The Effects of Psychological Safety, Team Efficacy, and Transactive Memory System Development on Team Learning Behavior in Virtual Work Teams

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Abstract

The purpose of this study was to provide an analysis of the relationship between psychological safety, team efficacy, transactive memory system (TMS) development, and learning behaviors of virtual teams. Background for this study was provided by four existing theoretical models of team learning. This study utilized correlation analysis and multiple regression analysis methods to help establish that there is a relationship between psychological safety, team efficacy, TMS, and virtual team learning behaviors.

A population that consisted of a variety of teams made up of members of a leading North American plastic pipe trade association were given an electronic survey. Responses from 124 individuals representing 47 individual member companies and 23 distinct teams were gathered. The constructs measured in the survey are conceptually meaningful at the team level. Data were gathered from individual team members to assess team-level variables that were aggregated at that level.

The results of the study indicate that the team interpersonal beliefs of psychological safety and team efficacy were positively associated with team learning behaviors. In addition, TMS was found to be positively associated with team learning behavior, and was moderately correlated to psychological safety and team efficacy.

The main research hypothesis of this study was that the relationship between team psychological safety, team efficacy, and team learning behaviors are moderated by TMS. The hypothesized model that placed TMS as a moderator did show a slight increase in the variation explained in virtual team learning behaviors versus the model with no moderating effect included. This result may indicate a potential moderating effect of TMS, but is not strong enough to make an unequivocal statement. However, the study

found a high degree of correlation between TMS and virtual team learning behaviors, which may indicate that TMS plays an important role in team learning.

This study provided quantitative data and analysis of the interpersonal factors driving team learning behavior, and the development of TMS for virtual teams in an organizational setting. It is believed that information specific to the relationship between the team-level constructs will allow HRD practitioners and researchers to further develop learning in this critical organizational form.

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Chapter 1

INTRODUCTION

Problem Statement

How can organizations facilitate team learning in a virtual environment? Teams have been identified as the key building blocks of organizations (Senge, 1990), and understanding team behaviors and processes is critical to organizational success. Cross-functional teams are a core organizing methodology to enhance performance, creativity, and innovation (Holland, Gaston, & Gomes, 2000).

The use of teams as an organizational unit for working and learning has been well documented (Edmondson, 1999; Garavan & McCarthy, 2008). "Human history is largely a story of people working together in groups to explore, achieve, and conquer. Yet the modern concept of work in large organizations that developed in the late 19th and early 20th centuries is largely a tale of work as a collection of individuals" (Kozlowski & Ilgen, 2006, p. 77). Only in the past few decades have organizations made conscious use of teams to accomplish work and to learn. In a study by Devine, Clayton, Philips, Dunford and Melner (1999) researchers estimated one half of all U.S. organizations make use of teams. Guzzo and Shea's (1992) study revealed that more than 80% of organizations with more than 100 employees use some form of team. It is difficult to think of an organizational setting that does not make use of teams to accomplish work.

An organization's ability to learn is dependent on the ability of its teams to learn (Senge, 1990; Edmondson, Dillon, & Roloff, 2007), yet the potential of collaborative teams to learn and innovate is not always reached (Van den Bossche, Gijselaers, Segers, & Kirschner, 2006). As noted by McCarthy and Garavan (2008), "team learning occurs

when the team decides to adapt or improve" (p. 511). The view that collective learning can occur implies a socio-cognitive process where the group develops its' own consciousness.

At the meso-level of analysis virtual teams have become a dominant organizing tool. "Their growing prevalence reflects many different factors, including the increased global reach of many organizations, changing workforce demographics, and heightened competitive pressures requiring greater organizational flexibility and responsiveness" (Cordery & Soo, 2008, p. 487).

A virtual team is defined as a team in which groups of geographically dispersed people with a common goal carry out interdependent tasks using mostly technology for communication (Bell & Kozlowski, 2002; Jarvenpaa & Leidner, 1998; Lipnack & Stamps, 1997). It has been estimated that upwards of 60 percent of tasks at global companies will be done by geographically separated virtual teams, and that 50 percent of virtual teams would fail to meet their objectives (Zakaria, Amelinckx, & Wilemon, 2004). The rapid evolution of virtual teams in organizations has created a situation where research into virtual teams has significantly lagged their implementation (Cordery & Soo, 2008).

Collaboration in a traditional collocated work setting is relatively easy due to physical proximity. However, when people collaborate from different places, such as in virtual teams, maintaining awareness and involvement presents a real challenge. Sole and Edmondson (2002) found that knowledge situated in different organizational locations inhibits collaboration in dispersed, cross-functional teams. "Spontaneous connections, informal encounters, and peripheral observations, taken for granted in traditional co-

located teams, are difficult if at all possible when collaborating partners are in different places in a virtual team" (Jang, 2009, p. 399). As a result, Virtual teams present another level of complexity in terms of communication and collaboration.

While the development of electronic information and communication technology has allowed virtual work to become easier, faster, and more efficient, Rosen et al. (2007) contended that virtual teams are particularly vulnerable to mistrust, communication breakdown, conflicts, and power struggles. In addition, Choi et al., (2010) noted a key problem underlying the socio-cognitive process in teams is the fact that knowledge in teams is unevenly distributed among individuals and artifacts. Recent studies (Lewis, 2003, 2004; and London, Polzer & Omeregie, 2005) have found that a socio-cognitive structure called transactive memory system (TMS) plays an important role in a team's ability to leverage team member's knowledge.

Team learning and team performance literature have expressed concern over the *knowing-doing gap* (Pfeffer & Sutton, 2000). Results show that no matter how much knowledge is shared among team members, it cannot enhance team performance unless it is effectively applied. As noted by Lewis (2004), face-to-face meetings provide the most information rich communication because they convey verbal and non-verbal information, and this is important in the development of transactive memory systems.

Edmondson et al. (2007) proposed that field-based research to understand context-specific factors and relationships is an important next step in team learning research. This need was noted by Edmondson et al. (2007) when they stated that "we find that scholars have made progress in understanding how teams in general learn, and propose that future work should develop more precise and context specific theories to

help guide research and practice in disparate task and industry domains" (p. 1). The antecedents to team performance are generally known, but not well understood in specific goals/contexts (Edmondson et al., 2007). One important team learning context that lacks research is non-collocated teams that operate in a technology-mediated environment. Research indicates that fruitful collaboration is not merely a case of putting people with relevant knowledge together. Understanding is required in the factors that make up successful collaboration (Van den Bossche et al., 2006). Research on virtual team learning has been largely ignored, and little research exists on successful collaboration and learning in virtual teams in non-educational organizations.

Teams have become the basic organizational unit for getting work done, and virtual teams are increasingly used in our ever flattening world. A gap exists in our understanding of how shared interpersonal beliefs and learning behaviors develop in virtual teams. "Much of our understanding of how such teams function, particularly extant work teams, is still at a very rudimentary stage, and more research clearly needs to be directed at identifying how to design and support highly virtual teams" (Cordery & Soo, 2008, p. 498). Teams are used to draw on a variety of expertise that needs to be coordinated and applied to accomplish work. Such groups or teams may be consulting teams, product development teams, research teams, or other cross-functional, or ad-hoc project teams (Lewis, 2003).

Given the proliferation of virtual and geographically dispersed teams, understanding the factors that help or hinder team learning is critical to their success. Much of the research related to team learning and virtual team learning has been based on student teams or teams within a single organization. No studies have explored the

development of transactive memory systems and team learning using virtual ad-hoc knowledge-worker teams.

Purpose of the Study

The purpose of this study is to provide an analysis of the relationship between psychological safety, team efficacy, transactive memory system (TMS) development, and learning behaviors of virtual teams. This study is guided by a review of the research in team learning (Argyris, 1999; Edmondson, 1999, 2006; Van den Bossche et al., 2006), virtual teams (Zakaria et al., 2004; Cordery & Soo, 2008; Jang, 2009), and transactive memory systems (Lewis, 2003; Wenger, Erber & Raymond, 1991). A literature review is provided in Chapter 2 of this study. Background for this study is provided by four existing theoretical models of team learning (Edmondson 1999; Kolb, 1984; McCarthy & Garavan, 2008; and Van den Bossche et al., 2006). The integration of existing models is captured in theoretical model of team learning proposed by Knapp (2010) which will be used to aid in the collection, organization, and analysis of the data. The proposed relationships presented in the models of team learning will not be tested in this research, but some of the constructs will be used in the study of virtual team learning. I was not able to identify prior studies that collected data to address the questions raised by the proposed new model of virtual team learning in collocated or non-collocated teams.

