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PERCEIVED RISKS AND ICT USE

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ABSTRACT

The objective of this research is to investigate the types of problems and their associated perceived risks as well as the effects of risks perceived on frequently used information communication technologies (ICTs) by globally distributed software development teams. We focused on perceived risk in reception, understanding and action and studied two global software teams that were at different software development phases (i.e. requirements analysis versus development and maintenance). Data for this research was collected from a leading global IT consulting company and we found that instant messaging, email and teleconferencing system were frequently used by the two teams. Our results indicate that perceived risks in reception and action were encountered by members in the systems development and maintenance phase. Additionally, we also found differences on the effects of perceived risks on the use of instant messaging, email and teleconferencing system between the teams.

Keywords: Software Development, Distributed Teams, ICT Use, Perceived Risk, Organization Communication

INTRODUCTION

Communication is an important determinant of an organization's functions and successes. The prevalence of global alliances, off-shore outsourcing and international trade has changed how organizational members communicate with each other. Information and communication technologies (ICT) play a critical role in enabling communication among globally distributed teams [16], [41]. In particular, ICT have made it possible for globally distributed software development teams (GSDT) to collaborate and communicate from distant locations [23] and to take advantage of resources at local sites [5]. However, previous research has also shown that use of ICT by distributed colleagues increases uncertainty into the communication process potentially threatening the success of the interaction [20]. Most of this research has not addressed the individual's recognition of the possibility of communication problems and their effects on ICT used to support distributed communication.

In this study, we examine perception of potential communication problems and their effects on the use of commonly available ICT such as email, instant messaging and teleconferencing in a globally distributed software development work environment. We view the perception of potential communication problems as the communication risk people perceive when they sense potential threats to successful communication [2]. In a globally distributed software development environment, work is spread between team members in different locations and therefore distributed communication is central to performance [32], [33]. Specifically, communication-based activities (i.e. interacting about systems requirements, ensuring understanding of shifting priorities at different locations) are critical yet challenging tasks that GSDT members are involved in regularly. Further, global

software development projects typically have to go through different software development phases. The different phases may involve different activities such as requirements and specification analysis, architectural design, detailed design, development (i.e. module coding, module testing, integration testing) and on-going product maintenance [12], [6]. These activities are different in nature; they require different tools and resources, require different skills from team members, need different inputs and have different deliverables [12]. As such, it is likely that GSDT in different software development phases may encounter different set of communication problems and perceive different risks.

Thus the objective of this exploratory research is to investigate the types of problems and their associated perceived risks as well as the effects of risks perceived on the ICTs used by GSDT. We focus on two software development phases (i.e. requirements analysis versus development/maintenance) in this study. The main reason for focusing on the requirement analysis phase is because it is considered to be the most problematic yet an important phase of the software development process [3]. We examine three types of perceived communication risks and they are perceived risk of reception, perceived risk of understanding and perceived risk of action [20]. In terms of the ICTs used, we focus on the commonly and most frequently used ICT by globally distributed software development teams. Examining perceived communication risks in an actual organization context is important as it sheds lights on the strengths and weaknesses of commonly available ICTs and how organizations can develop better strategies to better manage them. Further, Robert et al [31] in their experimental research also advocated the importance towards better understanding the effects of perceived risks in ICT-mediated communication in the workplace as research in this area is still very limited in scope.

BACKGROUND

Globally Distributed Software Development Teams

Offshore outsourcing of software development work from US to India began in the early 1970's and problems encountered by GSDT have been well documented in the literature [9]. As different activities within the software development process can be modularized, these activities can be distributed to different people in multiple locations. Past research has indicated that problems encountered by geographically distributed teams are likely to be exacerbated in the context of software development as global software projects are especially complex and prone to difficulty, and even failure [19].

ICT plays an essential role in a software development project [7] since the output of the software development process is a collection of binary files which comprise the documentation, source codes and executables [26]. These binary files can be transmitted to many different places rapidly via electronic

means. Since the work product can be electronically transmitted, software development team members can work from different locations and time zones. However, difficulties during such software development process range from substantial delay in any work split across sites [14] to increased need to cope with unforeseen events [13] have been documented in the literature.

