



Integrating knowledge transfer and computer-mediated communication: categorizing barriers and possible responses

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Abstract

Communication is at the heart of knowledge transfer (KT). But studies of KT barriers do not explicitly consider the relationship and impact of specific communication modalities on KT. The modalities of computer-mediated communication (CMC), namely email, Voice Over Internet Protocol, Instant Messaging (IM) and the like are generally viewed as a group 'CMC'. In this paper, we analyze the KT literature to distill 21 key barriers to successful KT. These barriers are then categorized according to basic communication theory. We then examine leading theories of CMC and discuss how based on these theories individual CMC modalities can be applied to KT barriers. We conclude with a model that presents the categorized KT barriers in a communication channel model that can be addressed by CMC modalities and that can potentially break down those barriers.

Knowledge Management Research & Practice (2007) 5, 249–259.

doi:10.1057/palgrave.kmrp.8500153

Keywords: computer-mediated communication; knowledge transfer; barriers; knowledge management; communications

Introduction

Moving knowledge from one part of an organization to another is a recognized challenge. Doing this while retaining – or replacing – context is an even greater challenge. But what is at the root of these challenges? Fragmentation caused by the distributed nature of the modern organization often necessitates virtual *ad hoc* teams that conduct most of their interactions through computer-mediated communication (CMC) (Weisenfeld *et al.*, 1998; Jennex, 2000; Schwartz *et al.*, 2000; McKay & Marshall, 2000). In fact, it is generally accepted that the ubiquity and simplicity of CMC is a major catalyst in pushing the distributed nature of work to its limits (see Figure 1). Knowledge transfer (KT) within the rubric of knowledge management (KM) attempts to effectively and efficiently move knowledge within an organization. However, while communications is at the heart of transfer, with very few exceptions there is a disconnect between the CMC literature and the KM literature reflecting a parallel disconnect in these two areas of research. We believe that if CMC is part of the 'problem' in having created an environment in which KT is so crucial, then it should be studied in depth and considered as part of the solution.

In this paper, our approach to enhancing the applicability of CMC to KT is to begin by identifying the known barriers to KT. These barriers are drawn from decades of research into KT, some of which has a technology focus but much of which does not.

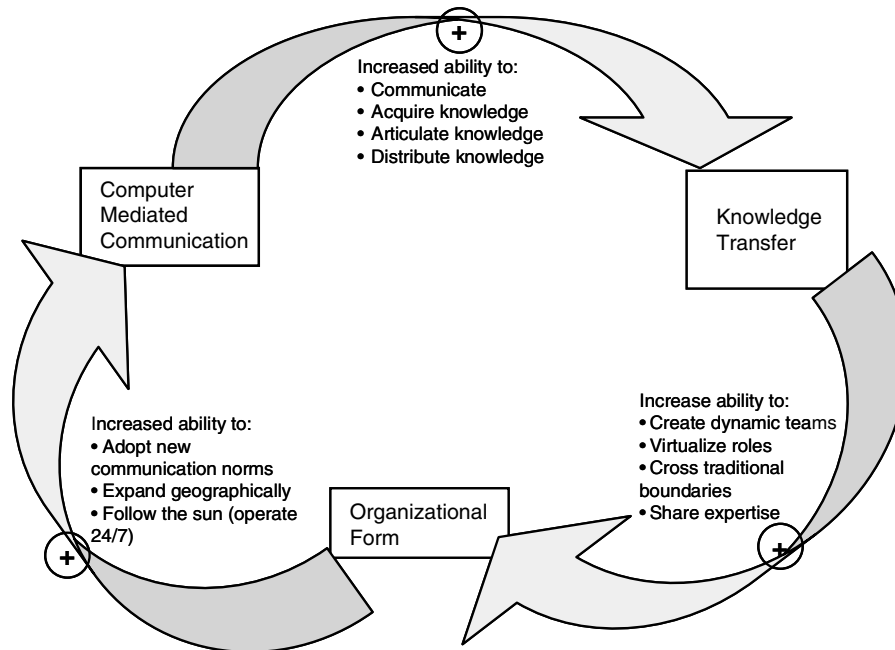


Figure 1 The CMC impact cycle: organizational function view (from Schwartz & Te'eni, 2007).

KT can find some of its roots in Group Decision Support Systems (GDSS). GDSS combine communication, computer, and decision technologies to support problem formulation and solution in group meetings (DeSanctis & Gallupe, 1987). The earliest focus on GDSS was on ways to improve communication and understanding between group members. While not formally identified as KT *per se*, GDSS research has much in common with current KT efforts.

