Journal of Technology Management*, Vol. 20 Nos 1/2, pp. 72-94.
- Batt, R. (1999), "Work organization, technology, and performance in customer service and sales", *Industrial and Labor Relations Review*, Vol. 52 No. 4, pp. 539-64.
- Bilgram, V., Brem, A. and Voigt, K.-I. (2008), "User-centric innovations in new product development: systematic identification of lead users harnessing the interactive and collaborative online-tools", *International Journal of Innovation Management*, Vol. 12 No. 3, pp. 419-58.

-
- Black, S.E. and Lynch, L.M. (2004), "What's driving the new economy? The benefits of workplace innovation", *Economic Journal*, Vol. 114 No. 493, pp. 97-116.
- Boutellier, R., Gassmann, O., Macho, H. and Roux, M. (1998), "Management of dispersed product development teams: the role of information technologies", *R&D Management*, Vol. 28 No. 1, pp. 13-25.
- Brem, A. and Voigt, K.-I. (2007), "Innovation management in emerging technology ventures: the concept of an integrated idea management", *International Journal of Technology, Policy and Management*, Vol. 7 No. 3, pp. 304-21.
- Bresnahan, T.F., Brynjolfsson, E. and Hitt, L.M. (2002), "Information technology, workplace organization, and the demand for skilled labor: firm-level evidence", *The Quarterly Journal of Economics*, Vol. 117 No. 1, pp. 339-76.
- Brown, S.L. and Eisenhardt, K.M. (1995), "Product development: past research, present findings, and future directions", *Academy of Management Review*, Vol. 20 No. 2, pp. 343-78.
- Büchel, B. (2005), "New product development team success: the team's knowledge network makes a real difference!", *Perspectives for Managers*, No. 129, available at: www.denisonconsulting.com/Libraries/Resources/Buchel-2005-Perspectives.sflb.ashx (accessed 12 September 2010).
- Carte, T. and Chidambaram, L. (2004), "A capabilities-based theory of technology deployment in diverse teams: leapfrogging the pitfalls of diversity and leveraging its potential with collaborative technology", *Journal of the Association for Information Systems*, Vol. 5 Nos 11/12, pp. 448-71.
- Chesbrough, H.W. (2003), "The era of open innovation", *MIT Sloan Management Review*, Vol. 44 No. 3, pp. 35-41.
- Chesbrough, H.W. and Crowther, A.K. (2006), "Beyond high tech: early adopters of open innovation in other industries", *R&D Management*, Vol. 36 No. 3, pp. 229-36.
- Cohen, W. and Levinthal, D. (1990), "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 128-52.
- de Jong, R., Schalk, R. and Curseu, P.L. (2007), "Virtual communicating, conflicts and performance in teams", *Team Performance Management*, Vol. 14 Nos 7/8, pp. 364-80.
- Diener, E. (1980), "Deindividuation: the absence of self-awareness and self-regulation in group members", in Paulus, P.B. (Ed.), *Psychology of Group Influence*, Erlbaum, Hillsdale, NJ, pp. 209-42.
- Ebrahim, N.A., Ahmed, S. and Taha, Z. (2009), "Virtual teams: a literature review", *Australian Journal of Basic and Applied Sciences*, Vol. 3 No. 3, pp. 2653-69.
- Edelman, L.F., Bresnen, M., Newell, S., Scarbrough, H. and Swan, J. (2004), "The benefits and pitfalls of social capital: empirical evidence from two organizations in the United Kingdom", *British Journal of Management*, Vol. 15, S1, pp. 59-69.
- Evans, P.B. and Wurster, T.S. (1997), "Strategy and the new economics of information", *Harvard Business Review*, Vol. 75 No. 5, pp. 71-82.
- Festinger, L., Pepitone, A. and Newcomb, T. (1952), "Some consequences of de-individuation in a group", *Journal of Abnormal and Social Psychology*, Vol. 47, pp. 382-9.
- Fjermestad, J. (2004), "An analysis of communication mode in group support systems research", *Decision Support Systems*, Vol. 37 No. 2, pp. 239-63.
- Forsyth, D.R. (1983), *An Introduction to Group Dynamics*, Brooks/Cole, Pacific Grove, CA.