Indeed, software development is a collaborative process requiring extensive communication. This collaborative process is prone to break down when working across time zones and distance. Communication problems such as miscommunication of requirements and lack of shared understandings have been reported in the literature [17], [19]. Furthermore, distributed communication can have a negative effect on the software development process. Herbsleb and Mockus [15] found evidence that software development work conducted across distributed sites took longer to perform than similar work at collocated sites.

To add to the complexity, a software project has to go through many phases of the software development life cycle such as requirements and specification analysis, architectural design, detailed design, systems development (i.e. module coding, module testing, integration testing) and on-going product maintenance [12], [6]. In this study, we focus on the requirement analysis phase and the development and maintenance phase. Requirements analysis can be characterized as “a highly creative iterative and subjective tasks — there is usually no right answer and the group seeks to find a ‘best-fit’ solution from the total solution space” [12]. Requirements determination has long been a problematic but an important area in software development [3]. The evolutionary nature of the requirements, which are clarified only through multiple iterations of information gathering, and the need for input from a variety of different people increase the complexity during requirements analysis. In contrast, development and maintenance tasks such as detailed design, coding and testing are more tightly designed activities with smaller solution spaces and with more readily identifiable problems that can be modularized [12]. In other words, there is less dependence on group interaction and the task is more highly specified during the software development and maintenance phase.

Hence, these phases are substantially different in nature: they require different tools and resources, different skills from team members and have different inputs and deliverables [12]. Intuitively, individuals working in different phases of the software development lifecycle may encounter different communication problems and may require different ICTs to support the different activities. Even though past research on geographically distributed teams has shed light on how teams can be more effective when working globally, most of this work does not address the complexities of using ICT and its relationship to the perceived problems and challenges encountered by GDSDT. In particular, very little empirical work in this area has been conducted on global software development work [9]. To fill this gap, we focus on the relationship between perceived problems in communication and the use of ICT by GDSDT.

ICT Use in the Distributed Work Environment

The impact of ICTs on individuals’ communication practices and work have been widely examined [10], [11]. Early studies on the use of ICT to support distributed work focus more on specific technologies used to support dispersed communication. For

instance, Scott and Timmerman [35] found that fixed phone and voicemail were the most frequently used ICT among distributed workers while video-conferencing was rarely used. Delone et al. [9], however, noted that video-conferencing was used mainly for socialization in the distributed workplace. More recent studies indicate that the development and implementation of newer tools such as instant messaging may replace the use of traditional ICT such as telephone and email. Sivunen and Valo [37] found that instant messaging and online discussion forum may to some extent have overtaken the fixed telephone for virtual teams. This is not surprising since Nardi et al. [25] found that instant messaging is perceived to be less intrusive than a phone call and is more likely than email to get an immediate respond. However, some studies found that even simple and traditional ICT such as email was flexible and effective for carrying out both simple and complex communication in the distributed work environment [42]. Indeed, email has found to replace informal conversations, brainstorming meetings and discussion [42], [28] or as a means for team leader to find out how distributed team members were doing [37].

In terms of the problem encountered by workers in a distributed work setting, multiple studies have indicated that people experience higher levels of conflict and misunderstanding when they have to work with distributed co-workers [17]. In particular, the use of ICT by distributed colleagues introduces significant uncertainty into different aspects of the communication process. Cramton found that communication was especially “leaky” in distributed environments leading to different perspectives and confusion among colleagues [8]. Errors in email addresses, failure to send copies to all relevant parties, and other problems with message distribution led to misunderstandings and ultimately poor performance. Olson and Olson found that the use of teleconferencing systems resulted in difficulties to keeping track of who was talking during a conversation, consequently reducing the effectiveness of the meeting [27]. Collectively, these studies show that the use of ICT in a distributed work place has been negatively associated with the reception and understanding of the message being conveyed, and the hindrance of effective action being taken by the recipient (e.g. [8], [20], [21], [27], [41]).

While this research has provided valuable insights into enhancing the performance of distributed work, some limitations exist. These studies have tended to investigate which ICT was used by workers in a distributed environment and for what purpose. However, little research has shed light on the perceived risks at different phases of the software development lifecycle and the relationships between the risks perceived during communication and the ICTs used during different phases of the software development lifecycle.