CMC or as Huber (2003) characterizes it, computer-assisted communication technologies (CACT), has grown to include e-mail, instant messaging (IM), chat rooms, video and computer conferencing, facilitating access to people inside and outside a given organization. It is safe to assume that additional technological tools will be added to the CMC toolbox in the coming years.

Since both GDSS and KT have a strong reliance on communication, it may be instructive to view KT as group decision support in which one or more members of the group was present at an earlier time in a different location and is transferring his or her knowledge for use by another member of the group at the present time and location. This conceptualization fits in quite well with the time-place analysis of communication popularized by DeSanctis & Gallupe (1987).

The CMC Impact Cycle (Schwartz & Te'eni, 2007) shown in Figure 1, describes the flow of organizational change moving from CMC to KT to organizational form and back to CMC. In that cycle, the impact of CMC on organizational form is not necessarily direct and can be better understood by interjecting KT as an intermediate step. Research into the CMC Impact Cycle has thus far been limited to the study of how organizational forms

change and has not looked at specific aspects of the KT stages of the cycle.

We begin by providing a review of related work in both KT and CMC. This is followed by a discussion of barriers to KT from which we distill a set of barriers that we wish to better understand through the lens of CMC. The KT barriers are then categorized and placed into a communications channel model. A theory-based discussion of CMC characteristics ensues which is followed by a mapping of those characteristics to the defined KT barriers. We conclude with a model of the relationship between KT and CMC, and provide directions for future research based on this model.

Background and related work

KT is defined by King (2006) as *the focused, unidirectional communication of knowledge between individuals, groups, or organizations such that the recipient of knowledge (a) has a cognitive understanding, (b) has the ability to apply the knowledge, or (c) applies the knowledge* (p. 254). In his discussion of KT, King draws from Argote (1999) and Darr & Kurtzberg (2000) reinforcing the approach that KT is the communication of knowledge from a source so that it is learned and applied by a recipient. A key element in both definitions is the term *communication*, or more specifically 'focused unidirectional communication'.

There is no universal agreement on the definitions of KT, and knowledge sharing, nor any extreme clarity as to the distinction between the two. For the purposes of this article we will follow King's (2006) definition as given above. One possible distinction between KT and sharing is that the latter is primarily concerned with the

individual's view and the former concentrates on the organizational view. In other words, one possible distinction is to say that 'people share knowledge' and 'organizations transfer knowledge'. We do not believe that this distinction is particularly useful in the context of the present work. The advantage of King's definition is that it requires some confirmation on the side of the recipient that knowledge has in fact been passed over. The term *sharing* often connotes the perspective of the initiator or sender (to use the term of choice in the current work), and disregards whether the recipient is actually able to assimilate the knowledge. As it is the *completion* of the transfer process emphasized by King, with recognizable benefits to the recipient, that is most pertinent to a discussion of barriers, we will refer to *transfer* throughout.

We define CMC in the broadest possible manner in order to cover the complete range of tools that are being or may be used in organizational environments. CMC means: *any form of communication between one or more people that uses some element of computer technology to initiate, edit, annotate, (re)transmit, store, retrieve, or view information.* Information, for the purpose of this definition, includes text, static graphics, animation, audio, video, and any other medium that can be represented in digital form for processing, transmission and storage on a networked computing platform. As such this definition would include email, message boards and forums, IM and chat rooms, Voice Over Internet Protocol (VOIP) conversations, network-based videoconferencing and RSS streams. We shall refer to all of the above CMC tools as CMC modalities. The common denominator between all of these modalities is the existence of:

- (a) one or more message sources or authors,
- (b) one or more message recipients,
- (c) a message comprised of one or more information elements.

Note that this definition entertains a number of aspects not considered in previous definitions of CMC. The first is the possibility that the source and recipient is one and the same person. While this type of interaction is in its infancy and has yet to be studied, there are indications from websites such as www.futureme.org and www.mail-to-the-future.com (Ewalt, 2005) that harnessing CMC to communicate with oneself at a future point in time may indeed have measurable impacts and become relevant in an organizational setting – particularly if such communication is role-based. For example, consider the current Chief Financial Officer of a company sending an email message to the Chief Financial Officer one fiscal year later.