- Gersick, C.J.G. and Hackman, J.R. (1990), "Habitual routines in task performing groups", *Organizational Behavior and Human Decision Processes*, Vol. 47 No. 1, pp. 65-97.
- Gibson, C.B. and Gibbs, J.L. (2006), "Unpacking the concept of virtuality: the effects of geographic dispersion, electronic dependence, dynamic structure, and national diversity on team innovation", *Administrative Science Quarterly*, Vol. 51 No. 3, pp. 451-95.
- Granovetter, M.S. (1973), "The strength of weak ties", *American Journal of Sociology*, Vol. 78 No. 6, pp. 1360-80.
- Hagedoorn, J. and Duysters, G. (1999), "Learning in dynamic inter-firm networks: the efficacy of multiple contacts", Research Memoranda 009, MERIT, Maastricht Economic Research Institute on Innovation and Technology, Maastricht, available at: <http://edocs.uu.unimaas.nl/loader/file.asp?id=146> (accessed 12 September 2010).
- Hansen, M.T. (1999), "The search-transfer problem: the role of weak ties in sharing knowledge across organizational subunits", *Administrative Science Quarterly*, Vol. 44 No. 1, pp. 82-111.
- Hempell, T. (2005), "Does experience matter? Innovations and the productivity of information and communication technologies in German services", *Economics of Innovation and New Technology*, Vol. 14 No. 4, pp. 277-303.
- Hempell, T. and Zwick, T. (2008), "New technology, work organization, and innovation", *Economics of Innovation and New Technology*, Vol. 17 No. 4, pp. 331-54.
- Hertel, G., Geister, S. and Konradt, U. (2005), "Managing virtual teams: a review of current empirical research", *Human Resource Management Review*, Vol. 15 No. 1, pp. 69-95.
- Hujer, R. and Radić, D. (2003), "Holistic innovation success? Complementarities between flexible workplace and human resource management practices in the innovation process", paper presented at the ZEW Workshop "Empirical Economics of Innovation and Patenting" at the Centre for European Economic Research, Mannheim, 14-15 March.
- Iansiti, M. and MacCormack, A. (1997), "Developing products on internet time", *Harvard Business Review*, Vol. 75 No. 5, pp. 108-17.
- Katz, R. (1982), "The effects of group longevity on project communication and performance", *Administrative Science Quarterly*, Vol. 27 No. 1, pp. 81-104.
- Kaufman, S. (1995), *At Home in the Universe: The Search for the Laws of Self-organization and Complexity*, Oxford University Press, New York, NY.
- Keller, R.T. (1986), "Predictors of the performance of project groups in R&D organizations", *Academy of Management Journal*, Vol. 29 No. 4, pp. 715-26.
- Kessler, E.H. (1996), "Innovation speed: a conceptual model of context, antecedents, and outcomes", *Academy of Management Journal*, Vol. 21 No. 4, pp. 1143-91.
- Kiesler, S., Siegel, J. and McGuire, T.W. (1984), "Social psychological aspects of computer-mediated communication", *American Psychologist*, Vol. 39 No. 10, pp. 1123-34.
- Kratzer, J. (2001), "Communication and performance: an empirical study in innovation teams", doctoral dissertation, University of Groningen, Groningen.
- Kreitner, R. and Kinicki, A. (1992), *Organizational Behavior*, Richard D. Irwin, Homewood, IL.
- Leana, C.R. and Van Buren, H.J. III (1999), "Organizational social capital and employment practices", *Academy of Management Review*, Vol. 24 No. 3, pp. 538-55.
- Lebie, L., Rhoades, J. and McGrath, J. (1996), "Interaction processes in computer-mediated and face-to-face groups", *Computer-supported Cooperative Work*, Vol. 4 Nos 2/3, pp. 127-54.