Perceived Risks in Distributed Communication

The ability to perceive communication problems is essential for organization communicators as perceptions form part of the web of sense making surrounding the organization [36] enabling communicators to minimize potential communication failures. Studies on ICT use have also indicated that an individual’s perception of the communication process has effects on the communication outcome during ICT-mediated communication (e.g. [4], [21]). Thus, by extension, understanding individuals’ perception of the communication problems is important as it may affect the ICTs used and ultimately affect the communication outcome.

A major challenge in examining the concept of perceived risk in an organization setting is the question of whether organization members utilize such information in risk assessments in their daily work environment. Specifically, human decision makers typically do not treat risk with a probability concept but rather they focus on their feelings towards the risk [20]. For this reason, some researchers further proposed that risk is socially constructed rather than an objective state of nature. As such, perceived risk is also judged in terms of social and psychological dimensions other than probability. High perceived risk situations involve a threat of a poor performance or an adverse outcome and success is defined through the avoidance of such alternatives [21]. This sociological view of perceived risk includes the social context of the communication considers how individuals feel about the negative consequence and their perception of whether they are able to control the negative consequence.

In this study, we draw on the concept of perceived risks in communication [20] to examine the types of communication problems encountered by GSDST members. According to the authors, perceived risks in communication develop when individuals perceive problems that will hinder successful communication and three types of perceived risks are identified. First, perceived risk of reception develops when individuals see a threat to accurate reception of the message while perceived risk of understanding develops when individuals become aware of potential problems in the receiver's understanding of the message during communication. Finally, perceived risk of action develops when individuals notice potential problems with the implementation or intended action of the communication.

Our review on GSDST indicates that the requirements analysis phase has long been considered the most problematic phases of the software development process while the development and maintenance phase addresses a more bounded area and requires less interaction. Further, it is likely that the communication risks perceived during different phases of the software development lifecycle may be different because due to the different activities conducted and different problems encountered in the different phases. However, it is not clear the differences between the risks perceived in the different software development phases. Hence, we propose the following research question:

R1: What are the differences in communication risks perceived between the requirements analysis phase versus the development/maintenance phase of software development?

As discussed earlier, perceived risk does not solely depend on the process of identifying and assessing risk but rather it is also related to an individual's perception of his ability to control the negative outcome by taking precautionary steps and actions to reduce the negative consequence to an acceptable level. In this study, we examine the effects of perceived risks on the use of commonly available ICTs as past research suggests that ICT use in a distributed environment may be linked to users' efforts to minimize potential problems [20]. For instance, email and teleconferencing have been documented as appropriate ICTs for developing common understanding [9], [20] and will likely be used when users deem that there is a lack of common understanding. Similarly, electronic tracking tools have been shown to be useful for software project management [9] as it provides resources to allow users to monitor progress and

actions. Further, prior research has suggested that technologies such as emails and instant messaging which afford persistence communication by allowing communications to be saved, archived and read at later convenient time are likely to play important roles in the workplace. In particular, such affordances are particularly useful for GSDST because problems and issues encountered in a software development work setting usually need to be documented. However, different phases of the software development lifecycle may encounter different communication problem and the needs for different ICT may vary. Hence, we propose the following research questions:

R2: What are the differences in the effects of perceived risks in communication on the use of ICTs between requirements analysis phase versus the development/maintenance phase?

METHODS

Research Setting

Past studies have advocated that a real world context is essential for research examining the interplay between organizational communication and communication technology usage [43]. Furthermore, research into actual work situations is particularly important for studies of distributed work context. For the above reasons, our study was conducted in a global IT consulting company. Employees in the company are geographically and temporally distributed with some employees located at the headquarters in India and other employees located at different clients' sites in the U.S. As the core business of the company is in IT consulting and custom software development, employees are involved in different aspects of software development work such as managing software development projects, coordinating business and functional requirements, developing customized software for various clients, providing IT consultation and providing help-desk and/or end-user support. Effective and efficient communication between employees located in different countries (India and U.S.) and time zones, as well as that between employees and clients is extremely vital for the company.