Second, under this definition information types can be expanded. For example, once digital medium representational abilities are expanded to include olfactory stimuli (Harel *et al.*, 2003; Torodan, 2005), the definition is predisposed to include digital scent as information to be communicated.

The effects CMC has on the changing nature of the organization is first discussed by Fulk & DeSanctis (1995). Using e-mail to create a shared knowledge context was introduced in Schwartz (1998) and expanded in Schwartz (1999), Schwartz & Te'eni (2000).

Aside from CMC, other areas have been recognized as crucial in achieving successful KT. The importance of trust in KT, despite its almost intuitive certainty, has been the subject of much attention. Sussman & Siegal (2003) study the influence CMC has on establishing trust relationships leading to the adoption of advice (i.e. direct KT) received via e-mail. Van den Hooff *et al.* (2003) reach similar conclusions with respect to knowledge sharing in communities of practice.

Much work has been done on the development and testing of modeling tools to facilitate KT (Basque *et al.*, 2004; Hädrich & Maier, 2006). The study of knowledge flow in the modern organization has been put forth as a crucial element of success, yet the application of theory to flow management through ICT has yet to be realized (Nissen, 2002; Nissen *et al.*, 2000). The relationship between organizational communications and KM is discussed by Te'eni (2006) and that of organizational support to knowledge sharing by Lin (2006). Other studies focus exclusively on the perspective and roles of the Source (Ford & Staples, 2006), or the Recipient (Davey, 2006) in KT processes, rather than the holistic organization-wide view discussed in this article.

Chat or IM technologies have been examined as possible channels for KT. Nardi *et al.* (2000) and Isaacs *et al.* (2002) study the nature of IM conversations with organizations. Ribak *et al.* (2002) examine integrating IM as part of knowledge search processes. Schwartz & Sadan (2006) explore the use of filters to derive context from IM sessions in order to integrate with KM systems. These studies examine the possible impacts of specific CMC modalities on KT without developing any overall framework or model through which these can be studied.

Katzy *et al.* (2000) study the relationship between KM and virtual teams. They present a typology of project interactions and suggest that the transfer of knowledge is 'handled largely by the technological infrastructure'. Majchrzak *et al.* (2000) study the use of *collaborative tools* in support of KT between the members of virtual teams. Their study, however, deals with dedicated collaborative tool applications that have been designed specifically for team collaboration, and not with CMC tools as discussed in this article.

Orlikowski *et al.* (1995), while studying technology use mediation, take a detailed look at how the use of CMC in an organization can be shaped and structured. Their conclusion is of particular importance to the present work – 'In the new and fluid organizational forms now emerging in the face of rapidly changing environments, contextualization of technologies will be a critical mechanism for helping communication norms and work practices adapt'. This conclusion serves as a call for finding formally structured organization and task-specific

adaptations of core CMC technologies – such as KT. Reagens & McEvily (2003) show how network structure and ensuing communication patterns impact knowledge structure in organizations. It is precisely such network structures and communication patterns that we seek to shape and structure in the design of CMC.

What is clear from the extant literature is (a) organizational forms change due to the introduction of CMC; (b) the challenges of KT increase with the advent of virtual projects, teams, and organizations; (c) KT within organizations influences and is impacted by network structure and communications patterns.

While all of the above work contributes to our understanding of how CMC can impact KT, there has been no systematic analysis done that helps explain how specific characteristics of CMC can address specific barriers to KT.

In the next section we distill a set of barriers to KT that will serve as the base hurdle that we wish to overcome through the application of CMC.

Categorizing KT barriers

In surveying the KT literature, we have focused on six studies. These studies deal with KT from either the perspective of explicit barriers or conversely through the identification of critical success factors, the absence of which would constitute a barrier. The studies were chosen based on (a) the thoroughness of the study, (b) a desire to reflect views of KT barriers from different disciplinary backgrounds. They are by no means the only such studies to deal with barriers to KT, but between them cover all the major influencing factors that appear in the literature and as such provide a comprehensive basis upon which to develop our model. After drawing the specific barriers from each study, we then consolidate those that appear in multiple studies, and distill a single list of barriers to KT.

Reagens & McEvily (2003) identify a series of factors critical to successful KT. Specifically:

1. *Ease of transfer* from source to a recipient with ease from the source's point of view being most important.
2. *Acknowledgement of transfer* and *proper attribution* on the part of the recipient is important by often unrecognized or misattributed.
3. *Absorptive capacity* of the recipient, implying that KT between a source and recipient with some common knowledge, background, or characteristics is more likely to succeed.
4. Strength of *interpersonal connection* between the source and recipient will positively affect the ease of KT.