Research Questions and Objectives

This study seeks to answer the question: does a significant relationship exist between psychological safety, team efficacy, transactive memory systems (TMS)

development, and team learning behaviors in virtual ad-hoc work teams? This broad research question leads to the following questions guiding this inquiry:

1. Are team learning behaviors and TMS exhibited by teams operating in a primarily technology-mediated, non-collocated environment?

2. Does psychological safety and team efficacy contribute to the development of team learning behaviors in a virtual setting?

3. Does TMS have a relationship to virtual team learning behaviors?

4. Does TMS moderate the relationship between psychological safety and team efficacy and team learning behaviors?

The research questions are studied using a quantitative analysis of the interaction between team interpersonal beliefs, transactive memory systems, and learning. Specific methodology will be described in Chapter 3 of this thesis.

Significance of the Study

This study intends to extend the prior research in the areas of organizational learning and development, and team learning by identifying a potential relationship between virtual team beliefs about psychological safety and efficacy, transactive memory system development, and team learning behaviors. This study has the potential to add to our knowledge of the effective processes used by non-collocated ad-hoc work teams to improve learning and effectiveness. A deep contextual understanding of how team beliefs about psychological safety, efficacy, and TMS affect learning behaviors and performance in a virtual team will provide the much needed insight in this growing form of organizational design.

There are numerous implications of this research for HRD theory and practice. This study provides quantitative data and analysis of the interpersonal factors driving team learning behavior, and the development of transactive memory systems for virtual teams in an organizational setting. It is believed that information specific to the relationship between the team-level constructs will allow HRD practitioners and researchers to further develop learning in this critical organizational form, namely virtual teams.

Chapter 2

REVIEW OF THE LITERATURE

Background and Key Constructs

This section provides background information that is the basis for the research model and questions proposed in this study, and will define key constructs used in the study of virtual team learning. The research model for this study is based on three main constructs: virtual team interpersonal beliefs of psychological safety and efficacy, transactive memory system (TMS) development, and virtual team learning behaviors. Each of these broad constructs is further divided into the sub-constructs that are believed to embody them.

A literature search was conducted using major scholarly search databases available through the University of Minnesota including: EBSCO Databases, Academic Search Premier, Business Source Premier, Google Scholar, PsychINFO, and JSTOR. The literature search was further narrowed by conducting searches in specific journals with the greatest number of relevant results from the major areas impacting this study including: HRD, pschology, small groups, management, and teams. This resulted in searches of the following specific journals: Advances in Developing Human Resources, Human Resource Development International, Human Resource Development Review, Foundations of Human Resource Development, Group and Organizational Management, Small Group research, Journal of Applied Psychology, Journal of Management, and Administrative Science Quarterly.

The literature search was conducted using the following relevant subject areas including: administrative science, organizational behavior, social psychology, management sciences, sociology, small group research, and education and learning. Keywords searched in the listed databases and specific journals included: team learning, meta-analysis of team learning, virtual team learning, collective or group efficacy, psychological safety, transactive memory, and transactive memory systems. This search returned a large number of studies particularly in the areas of team learning and collective efficacy. Studies specific to transactive memory systems and virtual team learning proved to be more limited and recent than the well-researched constructs of efficacy and psychological safety.

Teams and team learning have been studied extensively in the psychological, behavioral, and organizational literature since the early 20th century (Lewin, 1948; Mills, 1967; Tuckman, 1965) and more recently by Edmondson (1999) and van den Bossche et al. (2006). While part of team learning, the concept of virtual teams and how they learn is a much newer organizational phenomenon that has seen increasing research activity in the past 10 years, but many areas are yet to be explored. Definitions and research on teams, virtual teams, their interpersonal beliefs, and their learning behaviors will be explored in depth in this chapter.

The theory and research related to the constructs of team learning, team interpersonal beliefs, and transactive memory systems will be explored for face-to-face as well as virtual teams. Based on the existing literature (Edmondson, 1999; Lewis, 2003; Ortega, Manzanares & Rodriguez, 2010; Van den Bossche et al., 2006) it is believed that these constructs apply to teams regardless of their specific context. As such, virtual team

research will be integrated with existing face-to-face body of knowledge to extend the theory of team learning.

Teams

Coverage of the vast amount of research and literature on teams is well beyond the scope of this research. As such, teams are defined to extent necessary to support this research on virtual teams.

Since humans are social beings we have all participated in a team experience in our lives. This may have been in any number of areas such as: sports, education, work, hobbies, etc. While a group is generally thought of as a simple collection of individuals, a team is considered to be much more purposeful. Kozlowski and Ilgen (2006) provide a comprehensive definition of a team as:

> (a) two or more individuals who (b) socially interact (face-to-face or, increasingly virtually); (c) possess one or more common goals; (d) are brought together to perform organizationally relevant tasks; (e) exhibit interdependencies with respect to workflow, goals, and outcomes; (f) have different roles and responsibilities; and (g) are together embedded in an encompassing organizational system with boundaries and linkages to the broader system context and task environment (p. 79).

The key ideas in the definition of work-based teams are that they are a socially constructed organizational entity with a common purpose. Guzzo and Dickson (1996) use the terms "groups" and "teams" interchangeably, and define a work groups similarly to that posited by Kozlowski and Ilgen (2006). This study will also use the terms interchangeably.

Teams are used to draw on a variety of expertise that needs to be coordinated and applied to accomplish work. Such groups or teams may be consulting teams, product development teams, research teams, or other cross-functional, or ad-hoc project teams (Lewis, 2003). The main purpose of knowledge-worker teams, such as ad-hoc project teams, is to leverage members' expertise to create new knowledge in the form of new products, services, or solutions (Nonaka and Takeuchi, 1995). As noted by Lewis (2004) "knowledge worker team's tasks are complex, ambiguous, and require members to apply specialized knowledge gained through formal education or experience" (p. 1520). The characteristics that are embodied in ad-hoc knowledge-worker teams are well suited for study of virtual teams since they are dependent on member expertise to solve complex problems.

Team development is recognized as a holistic process in that all team members go through it together (Kozlowski & Ilgen, 2006). Two seminal models of the team development process include Tuckman's 4-stage model (1965) and Gersick's (1988) punctuated equilibrium model (PEM). Tuckman's (1965) model is recognizable as the linear stages of team development: forming, storming, norming, and performing. Bonebright (2010) provided a historical overview of field practice and academic research on the Tuckman model of team development, and noted that even as technology gained in importance, the model was applied to the development of virtual teams. In contrast to Tuckman's model, the PEM approach views group development as more stable process punctuated by a discontinuous shift that occurs at the midpoint of a group's lifecycle (Kozlowski & Ilgen, 2006).

Social categorization theory argues that when group members replace their categorization of existing groups with the group itself as a social category, thereby cutting across stereotypes, the deleterious effects of categorization are lessened (London et al., 2005). In contrast, some researchers (Ely & Thomas, 2001; Polzer, Milton & Swann, 2002) contend that groups do not have to override their differences to be effective, but instead can learn about each other's unique strengths and areas for potential contribution to the group.

Virtual Teams

Virtual teams are a more recent form of team that presents specific challenges and opportunities. Virtual team learning plays an important role in team development and has been shown to improve team performance in numerous studies (Edmondson, 1999; van den Boscche et al., 2006; Ortega et al., 2010).

Before exploring the development of virtual work teams, it is helpful and necessary to provide the definitions and conceptualizations that are part of this new form of work. Once virtual teams are defined, extant research on virtual teams is explored in greater depth.

A virtual team may be defined as a team in which groups of geographically dispersed people with a common goal carry out interdependent tasks using mostly technology for communication (Bosch-Sijtsema, 2007). Another definition is a virtual team as a group of people, most of whom are not collocated, who work interdependently with a shared purpose across space, time, and organizational boundaries using technology (Lipnack & Stamps, 2000).

Virtual teams have also been defined as "groups of people who work interdependently with shared purpose across space, time and organization boundaries using technology to communicate and collaborate" (Kirkman, Rosen, Gibson, Tesluk, & McPherson, 2002, p. 67). Virtual teams are frequently distinguished from traditional teams because members are temporally and spatially distributed, relying on technologically mediated forms of communication to coordinate their activities (Bell & Kozlowski, 2002). Lin, Chiu, Joe & Tsai (2010) contend that virtual teams are groups that communicate and work synchronously or asynchronously through technology, and their lifespan ranges from a few days to years depending on team type.

Ebrahim, Shamsudin & Taha (2009) provided a summary of the definition of a virtual team as: "small temporary groups of geographically, organizationally, and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks" (p. 2655).