Since organizational factors [41] as well as individuals' job categories [29] have been found to be potential factors that may influence organization members' use of ICT, we deliberately control for such possible confounds by holding the organization constant. Hence, together with a senior manager of the company, we selected two globally distributed project teams from the company that were in different phases of the software development life cycle to participate in our research study. The first team, Team A, was more recently formed and provided consulting services to a worldwide marketing information provider. All the projects that team A managed were in the initial *requirements analysis* phase of the software development lifecycle. The second team, Team B, provided consulting services to a global telecommunication company. Most of the projects that Team B handled were in the *development/maintenance* phase of the software development life cycle at the point of our data collection.

There were several reasons why this company and the two teams were appropriate for the research. First, employees from the two teams utilized many different types of ICTs in their daily work since communication with non co-located colleagues or clients was a major part of their work routines. Second, effective communication was extremely critical to the company

since potential communication failures could affect the software development process and result in failure to meet project deadlines, escalation of project costs, and erosion of customer satisfaction. Such undesirable consequences were likely to affect the reputation and financial bottom line of the company. Third, our aim was to select two most comparable teams within the same organization to eliminate other confounding influences. The two team selected were similar in many aspects such as profiles of the team members, team structures, resources available to both teams, ICTs available and time zone differences between onshore and offshore team members. Finally, by studying the two teams, we were holding the structural characteristics of the company and its industry constant. Furthermore, since the two teams were at different phases of the software development, we believed that with careful consideration, the comparison would be able to provide insights on the risks perceived and ICTs used at different phases of the software development cycle.

Data Collection

We collected data via two mechanisms — communication diaries and interviews. Participants were asked to keep a diary of their communication activities for one day. Twenty-seven employees from Team A and twenty employees from Team B participated in our study. The forty-seven respondents were full-time members of their respective teams. The respondents were requested to update a one-day diary of all communication activities over different time periods throughout the day. For each communication activity, respondents were to indicate ICT used, and the communication problems they encountered. Additionally, for each communication activity, the respondents were required to indicate their perceived risk of *reception*, *understanding*, and *action* in the communication diary and the ICTs they used for each of the communication activity. To help us better understand the contexts of ICTs used, we conducted follow-up semi-structured interviews with participants so as to elicit more detailed information about the participants' descriptions in the diaries. These interviews took place immediately following diary data collection for each person, in most cases the following day or immediately after working hours the same day. Interviews were conducted over the telephone and lasted approximately one hour. Interview questions were designed to clarify activities and impressions recorded in the diary and to probe for additional information, including any actions individuals may have taken to reduce perceived risk in the communication activity. Responses from participants were transcribed by the interviewer were primarily used to support the quantitative results in this study. Figure 1 summarizes the research procedures.

We collected a total of 445 communication activities from the 47 respondents. Of these 243 communication activities were from Team A while 202 communication activities were from Team B. More than 75% of the team members in both teams were male and have worked in the organization for more than 6 years. Around 60% of the team members in both teams were application programmers, IT consultants and business analysts while the rest were project managers and project leaders. Thirty-three respondents participated in less than 10 communication activities per day. The rest of the respondents participated in between 11 to 20 communication activities per day. Hence, all respondents participated in at least 1 communication activities and no more than 20 communication activities per day.

Measures

It should be noted that identical ICTs were available to both teams which included email, teleconferencing, instant messaging, NetMeeting™, shared electronic repository and videoconferencing. In this study, we focus on the three most frequently used ICTs which were IM, Email, and teleconferencing. Hence, three dichotomous variables (i.e. Use of IM, Use of Email, and Use of Teleconferencing) were used to measure ICT use by the respondents in our study. The operationalization of the three perceived risks in communication variables (i.e. perceived risk of reception (RR), perceived risk of understanding (RU) and perceived risk of action (RA) were based on Lee et al. [20]. Specifically, RR measured the degree of technical problems associated with message generation, transmission, and reception while RU measured the extent of the problems associated with understanding the message. Finally, RA measured to the degree of importance for the communication partners to take correct and immediate action and to fully understand the action to be taken.

Prior to analyzing the data, principal component factor analysis with varimax rotation was used to test the validity of these risk constructs and measures. As shown in table 1, three factors emerged with eigenvalues greater than 1.00 explaining a total of 81.68 percent of the variance. All the items loaded above 0.8 on the appropriate factor and there were no cross-loadings.