Minbaeva & Michailova (2004) discuss the notion of

1. *disseminative capacity* of organizations and show how the disseminative capacity of multinational corporations, can be measured by the dual factors of
2. ability and
3. *willingness* of knowledge sources to initiate transfer.

While their work focuses on the positive aspects of fostering such behavior, implicit in their results is the fact that the above items serve as barriers to KT if not properly developed and supported.

Simonim (1999) shows how *ambiguity* of knowledge impedes successful transfer. That discussion focuses on how proper context can help alleviate ambiguity and improve the likelihood of successful KT.

Szulanski's (2000) process model of KT highlights the importance of 13 constructs that can become KT barriers:

1. *Stickiness at initiation* where difficulties or impediments occur prior to decision to transfer knowledge.
2. *Stickiness at implementation* where difficulties occur between the decision to transfer knowledge and actual start of the KT process.
3. *Stickiness at ramp-up* where unexpected problems arise between start and finish of the KT process.
4. *Stickiness at integration* where difficulties occur after satisfactory completion of the transfer process.
5. *Ambiguity* as reflected by the depth of knowledge transferred.
6. Unproven nature of what has been transferred and its *degree of conjecture*.
7. *Motivation of the source* of knowledge.
8. *Reliability of the source* of knowledge.
9. *Motivation of the recipient*.
10. *Absorptive capacity* of the recipient.
11. *Retentive capacity* of the recipient which differs from absorptive capacity in that the former is an indication of long-term memory and the latter an indication of initial short-term memory.
12. *Organizational context*.
13. Nature of *relationship between knowledge source and recipient*.

Goh's framework for the transfer of knowledge (2002) indicates seven influencing factors:

1. *Organizational design* that may or may not be conducive to KT.
2. *Motivation* through a reward system that motivates source and recipient.
3. *Available time* for both source and recipient to engage in KT processes.
4. Recipient *knowledge capacity* (which is the same as absorptive capacity in Szulanski's work).
5. Nature of *relationship between source and recipient*.
6. *Type of knowledge* being transferred.
7. Source *propensity to share*.

In Lesser & Fontaine's (2004) analysis they focus on four primary barriers to KT, namely *Awareness*, *Access*, *Application*, and *Perception* where:

1. *Awareness* includes the parallel abilities of the potential recipient to know who might have relevant knowledge and of the knowledge source to know who might be interested in their knowledge.

2. *Access* is similar to Goh's *available time* in that it evaluates how the recipient is able to get the source to devote time to them, and how the source is able to avoid devoting too much time.
3. *Application* combines the concepts of *ambiguity* and *context* so that both source and recipient feel that the knowledge is being properly applied.
4. *Perception* deals with *willingness* and *attribution* of the source, and *motivation* of the recipient.

Consolidating the above six independent research studies results in a list of 21 barriers. We have further aggregated the barriers as pertaining to one of three categories, Source, Recipient, and Organization, as shown in Table 1.

The categorization is important as it will inform our discussion of the use of CMC. In CMC, as in any form of communication, we have at least two primary participants, namely the source of a message and the intended recipient of a message. Thus these two form natural categories for the study of barriers. The third categorization, organization, reflects the contextual element so important to communications (Te'eni, 2001, 2006).

Table 1 Barriers by category

Source
1. Ease of transfer <ol style="list-style-type: none"> a. Stickiness at initiation b. Stickiness at implementation c. Stickiness at ramp-up
2. Ability to transfer
3. Willingness to initiate transfer, propensity to share <ol style="list-style-type: none"> a. Acknowledgement and attribution b. Disseminative capacity c. Interpersonal connection d. Motivation of the source
4. Awareness of need
5. Ambiguity of knowledge
6. Available time/Access
7. Stickiness at integration
8. Motivation
Recipient
9. Awareness of availability
10. Reliability of the source
11. Motivation
12. Available time/Access
13. Ambiguity of knowledge
14. Degree of conjecture
15. Absorptive capacity
16. Retentive capacity
Organization
17. Organizational context
18. Organizational design
19. Motivation/reward system
20. Available time.
21. Nature of relationship between source and recipient.