Just as teams span a range of situations and contexts, virtuality is also a matter of degree. Some researchers have noted the potential for variation in the extent to which virtual teams (a) have a membership that spans functional, organizational, and cultural boundaries; (b) involve temporally distributed, rather than real-time, interactions; (c) have a limited lifespan; and (d) require members to perform multiple roles, both within and across teams (e.g., Bell & Kozlowski, 2002). Gibson and Gibbs (2006) further characterized virtual teams as typically varying along four dimensions: (a) *geographic dispersion* of members ranging from those that occupy the same physical space but who operate at different (non-overlapping) times to those whose members are distributed

across different continents and time zones; (b) *electronic dependence* or the degree to which the team depends on electronic devices for task-related communication can vary from teams able to mix electronic interactions with regular face-to-face meetings to others must interact completely via e-mail and the Internet; (c) *dynamic structure* where virtual teams may be formally constituted organizational teams with defined membership and standardized operating routines, or they may have fluctuating membership, shifting performance objectives, limited lifespan, and relatively informal rules of operation; and (d) *national diversity* with membership that spans many different nationalities. "The boundaries created by virtuality, in the form of geographic, cultural, and temporal–spatial separations; the lack of "richness" in many electronically mediated forms of communication; and the fluctuating membership of virtual team structures pose particular challenges to team knowledge development and information sharing" (Cordery & Soo, 2008, p. 491).

On the other hand, it has been noted by Sole and Edmondson (2002) that dispersed teams may be successful, not only because the teams themselves include an appropriate mix of specialists, but because they have enhanced awareness of a greater breadth of situated knowledge from which they are also better positioned to learn.

Virtual teams are not without their problems. As noted by Hinds and Weisband (2003), "members of virtual teams rely heavily on mediating technologies for their day-to-day communications, do not share the same work context, and are not geographically proximate" (p. 21), making knowledge sharing and the development of shared understanding more difficult than it is for collocated teams. Pawar and Sharifi's (1997)

study of collocated versus virtual teams classified teams in six categories, as shown in Table 2.1, which helps situate virtual teams in this study.

Table 2.1: Classifying physical teams versus virtual teams

Activity	Physical Teams Nature	Virtual teams nature
Nature of interaction	Opportunity to share work and non-work related information	The extent of informal exchange of information is minimal
Utilization of resources	Increases the opportunity for allocation and sharing of resources	Each collaborating body will have to have access to similar technical and non-technical infrastructure
Control and accountability (over and within projects)	The project manager provides the context for ongoing monitoring of activities and events and thus enhances their ability to respond to requirements	The collaborating bodies were accountable to the task leaders and th e project coordinator who had limited authority to enforce any penalties for failure to achieve their tasks
Working environment	They encountered constraints accessing information and interacting with others outside the collocated teams within the	Sometimes not able to share ideas or dilemmas with other partners

	company	
Cultural and educational background	Members of the team are likely to have similar and complementary cultural and educational background	The team members varied in their educational, culture, language, time orientation, and expertise
Technological compatibility	Situated and operating within a single organization, faces minimal incompatibility of the technological systems	Compatibility between different systems in collaborating organizations ought to be negotiated at the outset.

Virtual teams are a seemingly natural progression in today's knowledge-based economy. The accelerated pace of technological change, especially in terms of computing and information technology, coupled with the need to respond to global competition for goods, services, revenue, and talent, the need to adapt to change, plus the changes in worker preference toward autonomy and networking has spurred the growth of virtual teams.

Team Learning

Team learning has been conceptualized in a number of ways in the research literature. Some choose to view team learning as part of a community of practice (Brown & Duguid, 1991) or as a subset of organizational learning (Senge, 1990), while others

view team learning from a socio-cognitive perspective (van den Bossche et al., 2007; McCarthy & Garavan, 2008).

Choi et al. (2010) note a key problem underlying the socio-cognitive process in teams is the fact that knowledge in teams is unevenly distributed among individuals and artifacts. Recent studies (Lewis, 2003, 2004; and London et al., 2005) have found that a socio-cognitive structure called transactive memory system (TMS) plays an important role in a team's ability to leverage team member's knowledge.

According to London et al. (2005) the nature of group learning depends on situational demands. Group learning may be adaptive, generative, or transformative (Sessa & London, 2008). These forms of group learning have been described as:

> Adaptive learning is a reactive adjustment of the transitive memory system to changing organizational conditions without much thought or plan. Generative group learning is purposeful. It includes the development and use of new routines that become embedded in a revision to the transactive memory system such as how to orient a new group member or the formulation of contingency plans. Transformative learning entails considerable discussion (reflection) about group processes and member relationships. The identity negotiation process may reemerge, and the transactive memory system may be overhauled (London at al., 2005, p.130).

The communities-of-practice literature (Brown & Duguid, 1991; Garavan & McCarthy, 2008; Wenger, 1998) emphasizes unstructured and informal learning, and tacit knowledge sharing in non-canonical groups with boundaries beyond the organization, while team learning is focused on canonical groups within organizations.

While virtual teams cross the typical collocated organizational boundaries in the physical sense, the concept of team applies equally in this study since teams and team learning are being researched in an organizational context.

As noted by Knapp (2010), team learning may be conceptualized as the development of a combination of two constructs: reflexivity and mutually shared cognition. Reflexivity is the degree to which groups overtly reflect on the team's objectives, strategies, and processes (West, 1996). Collective meta-cognition plus team reflective practice comprise reflexivity. Metacognition was defined by Bruer (1994) as "the ability to think about thinking, to be consciously aware of oneself as a thinker, and to monitor and control one's metal processing" (p. 294), and McCarthy and Garavan (2008) considered this type of shared cognition to be a critical component of team learning.

Garavan and McCarthy's (2008) typology of collective learning in organizations places team learning parallel to collaborative learning and communities of practice emphasizing the cognitive dimension of learning. The cognitive dimension of learning is focused on how individual information is processed, how it is assessed and interpreted in situations, and how problems are solved. At the team level, the development of a shared conception of the problem, or mutually shared cognition, becomes the emphasis (Van den Bossche et al., 2006). Edmondson et al. (2007) view team learning as an "encompassing rubric", or a useful abstraction of an organizational phenomenon, and defined team learning as a process in which a team takes action, obtains and reflects on feedback, and makes changes to adapt or improve (Edmondson, 1999).

Another perspective of team learning is as a dynamic process in which the learning process, the conditions that support the learninig process and team behaviors,

change as the team changes (Sessa & London, 2008). Kayes, Kayes & Kolb (2005) posited that teams follow an experiential learning cycle based on experiential learning theory. Kolb (1984) defined experiential learning as "the process whereby knowledge is created through the transformation of knowledge" (p. 41).

The model proposed by Van den Bossche et al. (2006) presents team learning behaviors as combination of constructs including: construction of meaning, co-construction of meaning, and constructive conflict. In other words the individual construction of meaning is joined with the collaborative construction of meaning to develop new meanings that were not previously available. Constructive conflict is presumed necessary in order to reach agreement prior to group action.

Mills (1967) defined team learning as a reconfiguration of a group's purpose to achieve a continually greater and more complex purpose and described the highest level, growth, as a group capable of following multiple goals, creating high levels of innovation, managing diverse and conflicting types of innovation, and influencing a number of different domains. As noted by Knapp (2010), the highest levels of Mill's (1967) theory may be analogous to double-loop learning proposed by Argyris and Schön (1995) which would require the team to practice critical reflection and dialogue, routinely review basic assumptions about how they work, assess their motivation, and look for signs of defensive reasoning.

A key component in most definitions of team learning is the use of reflection. Reflective practice (Schön, 1983) speaks of the need of practitioners to think about what they are doing while they are doing it. In reflective practice, learning takes place through an iterative process of purposeful actions, discovered consequences, implications,

reassessments, and further actions (Torraco, 2002). Reflection in action is a critical function through which we consciously or unconsciously question the assumptions of our present knowledge (Torraco, 2002).

Knapp (2010) noted that small group and team research in the psychological literature (Guzzo & Dickson, 1996; Ilgen, Hollenbeck, Johnson, & Jundt, 2005) have looked at process models used to conceptualize team constructs, including mediational processes, learning, and performance. Much existing research has been influenced by the well-known systems-driven input–process–output (I-P-O) framework (McGrath & Altman, 1966) of teams. Recognizing that the I-P-O model does not account for "the emerging consensus about teams as complex, adaptive systems," Ilgen et al. (2005, p. 519) introduced the input–mediator–output–input (IMOI) model indicating the complex, nonlinear, cyclical nature of teams.

Most models and discussions of team learning linked team performance to organizational performance. Knapp (2010) posited that a combination of I-P-O models and IMOI models would provide a more comprehensive model of team learning. Teams as a subsystem of a larger organization or community of practice have partially defined, permeable boundaries that require some type of input and output. At the same time, the IMOI-based models presented and researched demonstrate the validity of viewing collective learning as a process developing behaviors that facilitate collective learning.