-
- Lee-Kelley, L. and Blackman, D. (2005), "In addition to shared goals: the impact of mental models on team innovation and learning", *International Journal of Innovation and Learning*, Vol. 2 No. 1, pp. 11-25.
- Leonard-Barton, D. (1995), *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*, Harvard Business School Press, Boston, MA.
- Lindbeck, A. and Snower, D. (2000), "Multitask learning and the reorganization of work: from Tayloristic to holistic organization", *Journal of Labor Economics*, Vol. 18 No. 3, pp. 353-76.
- McLeod, P.L., Lobel, S.A. and Cox, T.H. (1996), "Ethnic diversity and creativity in small groups", *Small Group Research*, Vol. 27 No. 2, pp. 248-64.
- Madhavan, R. and Grover, R. (1998), "From embedded knowledge to embodied knowledge: new product development as knowledge management", *Journal of Marketing*, Vol. 62 No. 4, pp. 1-12.
- Malhotra, A., Majchrzak, A., Carman, R. and Lott, V. (2001), "Radical innovation without collocation: a case study at Boeing-Rocketdyne", *MIS Quarterly*, Vol. 25 No. 2, pp. 229-49.
- Martins, L.L., Gilson, L.L. and Maynard, M.T. (2004), "Virtual teams: what do we know and where do we go from here?", *Journal of Management*, Vol. 30 No. 6, pp. 805-35.
- Nakata, C. and Im, S. (2010), "Spurring cross-functional integration for higher new product performance: a group effectiveness perspective", *Journal of Product Innovation Management*, Vol. 27 No. 4, pp. 554-71.
- Newell, S., Tansley, C. and Huang, J. (2004), "Social capital and knowledge integration in an ERP project team: the importance of bridging and bonding", *British Journal of Management*, Vol. 15, S1, pp. 43-57.
- Nohria, N. and Gulati, R. (1996), "Is slack good or bad for innovation?", *Academy of Management Journal*, Vol. 39 No. 5, pp. 1245-64.
- Peters, L.M. and Manz, C.C. (2007), "Identifying antecedents of virtual team collaboration", *Team Performance Management*, Vol. 13 Nos 3/4, pp. 117-29.
- Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004), "Networking and innovation: a systematic review of the evidence", *International Journal of Management Reviews*, Vol. 5/6 Nos 3/4, pp. 137-68.
- Powell, A., Piccoli, G. and Ives, B. (2004), "Virtual teams: a review of current literature and directions for future research", *ACM SIGMIS Database*, Vol. 35 No. 1, pp. 6-36.
- Powell, W.W., Koput, K.W. and Smith-Doerr, L. (1996), "Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology", *Administrative Science Quarterly*, Vol. 41 No. 1, pp. 116-45.
- Ramesh, B. and Tiwana, A. (1999), "Supporting collaborative process knowledge management in new product development teams", *Decision Support Systems*, Vol. 27 Nos 1/2, pp. 213-35.
- Read, A. (2000), "Determinants of successful organizational innovation: a review of current research", *Journal of Management Practice*, Vol. 3 No. 1, pp. 95-119.
- Riggs, J.L., Goodman, M., Finley, R. and Miller, T. (1992), "A decision support system for predicting project success", *Project Management Journal*, Vol. 23, September, pp. 37-43.
- Ritter, T. and Gemünden, H.G. (2003), "Network competence: its impact on innovation success and its antecedents", *Journal of Business Research*, Vol. 56 No. 9, pp. 745-55.