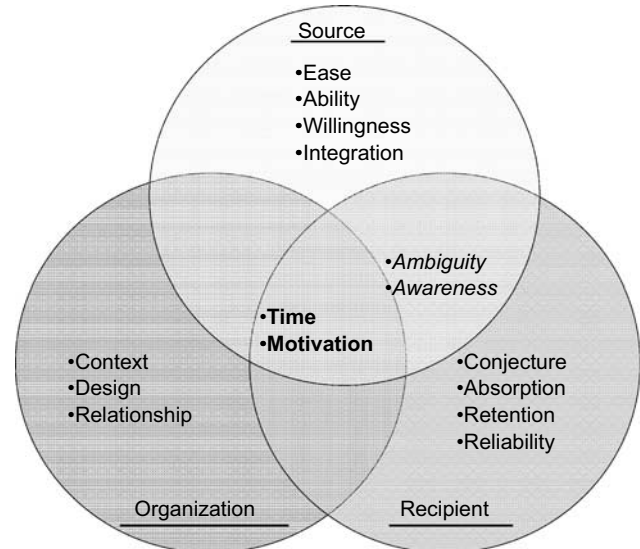


Figure 2 Categorization of knowledge transfer barriers.

Figure 2 graphically depicts the interrelationships and overlaps of each set of barriers.

Mapping barriers to a communications channel model

In general, the contextual element of communication, in this case represented by the organization, serves alternatively as a filter or enhancer to organizational communication. The centrality of the organization's role in facilitating knowledge sharing has been well established (Kelloway & Barling, 2000; Lin & Lee, 2004; Bock *et al.*, 2005; Lin, 2006). Placing the Source and Recipient at either end of a communication process, the organization in the middle as filter/enhancer, and the respective barriers of each group in place, results in the diagram shown in Figure 3. This sets the stage for a view of KT that can be informed by a communications model.

Our next step is to map these grouped barriers on to a basic communication model. One of the earliest and most widely accepted models for organizational communication is that of Schramm (1954, 1960). Schramm's model initially consisted of simply a Sender, Recipient and Message (1954). He later modified the model to include Media (1960) that is the channels used to communicate the message, mitigate its passage, and enhance its chances of completing a communicative act. For a comprehensive historical presentation of communication models and approaches, see Peters (1999). The theoretical background of communication models is important for our model as it provides a foil against which we will examine both KT and CMC.

In essence, the derived communication model that we present replaces Schramm's *media* element with the *organization* as mitigator and facilitator of the communicative act. Each of the identified barrier elements can

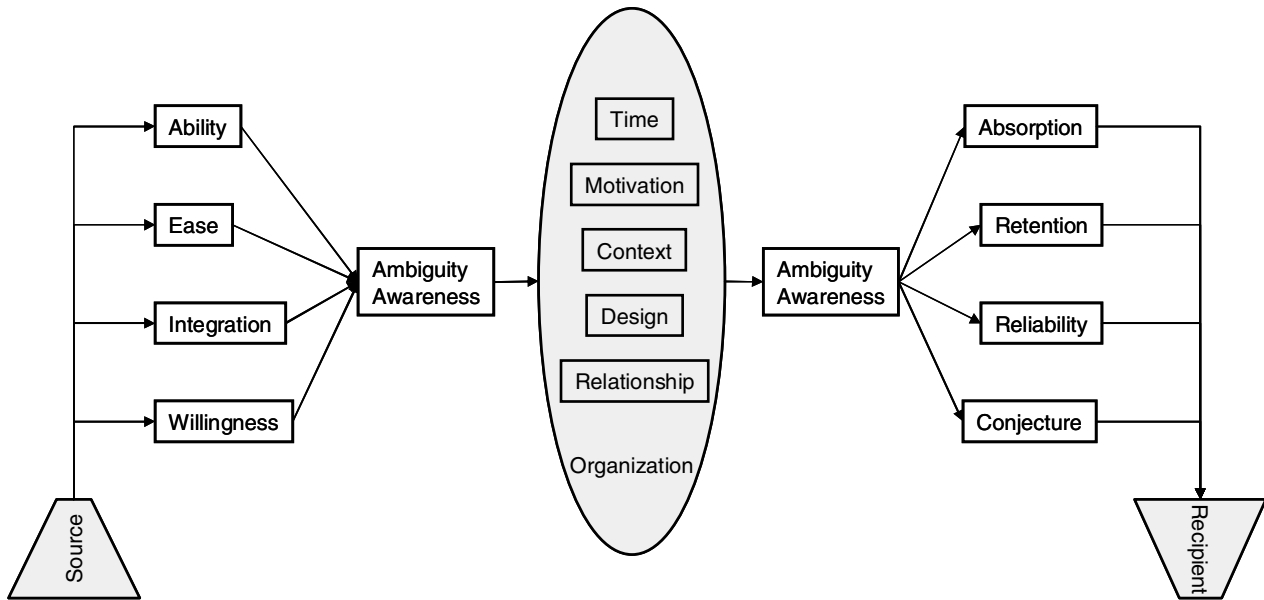


Figure 3 Knowledge transfer barriers as communication channels model.

then be ascribed to either the Sender, Recipient, or Organization.