A combination of I-P-O and IMOI frameworks was proposed by Knapp (2010) as a theoretical composition of four seminal models of team learning (Figure 2.1) to conceptualize team learning as a process while realizing that it is affected by external (to

the team) structure and context and that it results in some performance or effectiveness outcome.

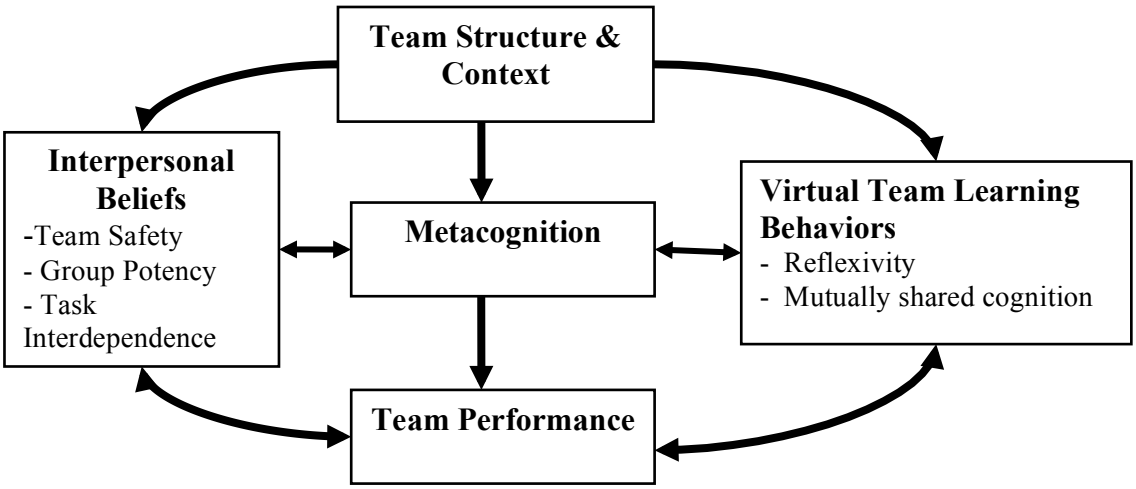

Figure 2.1: Team Learning Beliefs and Behaviors Model (Knapp, 2010)

This conceptualization of team learning is intended to provide a model to help frame the discussion and research of team learning including its antecedents and constructs that research has shown to be important in team learning.

Empirical research has shown that there is a positive correlation between team learning behavior and team performance (Edmondson, 1999; van den Bossche et al., 2006). More recently Ortega et al. (2010) demonstrated a positive relationship between team learning and team performance in virtual teams, and that team learning not only increased team performance, but satisfaction and viability reported by members of virtual teams.

Research on virtual team learning has been able to extend the research on face-to-face teams suggesting that we can apply at least part of the substantial body of theory about team learning in face-to-face contexts to virtual teams (Ortega et al., 2010). While

virtual team learning is not explicitly mentioned in the Ortega et al. (2010) review of team learning, the principles, constructs, and their relationships are treated equally. Research on virtual team learning (Sole & Edmondson, 2002; Ortega et al., 2010) has shown that the same constructs apply. Virtual teams work differently thus the strength of the relationships between constructs may differ from collocated teams.

Interpersonal Team Beliefs

Understanding the antecedents to successful collaboration and team learning, the beliefs that each team member brings into a team, and the beliefs that are developed by the team are important for the study of team learning. As noted by Roschelle and Teasley (1995), the identification of the social conditions under which teams make the effort to reach shared knowledge is an essential prerequisite for developing enhanced understanding of successful collaboration. The main question to be dealt with is: how does this team perceive the interpersonal context formed by their team? Subsequently, these beliefs will influence the behavior of the team (Cohen & Bailey, 1997) and, more specifically, the learning behavior of the team.

As noted by Salomen, Globerson and Guterman (1989), most social effects arise from the evolution of the group as a social system. The shared beliefs that emerge from that interaction are group-level variables which characterized the team more than individuals (Edmondson, 1999). Interpersonal team beliefs identified in the research of team learning (Edmondson, 1999; Kayes, Kayes & Kolb, 2005; McCarthy & Garavan, 2008; Van den Bossche et al., 2006) and virtual team learning (Edmondson, 1999; Ortega et al., 2010) that impact team performance or learning behaviors include: team

psychological safety, group potency or team efficacy, and task interdependence. It is supposed that they form a context that stimulates or inhibits learning behavior (Van den Bossche et al.,2006). All of the identified beliefs about the interpersonal context set the stage for the occurrence of the team learning behavior.

In order to limit the number of variables and focus the research on conceptually similar constructs, task interdependence is not explored in this study of virtual teams, but is believed to be similar across ad-hoc knowledge worker teams included in this research. The team level constructs of psychological safety and efficacy form the context in which teams are motivated to display the crucial learning behavior, and are explored in greater depth in the following sections.

Team psychological safety. Edmondson (1999) introduced the construct of team psychological safety based on the previous work by Schein and Bennis (1965). It should be noted that in this study psychological safety is not the same as group cohesiveness. Edmondson (1999) describes team psychological safety as "a team climate characterized by interpersonal trust and mutual respect, in which people are comfortable being themselves" (p. 354).

Team psychological safety is defined as the shared belief that the team is safe for interpersonal risk-taking (Edmondson, 1999). Learning in groups can be stressful, but the paradox is that learning is often facilitated by taking risks and thinking freely (Van den Bossche et al., 2006). Team psychological safety facilitates learning behavior in teams because it minimizes concerns over team member reactions that can be embarrassing or threatening (Edmondson, 1999). Research has shown that team psychological safety is

positively associated with team learning behavior in studies of collocated teams (Edmondson, 1999; Van den Bossche et al., 2006). Psychological safety allows team members to think critically, feel safe, and take risks which are important components of learning. The confidence needed to learn stems from mutual respect and trust among team members (Edmondson, 1999). However, as noted by Jang (2009), the development of trusting relationships in virtual teams is difficult.

Trust is necessary for members to reduce the risk of opportunistic behaviors and to develop a long-term orientation and determination toward collaboration of a team (Lin et al., 2010). Social exchange requires an individual to trust others to discharge his or her own obligations, as there is no way to force others to reciprocate (Moore & Cunnigham, 1999). Learning requires experimentation and the freedom to express ideas. As noted by Edmondson & Nembhard (2009), these behaviors require interpersonal risk and emphasize the need for psychological safety to mitigate these interpersonal risks.

One of the key elements in trust development is repeated interaction between trusting parties (McAllister, 1995). However, the lack of physical proximity in virtual teams makes communicating and coordinating with distant team members more difficult. Complications arise from physical dispersion, coupled with fluid membership, cultural differences, and lack of prior history in many virtual teams (Lipnack & Stamps, 1997). The study by Gibson and Gibbs (2006) explored the role of psychological safety in virtual teams, and found that a psychologically safe communication climate helped mitigate many of the potential process losses associated with virtual team working. Ortega et al. (2010) study showed that psychological safety stimulates interactions oriented toward learning in project teams that operate virtually. Increased psychological

safety is expected to facilitate team learning behaviors regardless of the context since it facilitates the appropriate environment for learning behaviors.

Virtual team efficacy. The definition of a virtual team has been established allowing us to apply the concept of group or team efficacy to this special type of team. Edmondson (1999) built on the earlier work of Bandura (1977) and extended the concept of team efficacy, in her seminal study of team learning beliefs and behaviors.

Bandura (1997) postulated that an efficacy expectation is the conviction that one can successfully execute the behavior required to produce the desired outcomes, and that efficacy expectations are a major determinant of people's choice of activities, how much effort they will expend, and how long they will sustain their effort. The cognitive mechanism of efficacy, as described by Bandura (1977), logically leads to higher levels of conviction and effort necessary to enhance learning and performance.

Building on earlier work, Bandura (1997) extended self efficacy to groups and stated that collective efficacy can "influence the type of future people seek to achieve, how they manage their resources, the plans and the strategies they construct how much effort they put into their group endeavor, their staying power when collective efforts fail to produce quick results or encounter forcible opposition, and their vulnerability to discouragement" (p. 418).