To compare perceived risks in communication at requirement analysis versus systems development/maintenance phase of

FIGURE 1: Research procedures

TABLE 1: Factor Analysis, N=445

	Component			Reliability
	1	2	3	
Risk of Reception				0.91
Message generation problems	0.85	0.15	0.24	
Message transmission problems	0.92	0.14	0.18	
Message reception problems	0.87	0.11	0.21	
Risk of Understanding				0.84
Lack of shared background to understand	0.52	0.03	0.69	
Cognitive difficulty to understand	0.42	0.10	0.76	
Extent of information that be mis-communicated	0.27	0.18	0.79	
Lack of communication cues to understand	-0.03	0.32	0.75	
Risk of Action				0.95
Not taking correct action	0.12	0.95	0.11	
Not taking immediate action	0.14	0.90	0.21	
Not understanding the action taken	0.12	0.94	0.19	

**TABLE 2:
ANOVA Results Perceived Risks For Teams A and B**

	Team A <i>Requirements Analysis Phase</i>	Team B <i>Systems Development/Maintenance Phase</i>	
	N=243 <i>Mean (S.D.)</i>	N=202 <i>Mean (S.D.)</i>	F-values
Risks perceived			
Reception (RR)	1.73 (0.85)	1.94 (0.68)	7.73+
Understanding (RU)	2.63 (1.01)	2.48 (0.95)	2.44
Action (RA)	3.11 (1.46)	3.46 (1.32)	6.82**

Note: ** p<0.01, + p <0.10

the software development life cycle, we separated the communication activities from Team A (requirement analysis) and B (systems development/maintenance). First, ANOVA tests were conducted to study the relationship between perceived risks in RR, RU and RA across the two teams. Second, six logistic regression models was applied to test the relationship between perceived risk in the communication and the use of IM, Email and teleconferencing across the two teams. Specifically, three logistic regression models to examine the relationship between the three perceived risk variables and the use of IM, Email and telephone/teleconferencing were tested on communication activities from Team A. Another three models examined the relationship between the three perceived risk variables and the use of IM, Email, and telephone/teleconferencing were tested

on communication activities from team B. Finally, as a base-line comparison, three logistic regression models to examine the relationship between the three perceived risk variables and the use of IM, Email, and telephone/teleconferencing were tested on the overall sample.

It should be noted that the binary logistic regression technique was chosen to analyze the relationship between perceived risk and the use of ICT because the dependent were dichotomous [18]. Wald test was used in the significance test for the logistic regression models. The -2 log-likelihood ratio was used to test the overall logistic model. Specifically, the -2 log-likelihood ratio (-2LL) is also known as the model chi-square statistic. All the statistical analyses in this study were conducted using SPSS.

RESULTS

Our results (refer to table 2) show that except for perceived RU, the risks perceived by respondents from Team A (Requirements Analysis Phase) were significantly different from the risks perceived by respondents at Team B (Development/Maintenance Phase). Specifically, RR (p<0.1) and RA (p<0.01) are significantly higher for Team B than Team A indicating that respondents involving with systems development/maintenance activities were more concerned with RR and RA than respondents involving with software requirements analysis activities. It should be noted that perceived risk in understanding (RU) was not significantly different between the two teams at different phases of the software development phases.

Next, we examined the effects of perceived risks on ICT used by the overall sample and the two teams separately. For the overall sample, we found that RR (p<0.01) was significantly associated with the use of IM, RU and RA (p<0.01) were significantly associated with the use of email, and RR, RU and RA (p<0.01) were all significant associated with the use of teleconferencing (refer to columns 2 in tables 3 to 5).

When we analyzed the sample separately for the two teams, our results show that the effects of perceived RR (p<0.1) and RA (p<0.01) on the use of IM were significant for Team B (development/maintenance) but not for Team A. In fact, there were no significant effects on the use of IM for Team A. In addition, we also found that the effects of perceived RU (p<0.01) and RA (p<0.1) were significant on the use of Email for Team A. However, for Team B, only the effects of perceived RA (p<0.01) on the use of Email was significant. Lastly, we found that the effects of perceived RR (p<0.01) and RA (p<0.01) on the use of telephone/teleconferencing were significant for Team A. As for Team B, only the effects of perceived RU (p<0.01) and RA (p<0.01) on the use of telephone/teleconferencing were significant. The results are shown in tables 3 to 5 (columns 3 and 4). Our results indicate that effects of perceived risks in RR, RU and RA on ICTs used varied for respondents in the two teams.