Figure 3, which shows KT barriers juxtaposed as a communications model, provides us with what can be an evocative and effective tool with which we can apply CMC elements as barrier mitigators.

Related barrier models

There is much other relevant work that deals with KM barriers from different perspectives, some of which discusses the importance of creating and studying basic communication models. Our proposed model is not alone in attempting to use some form of communication model to map knowledge barriers.

Lindsay (2006) presents an exhaustive list of knowledge sharing barriers, which while often related to the individual sharing level rather than transfer *per se*, are also instructive. He presents a communications model that incorporates encoding, decoding, feedback, and channel selection in addition to Sender and Receiver.

Eppler (2006) documents 27 different barriers to knowledge communication that he categorizes into five main groups:

1. Expert-caused difficulties
2. Manager-caused difficulties
3. Mutual behavior
4. Interaction situation
5. Overall organizational context.

Our categorization differs in that it was developed in order to focus specifically on a simplified communication model incorporating just sender, organization, and recipient. The choice of the simplified model is justified in that our focus is solely on the expedience and use of

CMC and not on KT in general. As such, it is useful to create a categorization that parallels communications models, and not a more finely detailed categorization such as that of Eppler (2006).

Jacobson (2006) focuses on the importance of communication channels and modeling communication channels as 'a starting point for a more systematic and scientific approach' (p. 512) to understanding knowledge sharing problems. The *dyadic communication* model espoused by Jacobson considers six factors:

1. Knowledge source
2. Message
3. Knowledge receiver
4. Channel
5. Feedback
6. Environment or Organizational context.

The model that we present retains factors 1, 3, and 6 but views 2, 4, and 5 as external to the communication model and provided or viewed through the lens of CMC functionality. Dividing these factors has the dual benefit of a simplified communication model, and the ability to isolate and focus on those characteristics of CMC that are beneficial to removing barriers to KT. We will now discuss some of those potential benefits.

CMC benefits

Research into CMC has shown that there are a number of specific benefits to the communication process that can be achieved through the introduction of computer mediation.

Karsenty (1999) showed that the inability to share visual task-related information strongly affects the efficiency of communication, implying the importance of

both image and video enhancements to CMC. Bordia (1997) looks at the relative benefits CMC can provide over face-to-face communication.

The importance of *social context* in any framework for CMC in organizations is elucidated by Mantovani (1996) who dismisses the view that 'CMC lacks adequate social cues and fosters impulsive behaviour' concluding that 'Cognitive processes such as categorization, stereotype construction, and social identification can make electronic environments even more strongly sensible to social norms than face-to-face communication'(p. 237).

Richness of communication is shown to be a primary beneficiary of CMC in work by Schwartz & Te'eni (2000), Te'eni (2006), and Schwartz (1999). According to Te'eni (2001), there are five specific communication strategies that are directly supported by CMC, as shown in Table 2:

Each of these strategies can be applied as a mitigating force to the relevant KT barriers presented in Figure 3. But selecting an appropriate strategy is not enough to help on the applied level. For communications strategies to affect change in the KT process, we need to look at the specific ways in which CMC can be applied to implement these and other barrier-reducing strategies.

Applying CMC to the KT barrier communication channel model

Before discussing how specific CMC modalities can affect barrier reduction, we must first enumerate the particular CMC tools or systems relevant to our discussion.

Riva (2001, 2002) suggests a theoretical framework in which the CMC experience involves social actors who negotiate the meaning of various situations through the exchange of multiple cues. In doing so, Riva develops a taxonomy of CMC modalities that consists primarily of *text*, *audio*, and *video* incorporated in IM, Shared Hypermedia, Weblogs, and Graphical Chats, and Video Chats. While considering Positioning Theory, Situated Action Theory, and Social Information Processing Theory, Riva's work does not examine the basic Communications Theory model of Schramm discussed above. It does, however, provides a clear direction to follow in developing a theory that integrates CMC and KT by advocating the explicit consideration and differentiation between the different CMC modalities.