Group or team efficacy has been used interchangeably with group potency and is defined as "the collective belief of group members that the group can be effective" (Shea & Guzzo, 1987b, p. 26). There are slight differences between the two construct. Group potency has been defined as a measure of a group's perceived general effectiveness

(Guzzo,Yost, Campbell & Shea, 1993). Collective or group efficacy has been defined as a measure of a group's perceived conviction that it can successfully complete a specific task (Bandura, 1997). Jung and Sosik (2003) noted the conceptual overlap of these two terms (Jung & Sosik, 2003). Team efficacy is similar to group potency in that both are intended to mean the team's collective belief that they can accomplish their objectives. For the purpose of this research, which is focused on teams, we will refer to both constructs under the term team efficacy.

Tasa, Taggar, and Seijts (2007) note three factors important to teamwork behavior: task relevant knowledge, self efficacy for teamwork, and collective efficacy in the team. While noting the importance of teamwork in any team outcome, we will only explore the collective efficacy aspects in this study. In addition, Tasa et al. (2007) suggested that teams create a context in which constructive individual behaviors are expected.

Gibson (1999) explained that "group efficacy forms as group members collectively acquire, store, manipulate, and exchange information about each other, and about their task context, process, and prior performance" (p. 138).

As noted by Tasa et al. (2007), a meta-analysis performed by Gulley, Incalcatera, Joshi, and Beaubien (2002) showed that the relationship between collective efficacy and team performance was positive. According to social cognitive theory, efficacy is a prime determinant of the extent to which individuals or teams are likely to put forth the effort required to perform successfully (Bandura, 1986).

Edmondson (1999) found that team efficacy, which is closely related to group potency, was positively associated with team learning behavior, while Van den Bossche

et al. (2006) found that group potency was positively related to team learning beliefs. While these studies of collocated teams have investigated the use of team efficacy or group potency, "researchers cannot assume that team members will develop group efficacy beliefs in a technology mediated environment the same way they would if they were collocated and able to interact face-to-face" (Hardin, Fuller & Valacich, 2006, p. 82). The difficulties posed by virtual team environments may change the development of group efficacy. Both the lack of collocation and the need to use sophisticated information technology are factors that add complexity to team interactions (Lipnack & Stamps, 2000) and consequently may affect the efficacy beliefs related to those interactions (Hardin, Fuller & Valacich, 2006). Ortega et al. (2010) study of student project teams found that collective efficacy was positively related to virtual team learning, but no such result exists for virtual ad-hoc work teams.

It is understood that while virtual teams present a different context than collocated teams, the development of collective efficacy is believed to be similar. Hardin et al. (2006) proposed a measure of virtual team efficacy to measure the belief of a team in its' ability to use sophisticated information technology. While conceptually well developed, the virtual team efficacy measure focused solely on the group's ability to use information technology. Many ad-hoc knowledge worker teams today routinely use communication technology so this measure was not seen as applicable to the driving construct of team efficacy that impacts team learning. Therefore, virtual team efficacy measure proposed by Hardin et al. (2006) is not used here.

As noted in this review, recent research re-affirms earlier findings that demonstrate the positive influence of team psychological safety and team efficacy on

team learning behaviors. The constructs of psychological safety and team efficacy were selected as the primary components of interpersonal beliefs for this research since they have been shown to play a significant role in team learning in collocated and non-collocated settings, and are theoretical similar. Issues of openness and trust, and the team's belief in their ability to perform in a virtual setting are not as well understood and lack empirical research.

Transactive Memory Systems (TMS)

As noted by Lewis (2003), the notion of transactive memory systems was conceived by Wegner (1987), who observed that members of long-tenured groups tend to rely on one another to obtain, process, and communicate information from distinct knowledge domains. Wegner (1987) termed this system of cognitive interdependence a TMS. According to transactive memory theory, group members divide the cognitive labor for their tasks, with members specializing in different domains. Members rely on one another to be responsible for specific expertise such that collectively they possess all of the information needed for their tasks.

Wegner (1987) further argued that transactive memory systems also operate in groups that divide the cognitive labor for a project and rely on one another to learn, remember, and communicate information from different knowledge domains. "Although transactive memory is embedded in each group members' mind, the transactive memory system is embedded in the collective knowledge of the group and the ability of the group members to access each other's knowledge" (London et al., 2005, p. 124).

Roschelle and Teasley (1995) concluded that "collaboration does not just happen because individuals are co-present; individuals must make a conscious, continued effort

to coordinate their language and activity with respect to shared knowledge" (p. 94). This is true of any team, and may be more important in virtual teams where lack of proximity makes interpersonal communication more difficult. Transactive memory systems focus on group members' expertise and mental representation of that expertise, and this is especially useful for understanding how teams develop, share, integrate, and leverage members' different expertise (Lewis, 2003; Mohammed & Dumville, 2001).

Transactive memory system was further characterized by Lewis (2003) as "the active use of transactive memory by two or more people to cooperatively store, retrieve, and communicate information" (p. 588), and is comprised of three sub-categories: specialization, credibility, and coordination. According to Lewis (2003), researchers such as Liang, Moreland & Argote (1995), Moreland (1999), and Moreland & Myaskovsky (2000), proposed that transactive memory systems could be discerned from the differentiated structure of members' knowledge (specialization), members' beliefs about the reliability of other members' knowledge (credibility), and effective, orchestrated knowledge processing (coordination).

"Transactive memory itself consists of metaknowledge about what another person knows, combined with the body of knowledge resulting from that understanding" (Lewis, 2003, p. 588). Although transactive memory is embedded in each group member's mind, the transactive memory system is embedded in the collective knowledge of the group and the ability of the group members to access each other's knowledge. A TMS is comprised of three substructures: (1) specialization of knowledge; (2) cognitive trust of other's knowledge, and (3) an ability to coordinate knowledge according to the task structure and members' unevenly distributed knowledge (Lewis, 2004).

The distribution and sharing of team members' knowledge is transactive in that members are able to retrieve the information stored in other group members' memories (Lewis, 2003). The transaction happens through communications between the members and may be nonverbal, verbal, or written. Thus in-person interaction is important for transactive memory processes to operate well, and close relationships foster the development of shared memory schemes (Wegner, Erber, & Raymond, 1991). Even in virtual contexts early team members' volume of communication decreases over time as the group members develop transactive memory (Yoo & Kanawattanachai, 2001).

Laboratory research on group TMSs confirms that these cooperative memory systems do exist and that they improve team performance (Lewis, 2003). Research by Moreland and colleagues (Liang, Moreland et al., 1995; Moreland, Argote, & Krishnan, 1996; Moreland & Myaskovsky, 2000) demonstrated that group members who were trained together on a task developed the differentiated and specialized knowledge characteristic of transactive memory and jointly recalled a greater volume of task-relevant information.

A mature, well-developed transactive memory system may provide group members with a way to draw on broad knowledge, communicate among themselves more easily, and have a means for new knowledge related to the task thus improving group performance (London et al., 2005). TMS research has shown that TMS improves team performance by providing faster access to greater amounts of deep expertise and by improving, integrative processes (Lewis, 2004, Moreland, 1999, Wenger, 1998). As groups learn and perform they will feel increasingly positive about being part of the group because, as noted by London et al. (2005) "they have an accurate understanding

who knows what and have ways to determine and fill knowledge gaps and apply exiting and new information to solve complex problems" (p. 125).

Findings by Lewis (2004) imply that "TMSs may be difficult to create in virtual team environments, especially those environments that prohibit face-to-face meetings early in the project" (p. 1530). The development of TMS in a virtual environment could prove to be more difficult than in collocated settings. Hollinghead's (1998b) study showed that communicating over the computer suppressed some communication behaviors important to TMS. Team members using the computer were less likely to explain their answers and less likely to solicit task-relevant information form their partners. In contrast, the study by Choi et al. (2010) noted that the use of information technology was likely to positively influence the development of TMS by supporting frequent and effective communication.

Summary of Literature Review

It is believed that interpersonal context as defined by psychological safety and efficacy should help shape the development of TMS in a collocated or virtual context. Lewis (2004) suggests that initial team conditions play a role in developing the early structure of a TMS. The group beliefs of trust, confidence, and transactive memory systems are anticipated to develop differently in virtual versus a collocated setting due the difficulties presented by distance and the reliance on technology for communication.

The value of a team's transactive memory system is in facilitating access to greater amounts of information, encouraging knowledge sharing, and encouraging members to cultivate specialized knowledge (Lewis, 2003). This division of cognitive

labor allows individual members to learn more deeply in their own areas of expertise rather than learning a little about multiple areas to complete the task (London et al., 2005). The lightening of the cognitive load and opportunity to focus for each team member may enhance the overall team's ability to learn. As noted in London et al. (2005), "group members come to expect that other members rely on them for knowledge in specific areas, and this expectation motivates them to learn and recall new information" (p. 124).