- Schmid, B. (2000), "What is new about the digital economy?", *Electronic Markets*, Vol. 11 No. 1, pp. 44-51.
- Scott, S.G. and Lane, V.R. (2000), "A stakeholder approach to organizational identity", *Academy of Management Review*, Vol. 25 No. 1, pp. 43-62.
- Sethi, R., Smith, D.C. and Park, C.W. (2001), "Cross-functional product development teams, creativity and the innovativeness of new consumer products", *Journal of Marketing Research*, Vol. 38 No. 1, pp. 73-85.
- Sethi, R., Smith, D.C. and Park, C.W. (2002), "How to kill a team's creativity", *Harvard Business Review*, Vol. 80 No. 8, pp. 16-17.
- Siegel, J., Dubrovsky, V., Kiesler, S. and McGuire, T. (1986), "Group processes in computer-mediated communication", *Organizational Behavior and Human Decision Processes*, Vol. 37 No. 2, pp. 157-87.
- Simon, H.A. (1985), "What we know about the creative process", in Kuhn, R.L. (Ed.), *Frontiers in Creative and Innovative Management*, Ballinger Publishing Co., Cambridge, MA, pp. 3-22.
- Sole, D. and Edmondson, A. (2002), "Situated knowledge and learning in dispersed teams", *British Journal of Management*, Vol. 13, S2, pp. 17-34.
- Sproull, L.S. and Kiesler, S. (1986), "Reducing social context cues: the case of electronic mail", *Management Science*, Vol. 32 No. 11, pp. 1492-512.
- Staples, D.S. and Zhao, L. (2006), "The effects of cultural diversity in virtual teams versus face-to-face teams", *Group Decision and Negotiation*, Vol. 15 No. 4, pp. 389-406.
- Svetina, A.C. and Prodan, I. (2008), "How internal and external sources of knowledge contribute to firms' innovation performance", *Managing Global Transitions*, Vol. 6 No. 3, pp. 277-99.
- Tether, B.S. (2002), "Who co-operates for innovation, and why: an empirical analysis", *Research Policy*, Vol. 31 No. 6, pp. 947-67.
- Townsend, A.M., DeMarie, S.M. and Hendrickson, A.R. (1998), "Virtual teams: technology and the workplace of the future", *Academy of Management Executive*, Vol. 12 No. 3, pp. 17-29.
- Tushman, M.L. (1977), "Special boundary roles in the innovation process", *Administrative Science Quarterly*, Vol. 22, December, pp. 587-605.
- Tushman, M.L. and Katz, R. (1980), "External communication and project performance: an investigation into the role of gatekeepers", *Management Science*, Vol. 26 No. 11, pp. 1071-85.
- Tushman, M.L. and Scanlan, T.J. (1981), "Boundary spanning individuals: their role in information transfer and their antecedents", *Academy of Management Journal*, Vol. 24 No. 2, pp. 289-305.
- Van den Bosch, F.A.J., Volberda, H.W. and De Boer, M. (1999), "Coevolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities", *Organization Science*, Vol. 10 No. 5, pp. 551-68.
- von Hippel, E. (1986), "Lead users: a source of novel product concepts", *Management Science*, Vol. 32 No. 7, pp. 791-805.
- Walther, J.B. (1995), "Relational aspects of computer-mediated communication: experimental observations over time", *Organization Science*, Vol. 6 No. 2, pp. 186-203.
- Walther, J.B. (1997), "Group and interpersonal effects in international computer-mediated collaboration", *Human Communication Research*, Vol. 23 No. 3, pp. 342-69.

-
- Watson, W.E., Kumar, K. and Michaelsen, L.K. (1993), "Cultural diversity's impact on interaction process and performance: comparing homogeneous and diverse task groups", *Academy of Management Journal*, Vol. 36 No. 3, pp. 590-602.
- Weisband, S.P., Schneider, S.K. and Connolly, T. (1995), "Computer-mediated communication and social information: status salience and status differences", *Academy of Management Journal*, Vol. 38 No. 4, pp. 1124-51.
- Zand, D.E. (1972), "Trust and managerial problem solving", *Administrative Science Quarterly*, Vol. 17 No. 2, pp. 229-39.
- Zand, D.E. (1981), *Information, Organization, and Power: Effective Management in the Knowledge Society*, McGraw-Hill, New York, NY.
- Zhuang, L. (1995), "Bridging the gap between technology and business strategy: a pilot study on the innovation process", *Management Decision*, Vol. 33 No. 8, pp. 13-21.
- Zwick, T. (2004), "Employee participation and productivity", *Labour Economics*, Vol. 11 No. 6, pp. 715-40.

About the author

Leif Jarle Gressgård is a Senior Research Scientist at the International Research Institute of Stavanger, Department of Social Science and Business Development, in Norway. He holds a PhD in Information Management from the Norwegian School of Economics and Business Administration (NHH), and his main research interests concern problem solving and innovation/creativity in teamwork, computer-mediated communication, and business models in electronic markets. His research has been published in journals such as *Journal of Electronic Commerce Research* and *International Journal of Mobile Communications*. Leif Jarle Gressgård can be contacted at: ljpg@iris.no