Expanding Riva's CMC taxonomy provides us with a simple categorization of the information types commonly supported by each CMC modality as shown in Table 3.

We begin by specifically enumerating those modes of communication that are considered CMC, namely email, IM, Chat (which we define as multi-participant IM), VOIP, and Video conferencing (or VVOIP – Video and Voice Over Internet Protocol). These seven modes of CMC are known to have increasing levels of both information richness and contextual support (Te'eni, 2001; Kahai & Cooper, 2003; Kock, 2004).

While newsgroups and forums have different technology legacies (the former being based on nntp protocols and the latter on bulletin boards), they essentially provide the same functionality and for our purposes are treated as one and referred to as Forums.

Each CMC modality, as shown in Figure 4, has the ability to reduce KT barriers and move us closer to frictionless transfer of knowledge between source and recipient. One need look no further than the primary theories being used to study CMC usage to see how the judicious application of CMC modalities could lead to a direct reduction of KT barriers.

Media richness theory (Daft & Lengel, 1986) and social presence theory (Short *et al.*, 1976) have been the most influential rational-choice models applied to study the use of communication technology. In rational-choice models, the communicator is expected to determine the most effective medium for conveying a message in a given situation. For example, media richness theory claims that in ambiguous situations, a richer medium, such as face-to-face communication, is more effective than a leaner medium, such as a fax (Te'eni *et al.*, 2001).

Social presence theory equates the degree of social presence with the degree of awareness. This implies that any CMC modality that increases social presence will have the effect of increasing *awareness* thus reducing the effects of that barrier to KT.

Media richness theory, which has grown to become a dominant force in CMC research, states that increasing the expressive capabilities of media in support of collaborative tasks can be the leading element in reducing ambiguity. Here yet another key KT barrier,

Table 2 Computerized support of communications strategies (from Te'eni, 2001)

Contextualization	Organizing and retrieving the context information, structuring the context information presented
Control	Provide feedback on the communication process by manipulating the media, displaying receiver's reactions, recording communication, monitoring progress
Attention focusing	Formatting and structuring the information presented, remote control of information presented
Affectivity	Templates of appropriate affectivity and feedback on current message (e.g., language check)
Perspective taking	Presentation of receiver's views (e.g. cognitive maps or physical objects) to sender at the time of message preparation

Table 3 Primary CMC modality support based on type of information

	Unstructured text	Structured text	Image	Video	Voice	Level of context
Email	X	X	X			Low
Forum	X		X			Medium
Portal	X	X	X	X	X	Medium
IM	X		X	X	X	High
Chat	X		X	X	X	High
VOIP					X	High
VVOIP				X	X	High

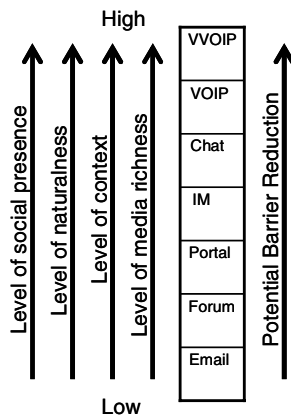


Figure 4 CMC modalities and communication characteristics.

the ambiguity identified on both the sender and recipient's side of the model, can be effectively reduced.

In a departure from the popular theories of social presence and media richness, Kock (2004) proposes a psychobiological model to explain the effectiveness of CMC. He suggests that there is a negative relationship between the 'naturalness' of a CMC medium and the cognitive effort required to achieve KT through the use of CMC. Naturalness refers to the extent to which CMC recreates face-to-face communication. The Media Naturalness Proposition, according to Kock, is as follows: 'Decreases in the degree of naturalness of a CMC medium lead to increases in the degree of cognitive effort required from an individual to use the medium for communication to accomplish a collaborative task' (p. 333). Reflecting on the converse of this proposition, we would expect that increases in the degree of CMC medium naturalness would lead to a lesser degree of cognitive effort required and this, we would argue, will directly reduce the barriers of absorption and retention in the side of the recipient and reduce the barriers of ease and willingness on the sender side.

The view presented by Figure 3 in which KT barriers are juxtaposed in a communication channel model helps direct us towards the appropriate and effective application of the CMC modalities, supported by CMC theories and enumerated in Figure 4.