The notion put forward by Bandura (1997) that a team's collective efficacy can influence how they manage their resources, the plans and the strategies they construct, and how much effort they put into their group is in line with transactive memory theory in that management of expertise and resources along with the efficacy to effectively utilize those resources are strong predictors of team learning. As Gibson (1999) explained "group efficacy forms as group members collectively acquire, store, manipulate, and exchange information about each other, and about their task context, process, and prior performance" (p. 138) clearly showing the conceptually overlap of efficacy and transactive memory systems.

The conceptualization of team learning as a social process of adaptation based on experience and reflection is consistent across models despite the dissimilarity of language. The idea of a collective thought process or mutually shared cognition presented by Van den Bossche et al. (2006) combined with the ideas of metacognition and critical reflection captured in the term *reflexivity* presented by McCarthy and Garavan (2008) in particular seems to capture the essence of team learning (Knapp, 2010).

While team learning literature has become more voluminous over the last 20 years, virtual team learning literature and research is still in its nascent stages. Team learning and team performance literature have expressed concern over the *knowing-doing gap* (Pfeffer & Sutton, 2000; Choi et al., 2010). Results show that no matter how much knowledge is shared among team members, it cannot enhance team performance unless it is effectively applied. It has been noted that groups perform better when members accurately recognize each other's expertise and allow the experts to affect the group process (Bunderson, 2003a). The development of TMS and team learning behaviors in a psychologically safe environment may provide the vehicle to enhanced team performance.

In summary, the theoretical constructs of team psychological safety, team efficacy, TMS, and team learning have been defined and situated in the team learning literature. The addition of TMS builds on the model of team learning proposed by Knapp (2010). TMS may more fully describe how groups develop cognitive interdependence and may replace metacognition as a central element in the process of team learning. The relationship between the proposed constructs is explored in this study.

Chapter 3

METHODOLOGY

An organization's ability to learn is dependent on the ability of its teams to learn (Senge, 1990; Edmondson, Dillon, Roloff, 2007), yet the potential of collaborative teams to learn and innovate is not always reached (Van den Bossche, Gijselaers, Segers, & Kirschner, 2006).

It has been estimated that upwards of 60 percent of tasks at global companies will be done by geographically separated virtual teams, and that 50 percent of virtual teams would fail to meet their objectives (Zakaria, Amelinckx, & Wilemon, 2004). The rapid evolution of virtual teams in organizations has created a situation where research into virtual teams has significantly lagged their implementation (Cordery & Soo, 2008).

This correlation study used a relational design where the connection between a number of constructs impacting team learning including interpersonal beliefs, TMS, and team learning beliefs were examined. The development of team learning in ad-hoc work teams in a virtual setting was investigated using a survey built from existing measures of psychological safety, team efficacy, transactive memory systems, and team learning. The survey results were analyzed using correlation analysis and multiple regression analysis in order to determine the relationships between constructs.

Research Model and Hypotheses

This study is based on the research framework as presented in Figure 3.1. The research model and subsequent hypotheses were derived from a review of existing models of team learning, and rely heavily on the previous research of Edmondson (1999) and Van den Bossche et al. (2006) as well as more recent research by Ortega et al.

(2010). The focus of the study is within the boundary of the research model shown in Figure 3.1 and includes: virtual team interpersonal beliefs, TMS, and virtual team learning behaviors. Virtual team structure is shown to flow into and influence these beliefs and behaviors, but will not be directly measured. Virtual team performance is shown as an outcome of the team and team learning, but will not be directly measured as it has already been well established that team learning is positively associated with performance (Edmondson, 1999; Ortega, 2010; Van den Bossche et al., 2006).

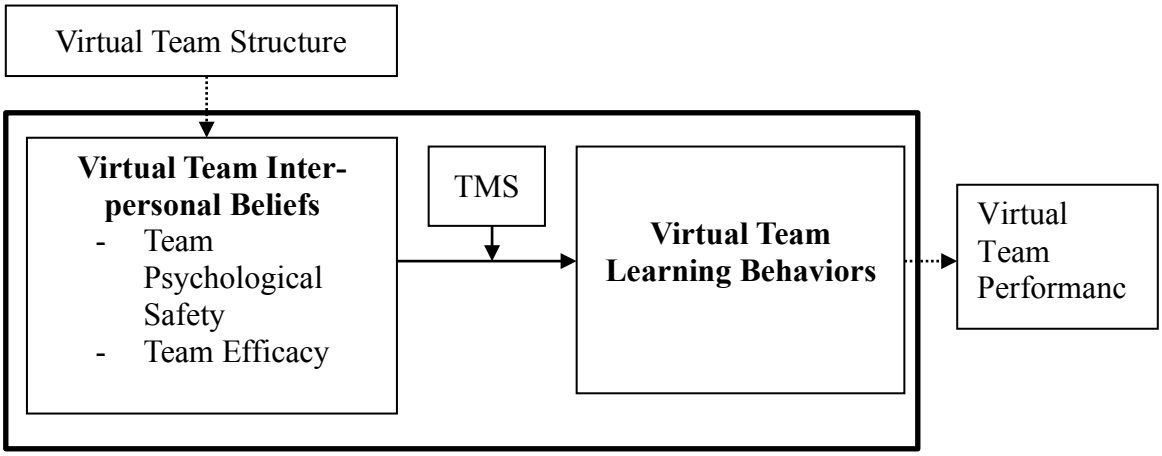

Figure 3.1: Research Model

This study seeks to answer the question: does a significant relationship between virtual ad hoc work team interpersonal beliefs, transactive memory systems (TMS) development, and team learning behaviors exist? This broad research question leads to the following questions guiding this inquiry:

1. Are team learning behaviors and TMS exhibited by teams operating in a primarily technology-mediated, non-collocated environment?
2. Does psychological safety and team efficacy contribute to the development of team learning behaviors in a virtual setting?

3. Does TMS contribute to the development of virtual team learning behaviors?

4. Does TMS moderate the relationship between team interpersonal beliefs and team learning behaviors?

Based on the research framework shown in Figure 2 and the posited research questions the hypotheses are described in detail in this section.

Team psychological safety is defined as the shared belief that the team is safe for interpersonal risk-taking (Edmondson, 1999). Learning in groups can be stressful, but the paradox is that learning is often facilitated by taking risks and thinking freely (Van den Bossche et al., 2006). Team psychological safety facilitates learning behavior in teams because it minimizes concerns over team member reactions that can be embarrassing or threatening (Edmondson, 1999). Research has shown that team psychological safety is positively associated with team learning behavior in studies of collocated teams (Edmondson, 1999; Van den Bossche et al., 2006). Psychological safety allows team members to think critically, feel safe, and take risks which are important components of learning. The confidence needed to learn stems from mutual respect and trust among team members (Edmondson, 1999). However, as noted by Jang (2009), the development of trusting relationships in virtual teams is difficult.

One of the key elements in trust development is repeated interaction between trusting parties (McAllister, 1995). However, the lack of physical proximity in virtual teams makes communicating and coordinating with distant team members more difficult. Complications arise from physical dispersion, coupled with fluid membership, cultural differences, and lack of prior history in many virtual teams (Lipnack & Stamps, 2000). The study by Gibson and Gibbs (2006) explored the role of psychological safety in

virtual teams, and found that a psychologically safe communication climate helped mitigate many of the potential process losses associated with virtual team working. Increased psychological safety is expected to facilitate team learning behaviors regardless of the context since it facilitates the appropriate environment for learning behaviors leading to the hypothesis H1: psychological safety is positively assocated with team learning behaviors.

Edmondson (1999) found that team efficacy, which is closely related to group potency, was positively associated with team learning behavior, while Van den Bossche et al. (2006) found that group potency was positively related to team learning beliefs. While these studies of collocated teams have investigated the use of team efficacy or group potency, "researchers cannot assume that team members will develop group efficacy beliefs in a technology mediated environment the same way they would if they were collocated and able to interact face-to-face" (Hardin, Fuller & Valacich, 2006, p. 82). The difficulties posed by virtual team environments may change the development of group efficacy. Both the lack of collocation and the need to use sophisticated information technology are factors that add complexity to team interactions (Lipnack & Stamps, 2000) and consequently may affect the efficacy beliefs related to those interactions (Hardin, 2006). In fact, Hardin (2006) proposed a measure of virtual team efficacy to measure the belief of a team in its ability to use sophisticated information technology. Ortega's (2010) study of student project teams found that collective efficacy was positively related to virtual team learning, but no such result exists for virtual ad-hoc work teams.

This study measured virtual team efficacy of non-collocated ad hoc work teams. The sense of confidence generated by high group potency may help teams persevere in the face of adversity and influence how teams regulate their processes and share information (Gully et al., 2002), and was expected to show the same positive relationship to team learning behavior in a virtual team setting. This leads to the hypothesis H2: team efficacy is positively associated with team learning behaviors.