DISCUSSION

Results from our study provide several important insights into the communication practices of GDSDT. Our objective was to 1) understand whether perceived risk in the communication process differed between GDSDT at different phases of the software development (i.e. requirements gathering phase versus those in systems development and maintenance phase), and 2) to identify differences between the effects of risks perceived on the ICTs used at different phases of the software development

Our empirical results indicate that perceived risks in RR and RA were significantly different between the two teams at different phases of the GSDST. In particular, our results indicate that respondents who were involved in requirement analysis activities tended to develop lower perceived risks in RR and RA than those in systems development and maintenance activities. A plausible explanation is that there are more bounded activities (i.e. defined deadlines) and tighter control in the systems development and maintenance phase. As a result, perceptions of communication problems related to reception of message and action required by

the recipients of the message will be of higher significance for the team working on systems development and maintenance than the team working on requirement analysis. Additionally, our findings suggest that there are no differences between perceived risks in RU between the two teams indicating that communication problems related to message comprehension affect both teams equally. The major findings between perceived risks in communication and the three most frequently ICT are highlighted in the following paragraphs. We first discuss instant messaging (IM), followed by email and teleconferencing system.

TABLE 3: Logistic Regression Results For the Use of IM

	Overall Sample N=445			Team A <i>Requirements Analysis</i> Phase N=243			Team B <i>Systems Development/Maintenance</i> Phase N=202		
	Exp (B)	Wald Statistic	Sig	Exp (B)	Wald Statistic	Sig	Exp (B)	Wald Statistic	Sig
RR	1.90	12.80	0.00**	1.54	2.20	0.14	1.72	3.37	0.07+
RU	0.89	0.54	0.46	0.99	0.00	0.96	1.26	1.13	0.29
RA	1.52	15.33	0.00	1.22	1.07	0.30	1.46	6.32	0.1**
-2 Log Likelihood: χ^2 = 17.01* (8, N=445)				-2 Log Likelihood: χ^2 = 13.74+ (8, N=243)			-2 Log Likelihood: χ^2 = 43.71* (8, N=202)		

Note: Dependent Variable: Use of IM; * p < 0.05, ** p<0.01, + p <0.10, RR: Risk of Reception, RU: Risk of Understanding, RA: Risk of Action, IM: Instant Messaging

TABLE 4: Logistic Regression Results For the Use of Email

	Overall Sample N=445			Team A <i>Requirements Analysis</i> Phase N=243			Team B <i>Systems Development/Maintenance</i> Phase N=202		
	Exp (B)	Wald Statistic	Sig	Exp (B)	Wald Statistic	Sig	Exp (B)	Wald Statistic	Sig
RR	1.28	2.44	0.12	1.17	0.64	0.42	1.26	0.57	0.45
RU	1.38	6.25	0.1**	1.73	10.11	0.0**	1.02	0.01	0.94
RA	1.39	17.48	0.0**	1.18	2.69	0.1+	1.92	19.65	0.0**
-2 Log Likelihood: χ^2 = 10.14 (8, N=445)				-2 Log Likelihood: χ^2 = 9.33 (8, N=243)			-2 Log Likelihood: χ^2 = 25.7** (6, N=202)		

Note: Dependent Variable: Use of IM; * p < 0.05, ** p<0.01, + p <0.10, RR: Risk of Reception, RU: Risk of Understanding, RA: Risk of Action, IM: Instant Messaging

TABLE 5: Logistic Regression Results For the Use of Teleconferencing

	Overall Sample N=445			Team A <i>Requirements Analysis</i> Phase N=243			Team B <i>Systems Development/Maintenance</i> Phase N=202		
	Exp (B)	Wald Statistic	Sig	Exp (B)	Wald Statistic	Sig	Exp (B)	Wald Statistic	Sig
RR	2.47	22.44	0.00**	2.12	10.00	0.0**	3.54	12.91	0.00**
RU	1.59	10.98	0.00**	1.31	2.12	0.15	2.25	11.8	0.00**
RA	1.37	13.86	0.00**	1.54	16.84	0.0**	1.01	0.0	0.96
-2 Log Likelihood: χ^2 = 11.05 (8, N=445)				-2 Log Likelihood: χ^2 = 15.01+ (8, N=243)			-2 Log Likelihood: χ^2 = 9.25 (6, N=202)		