In pursuing more effective KT, we argue that each barrier in the communication process can be attacked by application of the appropriate CMC modality in order to mitigate the barrier's impact through the specific strength of the CMC modality. Table 4 summarizes the potential barrier reduction based on the three theories discussed above.

If one observes the evolution of CMC over the past 5 years, it becomes clear that the technology is moving from standalone CMC modalities such as e-mail, independent forum systems, standalone Chat and IM, etc. to integrated CMC modalities. Current portal systems, for example, integrate a user's personal email alongside forum participation relevant to his/her organizational role. Of even greater import are the developments in the high context modalities. The most recent release of the popular Skype VOIP software, which initially included only IM alongside VOIP, has now been expanded to include both Chat, and Video (VVOIP). This creates a communications environment that incorporates all of the high context modalities in a single application. This may be attractive from a usability and user interface perspective, but it will make our task of reducing KT barriers all the more complex. The key may just be deconstructing CMC so that it can be applied most effectively to the problem points of KT.

Implications for practice and future research

The implications of the KT Barriers as Communication Channels Model are many and we suggest the following future directions.

1. Additional theories of CMC can be examined with respect to the KT Barriers model in a manner similar to what we have done with the Media Richness, Social Presence, and Psychobiological theories.
2. Robust high context KT systems could be built by integrating existing CMC applications; KT research in this area should focus on identifying which CMC modalities should be integrated into existing KM systems serving a KT function.
3. KT barriers can be addressed through a best-of-breed approach to adopting the CMC modality most proficient in reducing the given barrier; Research into how organizations select specific CMC modalities based on

Table 4 Summary of CMC theories addressing KT barriers

Applicable CMC theory	Knowledge transfer barrier reduction	Mitigating force
Psychobiological	Ease Willingness Absorption Retention	Naturalness and reduced cognitive effort Naturalness and reduced cognitive effort Reduced cognitive effort Reduced cognitive effort
Media richness	Ambiguity Context	Expressive capabilities Expressive capabilities
Social Presence	Awareness	Presence

Table 5 The time-place categorization of CMC (adapted from De Sanctis and Gallupe, 1987)

	Different place	Same place
Different time	eMail Newsgroups Forums Portals	Office bulletin Board
Same time	IM Chat VOIP VVOIP	Classroom Face-to-face meeting

multiple IT considerations should be conducted, and KT should be included as one of those considerations. Having KT on the agenda in the adoption process of CMC technologies will better position an organization to make the best use of that modality.

- The use of multiple CMC modalities may combine to address multiple barriers, depending on the organizational KT environment. Research that creates 'combination plates' of CMC modalities and targeted barriers can help determine preferred combinations.
- The behavior of specific KT barriers can be isolated and studied to see how each is impacted by specific CMC modalities.
- The Time-Space impact of CMC modalities on KT barriers must also be investigated. Much work in communications theory is based on the widely used space-time categorization of DeSanctis & Gallupe (1987). That model, when populated with various CMC solutions is useful in that it clearly delineates the temporal and location characteristics of each mode (Table 5).

The 2 × 2 classic matrix is expanded in Grundin (1994) to a 3 × 3 matrix that splits the 'different' aspect between

'different and predictable' and 'different and unpredictable'. Current KT research does not differentiate between *different but predictable* and *different and unpredictable* communication modes. This distinction may be important in the analysis of KT, depending on the distributed nature of the organization in question, and should be an area of future research.

Summary

There are a number of isolated attempts to connect KM systems to CMC. There is clear consensus that CMC is influencing the growth of virtual and distributed organizations while KT is recognized as being more difficult in these same types of organizations. We believe that for effective KT solutions to develop, a comprehensive orchestrated approach grounded in CMC is required. This article presents a mapping between the capabilities, affects, strengths, and weaknesses of CMC and the barriers to KT in organizations.

We have shown where CMC does indeed contribute to the problems of KT in organizations; we then surveyed the barriers to KT. This resulted in an aggregation of KT barriers that were then presented in a new communication channel model. With this analysis in hand we then enumerated CMC modalities and leading CMC theories, discussing how they should be harnessed and focused to address the specific KT barriers, explaining how the known characteristics of different CMC solutions are capable of being applied to different barriers. Based on the KT Barriers as Communications Channels model, a number of research directions were discussed.

The approach we have advocated is integrative, taking what we have learned from the KT literature and applying what we know from the CMC literature which continues to evolve. The ideas and model presented in this article can serve as the foundation for such an approach and help map out the basis upon which future KT systems integrated with CMC can be built.

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