Transactive Memory System (TMS) is applied and developed by team members drawing on the knowledge of each other's knowledge, skills, and abilities when the need arises. Group members begin to divide the cognitive labor to remember and retrieve more knowledge than any one of the members could retain alone. Also, they learn how to draw on each other's abilities and knowledge when needed. (London, Polzer & Omoregie, 2005). Overall, the value of the transactive memory system is in facilitating access to greater amounts of information, encouraging knowledge sharing, and encouraging members to cultivate specialized expertise (Lewis, 2003).

A mature TMS has been shown to result in high team performance by allowing team members to integrate their expertise and specialized knowledge. In fact, Lewis et al. (2003) argued that TMS enable individual level and team level learning that transfers to other similar tasks. The cooperative division of labor for learning, remembering, and communicating team knowledge (Lewis, 2003), are central elements of group learning that arise from feedback processes and interventions. As noted in London et al. (2005), "group members come to expect that other members rely on them for knowledge in specific areas, and this expectation motivates them to learn and recall new information" (p. 124). The processes and behaviors associated with TMS were expected to promote

team learning behaviors leading to hypothesis H3: TMS is positively associated with team learning behaviors.

This study hypothesized a moderating effect of TMS. As noted in the classic reference on this topic: "In general terms, a moderator is a qualitative (e.g., sex, race, class) or quantitative (e.g., level of reward) variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable. Specifically within a correlational analysis framework, a moderator is a third variable that affects the zero-order correlation between two other variables." (Baron & Kenny, 1986, p. 1174).

In other words a higher level of TMS development in the team is hypothesized to result in a higher level of team learning behavior. It is likely that TMS affects the sustainability of within-group integrating processes, both influencing and being influenced by such social processes such as interpersonal trust, participation, conflict, communication, and cohesion (Cordery & Soo, 2008). Incongruent interpersonal perceptions and low transactive memory may stem from the difficulty people have disclosing information about themselves and giving one another feedback (London et al., 2005). This idea may be compounded in a virtual environment, but where interpersonal beliefs are high and interpersonal perceptions are congruent, TMS is expected to develop more readily and improve team learning processes and behaviors.

Main Research Hypothesis H4: The relationship between team psychological safety, team efficacy, and team learning behaviors will be moderated by TMS.

In summary this study attempts to integrate theory of interpersonal team beliefs, transactive memory system development, and team learning behaviors. Interpersonal belief factors are complementary in that they are all expected to be positively associated with team learning. The following graphic in figure 3.2 represents the research model employed in this study.

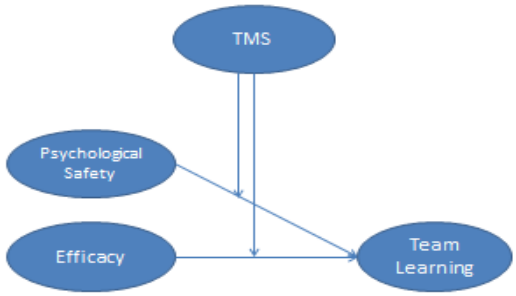

Figure 3.2: Research Model - Hypothesized Relationships

The proposed relationship between psychological safety, team efficacy, TMS, and virtual team learning beliefs can be shown using the following research model relationship that was used in the regression analysis:

VTLB = PS + Efficacy + TMS + (PS*TMS) + (Efficacy *TMS)

Where,

VTLB = virtual team learning behavior

PS = psychological safety

TMS = Transactive memory system

Sample and Population Description

Sampling was guided by the research questions and by the theory that underlies the conceptualization of the case. The research site is a leading non-profit trade association of plastic pipe manufacturers, resin producers, and professional consulting members with more than 120 member companies and more than 200 active individual members. The organization is divided into 5 operating divisions (Building and Construction, Energy Piping Systems, Municipal and Industrial, Corrugated Plastic Pipe, and Conduit) that are focused on different market applications, as well as an independent product listing authority (Hydrostatic Stress Board), and a Board of Directors. Each division and operating section completes work through the use of ad-hoc work teams. The ad-hoc teams are generally comprised of employees of member companies that volunteer to work on projects based on interest and include a task group chair selected from the members. The project team, which is made up of anywhere from 2 to 10 members, typically included an employee of the association to ensure anti-trust rules are followed, and to provide project support and direction as needed. A full list of projects including objectives, and members are identified in a central database on the members only section of the trade association's website.

Gibson and Gibbs (2006) further characterized virtual teams as typically varying along four dimensions: (a) *geographic dispersion*; (b) *electronic dependence*; (c) *dynamic structure*; and (d) *national diversity*. In line with Gibson and Gibbs characterization, the sample consisted of all active ad-hoc teams and teams that have either completed their

work within the past 12 months or have had team activity during that time. The study was comprised of a total of 40 ad-hoc teams with an average of 6.7 members. The total number of individual participants in the study was 73 due to overlap in ad-hoc team membership and member participation.

Individuals, teams, and their respective project leaders (chairs) were identified through project tracking lists maintained by the trade association. Study qualifications include: member of a team that was active in the past 12 months that worked in a primarily technology-mediated environment, or virtual team.

The purpose of the ad-hoc teams is to complete specific projects identified by members, and approved by the division management committee. Projects are initiated based on member needs to accomplish a range of goals including: research and development on issues affecting each market and material, technical literature development, educational materials, marketing collateral, product standard development, and position statements.

Virtual teams consist of small groups of volunteer member company representatives with relevant knowledge and interest in the project outcome. Project teams are led by a team member, which is appointed as chair by the task group. In addition, association staff may have been included on the project team to facilitate all facets of the project and ensure anti-trust rules are adhered to.

The composition, size, and membership of the virtual team may have implications on team learning behavior. The voluntary structure of the organization and teams may present different issues as compared to mixed or for-profit teams comprised of assigned members.

Each ad-hoc work team and respective team chair was provided feedback during the research process relating to their scores on each measure and overall team performance. Feedback to participants has been shown to improve survey response (Dillman, 2000), and can provide learning throughout the research process. In addition, feedback may be used by the participating organizations to assist in the future development of team learning processes.

These non-collocated ad-hoc teams are expected to conduct the majority (more than 2/3) of their work in a technology-mediated environment with occasional in-person meetings. Face-to-face meetings are typically held twice per year in conjunction with the trade associations' annual and semi-annual meetings, but may be scheduled outside of those specific venues. Teams or task groups from any of the divisions may work on diverse topics from various market segments, or work on a common project with a common purpose that crosses all divisions. Primarily ad-hoc teams are involved with the development of technical papers based on the collective knowledge of the group, or based on external research coordinated by the team. These technical documents are used to satisfy member needs, or may be posted on the trade association website or released for publication in trade journals. Teams and their respective projects do not have to be related to one another, but all operate under the bylaws of the trade association.

In following the degree of virtuality, virtual teams as defined in this study include teams where the majority (greater than 2/3) of team work is conducted in a non-collocated (virtual) environment through the use of various technologies such as: web conferencing, phone conferencing, and e-mail. Occasional face-to-face meetings may

occur as warranted by the project. In many cases, these meetings are required for reporting or critical decision making.

Measures

Team interpersonal beliefs, TMS, and team learning behaviors were assessed using an electronic web-based questionnaire (Qualtrics) developed from validated questionnaires. Instrument selection was guided by conceptual match and psychometric properties, both of which were expected to be high. The primary construct measures of team interpersonal beliefs and team learning were drawn from Edmonson's (1999) seminal study of team learning behaviors. The TMS measure was selected from Lewis's (2003) study. A summary of the measures used in this study is shown in Table 2. The specific items which comprise each measure can be found in Appendix A.

Team psychological safety is defined as the shared belief that the team is safe for interpersonal risk-taking (Edmondson, 1999). This construct was measured using a 7 item, 7-point scale (very inaccurate to very accurate) developed by Edmondson (1999) with an acceptable Cronbach's alpha of 0.81. A sample question is: "Members of this team are able to bring up problems and tough issues".

Team efficacy scale was developed by Edmondson (1999) based on the earlier work of Bandura (1986). The virtual team efficacy instrument developed by the Hardin et al. (2006) was considered, but not included in this study since all participants were known to be very comfortable with the use of technology for communication and work. Edmondson's (1999) instrument was found to be predictive of team effectiveness, and the Cronbach's alpha for the measure was found to be somewhat acceptable at 0.63.