Note: Dependent Variable: Use of IM; * p < 0.05, ** p<0.01, + p <0.10, RR: Risk of Reception, RU: Risk of Understanding, RA: Risk of Action, IM: Instant Messaging

In general, our study indicates that instant messaging is used to insure recipient is available to receive communication (i.e. to reduce perceived risks in RR). An example of a typical response regarding the use of IM to reduce perceived risks in RR is, *"We use instant messaging as the first point of communication as this makes [sure] the person is easily reachable and notified."* We further found that the association between the use of IM and RR and RA was significant for the development/maintenance phase but not significant for the requirements analysis phase. Specifically, we found that respondents involving in systems development/maintenance activities, frequently used IM to support spontaneous communication and to check availability of their communication partners. We believe that this was due to the different problems encountered in the two phases. Specifically, problems in the development/maintenance software development phase may be somewhat unpredictable requiring more ad hoc communication with different partners than problems encountered during the requirements analysis phase. In particular, IM can be useful ad hoc communication past research has indicated that IM is often used to simulate "water-cooler" or "corridor" talk in situations where face to face communication is not possible. Such "corridor" or "water cooler" talk is essential in software development teams for keeping people aware of project-related events and concerns, such as who is doing what in what time frame [15], and more generally, the context in which other people are working [34]. Hence, the unobtrusive nature of IM may have been valuable to check the availability of team members for unscheduled and spontaneous communication for respondents working in the software development and maintenance phase.

We found that respondents who were working on requirements analysis activities used email to manage perceived RU and RA while respondents who were working on systems development used email to manage perceived RA. Team members working at the requirements analysis were particularly concerned about the miscommunication that could occur between the members at the US client's sites and members situated at the company's headquarter in India because of the lack of shared understandings. In such situations, email was an effective tool to provide all the detailed contextual information to prevent any miscommunication. One of the respondents located at the US client's explained that *"email provides detailed contextual information and background information"*. Another important finding from our study is the use of email to manage perceived RA for both teams suggests that email is valuable for different software development phases to manage perceived risk of RA. We attribute this to the permanence of email which allows email messages to be archived and documented which is a critical procedure for software development [1]. Indeed, Markus [24] has found that people would put even simple requests in email just for the sole purpose of documentation. Further, email copies to third parties (team leader or project manager in this case) help to put pressure on the email addressee to conform to certain action required by the respondent [38] which is important during situations with high perceived RA. For instance, an example of an interview response indicating the importance of email to manage perceived risk of RA is: *"I send email to primary guy and backup guy off-shore just in case primary guy doesn't respond or is not around."*

Interestingly, we found that the associations between the three perceived risk variables and the use of teleconferencing system were significant in the overall result. However, when we analyzed Team A and Team B separately, we found that perceived

RA and the use of teleconferencing was significant for Team A (requirement analysis) but not for Team B (development/maintenance) while perceived RU and the use of teleconferencing system was significant for Team B (development/maintenance) but not for Team A (requirement analysis). This clearly indicates that the use of teleconferencing system provides different resources for software development teams at different phases. Specifically, both teams frequently used teleconferencing to enable distributed knowledge sharing sessions suggesting the importance of teleconferencing tools for GSDT to share knowledge during the requirements analysis phase as well as the software development/maintenance phase. This concurs with the findings from past research which has acknowledged the important role facilitated by ICT in supporting knowledge management initiatives [22]. Further, it was reported that knowledge sharing sessions will be most effective in distributed teams when members have accurate knowledge of "who knows what" in the group and when members share their unique knowledge resources freely with other members [2]. Our results further indicate that regular teleconferencing-enabled knowledge sharing sessions are effective for GSDT to support knowledge sharing in both requirements analysis and development/maintenance phases of software development.

Implications for Research

First, our findings contribute to the scant empirical literature on the dynamics of distributed software development teams particularly those embedded in an organizational setting. We also provide a comparison between requirements analysis phase versus development and maintenance phase of software development. Such a comparison enhances our understanding on perceived risks in communication and ultimately their effects on ICT use in different software development phases. Next, we found support for the investigation of the different components of the communication process, especially ICT usage, from a risk perspective as proposed by Lee et al. [20] indicating that different aspects of risk across the three components of the communication process exist in a global software development work environment. The role of perceived risk across the communication process is an important relationship which deserves further study. While there appears to be some consensus that use of ICT by distributed colleagues is often accompanied by communication problems and research has addressed ways to minimize these problems, little research has addressed specific strategies used by individuals to manage perceived risk. As indicated by Orlikowski and Scott [28], the growing complexity and specialization of organizational life requires detailed investigation of multiple issues such as economic, political, strategic and sociological alongside technological ones. Thus, this research takes a first step in this direction. Specifically, we found that the use of some ICT may be useful to manage the risks in communication. We believe more research is needed to understand the effects of context on work practices of global teams, in particular, the affect of local conditions on the development and adaptation of communication media practices in the performance of work activities [41], [42].

Implications for Practice

Our research indicate that different perceived risks are encountered at different phases of software development and hence different ICTs are used to reduce potential threats of potential communication problems encountered at different

phases of GSDST. This suggests different competences that are required to handle the different communication problems and ICT used at different phases of GSDST. In line with this viewpoint is the concept of computer media communication (CMC) competence which briefly refers to the knowledge and skill set required to handle new media technologies [39]. According to the author [39], communicators should be equipped with necessary competence during ICT-mediated communication to achieve effective outcomes. From this perspective, our results imply that managers managing different phases of the software development lifecycle need to be more aware of the different communicative dynamics involved in different phases of the software lifecycle and to provide relevant training to individuals so that they can be equipped with relevant ICT-based communication competence at different phases of the software development phases. Further, our findings on the risks perceived and the ICTs used during different software development also have important implications for developers and researchers working on the evolutionary unified communication infrastructure [30]. Unified communication infrastructure broadly describe an integrated communication infrastructure that has text, audio, video and voice capabilities and focus on providing maximum communication flexibility to users by unifying the messages from the different communication devices available to users. Thus, our finding highlights the types of communication problems encountered by software development teams and the ICTs they used provide important design considerations for developing unified communication systems.

CONCLUSION

In this research, the concept of perceived risks is viewed from the perspective that risk is socially constructed rather than an objective state of nature. Drawing from past research [20], we argue that perceived risks in communication develop when individuals perceive problems that will hinder successful communication and three types of perceived risks are identified — perceived risks in reception, understanding and action. We investigated perceived risks in communication in two globally distributed software development teams within an organization. We found that these three types of perceived risks were encountered in a global software development work environment and showed that there were significant differences in the perceived risks developed by members working in different phases of the software development phases. Additionally, we also identified significant differences on the effects of perceived risks in communication on the use of frequently used ICT. In particular, we found that significant differences in the use of IM, email and teleconferencing systems among members in our two teams. Our overall results indicate that the effects of perceived risks on the use of these ICTs were different for the two teams studied. This suggests that the use of these ICTs are likely to provide difference resources to help software development teams at different phases to manage the different perceived risks encountered at different phase of the software development lifecycle.

We realize the generalizability of our results is limited as this research was conducted in one company with two teams. As this was a field investigation on perceived risks in communication in GSDST, our objective was to eliminate the influence of as many extraneous variables as possible. Specifically, our research design allowed us to investigate teams at two different

phases of software development within the same organization. Because this was a field setting, the teams differed in certain areas, e.g. the history of the teams, the business domain of the software applications. In addition, we note that while the team members were employed by the same organization, the on-site team members were housed at the facilities of two different client organizations. We acknowledge that these factors may have had some influences on risk perception and communication media usage. Nevertheless, our findings provide important insights for future research and for practice. In addition, our study was cross-sectional and we realize a longitudinal design with time lags appropriate to the variables involved would better capture the contextual elements of ICT choice and usage and provide deeper understanding of the complete communication practices in actual work settings.

In sum, this research points to a number of important questions that need to be examined to better understand the performance of GSDST. The complexity of this work environment and the interrelationships between ICT used are just beginning to be identified and untangled. Further research should aim to foster improvements in performance in GSDST.

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