According to Nunnally's (1970) research 0.7 or higher is generally acceptable level of Cronbach's alpha. Although the Cronbach's alpha was lower in Edmonson's (1999) study, discriminant validity was established through factor analysis. Subsequent study by Van den Bossche et al. (2006) using conceptually similar scales from group potency, established as conceptually identical to group or team efficacy, produced better Cronbach's alpha. Van den Bossche et al. (2006) study used a group potency scale based on the work of Sargent and Sue-Chan (2001) that was very closely related to Edmondson's (1999) scale with a Chronbach's alpha of 0.89. Edmondson's (1999) scale was selected over other potential scales since it fit better with the underlying model of team learning beliefs and behaviors used in this study.

A sample question is: "This team can achieve its task without requiring us to put in unreasonable time and effort". The measurement of team efficacy using the group-level aggregation of individual team members' group efficacy beliefs has been proposed as a more suitable method for use on virtual teams (Gibson et al., 2000) because of its reliance on data collected from individually administered surveys. Remote team members can be individually asked to complete an efficacy questionnaire, and the responses can then be aggregated (Hardin, 2006).

Team learning behaviors

Team Learning was measured using a 7-item, 7-point scale (very inaccurate to very accurate) developed by Edmondson (1999). Cronbach's alpha for team learning measure was found to be acceptable at 0.88. An example question includes: "People in this team often speak up to test assumptions about issues under discussion".

Transactive memory system (TMS)

TMS is conceptually comprised of three constructs: specialization, credibility and coordination. TMS scale constructs were found to be acceptable with Cronbach's alpha ranging from 0.82 to 0.92. Each was measured using the 15-item, 5 point (1 = strongly disagree; 5 = strongly agree) scale developed by Lewis (2003). An example question for the construct of specialization is "Each team member has specialized knowledge of some aspect of our project", for credibility is "I was comfortable accepting procedural suggestions from other team members", and for coordination is "Our team worked together in a well-coordinated fashion".

In summary, the survey was comprised of four parts, including four distinct constructs and the control variables. Table 3.1 summarizes the primary research instruments, the number of items, and known reliability coefficients.

Table 3.1: Research Instrument Summary

Model Construct	**Instruments**	**Items**	**Scale**	**Item correlations (Cronbach's alpha)**
Team Psychological Safety	Edmondson (1999)	7	7pt. Likert scale (very inaccurate to very accurate)	0.81
Team Efficacy	Edmondson (1999)	3	7pt. Likert scale (very inaccurate to very accurate)	0.63
TMS	Lewis (2003)	15	5 pt. Likert scale (disagree – agree)	0.82 – 0.92
Team Learning Behaviors	Edmondson (1999)	7	7 pt. Likert scale (very inaccurate to very accurate)	0.88

TOTAL		32		

Control Variables

Due to the use of multiple teams with varying levels of diversity and degrees of "virtuality", it is sometimes necessary to control for the possibility of variation. Virtual teams can vary in terms of their expected outcomes, locations, membership, and diversity in the form of nationality, age, and position. In this study team virtuality (non-collocated) was known to be 100 percent based on project/team records of the participating organization and was not measured. Based on project/team records, types of team or task (project, management, or executive) were identified and measured. It should be noted that Edmondson (1999) found that team type and team tenure were not significantly related to team learning. Therefore, these variables were not included in this study.

Aggregation of Measures

All of the variables in the present study were analyzed at the team level. Team learning, psychological safety, and team efficacy are all referent-shift consensus measures, while TMS is a direct consensus measure (Chan, 1998). "The direct consensus model uses within-group consensus within the lower level units as the functional relationship to specify how the construct conceptualized and operationalized at the lower level is functionally isomorphic to another form of the construct at a higher level" (Chan, 1998, p. 237). In referent shift consensus composition, "the lower level attributes being assessed for consensus are conceptually distinct though derived from the original individual-level construct" (Chan, 1998, p. 238). The individual referent for the group-level construct shifts from the individual's report to an individual's perception of the group members. Both types of aggregation methods require that "unit members must

show within-group agreement in their perceptual ratings or unit-level measure – the aggregation of individual level responses to the unit-level – has no construct validity" (Klein, Conn, Smith, & Sorra, 2001, p. 4).

Since all measures have shown strong within-group agreement and meaning at the team level of analysis they were aggregated to the team level from individual responses by averaging responses by team. Individuals were asked to complete a separate survey for each team they participated on.

Data Collection

As with much of the research conducted on teams, the constructs measured in the survey are conceptually meaningful at the team level. Data were gathered from individual team members to assess team-level variables that were aggregated at that level.

After initial contact and with and approval from the trade association Executive Director and Board of Directors, Divisional management committees, and following approval from the IRB, a pre-notice survey message was sent via email to the task group (virtual team) chairs to help identify teams and respective team members that qualify for the selection criteria. Based on the guidelines provided and a review of the association's project records, the researcher worked with the team chairs of each participating team to confirm a list of participants.

The design of the survey instrument follows Dillman's (2000) tailored design method to improve response rates, and was administered online to the target population using a web-based survey tool (Qualtrics). A web-based survey is appropriate for a fairly large, self-contained group that has internet access. A total of 124 questionnaires were collected with a response rate of nearly 50%. There were 18 survey respondents that

started, but did not complete the survey so their responses were not utilized in the analysis.

A follow-up email thank you and reminder was sent approximately one week and two weeks after the initial delivery of the questionnaires to improve the overall response rate. Personal emails were sent to team members on teams that showed limited response to further improve response rates. Following the reminder an additional 10 responses were received.

Survey

The survey was comprised of questions assessing team demographics, and questions on team interpersonal beliefs, TMS, and team learning behavior based on the instruments listed in Table 2. The survey contained a mix of positively worded and negatively worded items to mitigate response set bias (Edmondson, 1999). Non-response bias was evaluated by comparing the results between early and late responders. A pilot study using all measures was conducted with a small sample group of 3 ad hoc teams that have completed their tasks within the past 12 months. The pilot study followed Dillman's (2000) four stage process:

1. The survey was reviewed by knowledgeable colleagues in multiple locations within the organization.
2. Interviews of potential survey respondents were conducted to evaluate the cognitive and motivational qualities of each question.
3. Conducted a small pilot test of the complete survey instrument and altered the survey design and questions based on feedback.
4. Used a small group of outside reviewers to provide a final check.

The results of the pilot study were used to reword survey questions that were unclear. The complete survey instrument can be found in Appendix A.

Data Analysis

Descriptive statistics, correlations, inferential statistics (i.e., ANOVA), and regression analysis was conducted. When the p-value was less than .05, it was considered statistically significant. Survey results were coded to identify respondents by team rather than individually.

The first step in the analysis was to compute descriptive statistics and correlations between input variables to test for collinearity. The inter-correlations between group-level survey variables, and correlations of team belief factors, TMS, and learning behavioral factors were computed at the group level of analysis to measure each variable.

Studies conducted by Van den Bossche et al. (2006), Edmondson (1999), and Ortega (2010) have shown that the constructs measured in the survey are conceptually meaningful at the team level. Therefore, the data gathered from the individual team members to assess team level variables must be aggregated at that level. Results of the survey were aggregated based on averaging of individual responses at the team level.

Correlation analysis

To test the first research question and hypotheses 1 - 3, correlation analysis was used.

The correlation coefficients among psychological safety, interdependence, team efficacy, TMS, and team learning behavior were computed. Means, standard deviations, and inter-correlations among the variables were reported. Correlation analysis is appropriate for

investigating relationships between continuous variables that can vary on a dimension from high
to low, and it allows for a measure of the degree of a relationship between two variables rather
than just whether or not a relationship exists. According to McMillan (2000), correlations between .10 and .30 are small or weak positive relationships, correlations between .40 and .60
are moderate positive relationships, and .70 and above are high positive relationships.

Regression Analysis.

As noted by Gall et.al. (2007), the purpose of multiple regression is to determine which of the influence variables can be combined to form the best prediction of the criterion variable. In this case the influence variables include team psychological safety, team efficacy, and TMS with the criterion variable being team learning.

To test the main H4 effect hypothesized in this study a multiple regression analysis was conducted to assess the predictive ability of independent variables on team learning behavior. The hypothesized interaction effects between team efficacy and transactive memory system (TE*TMS) and team psychological safety and transactive memory system (TPS*TMS) were calculated using SPSS. Then a second multiple regression analysis including the interaction effects was conducted to analyze if TMS moderated the identified interpersonal team beliefs of psychological safety and team efficacy and team learning. Because respondents belonging to the same team are not independent, a regression analysis of the team-level data was performed so as not to violate the regression assumption of independence (Edmondson, 1999).

The research hypotheses and the corresponding statistical techniques used to address each hypothesis are summarized in Table 3.2.

Table 3.2: Statistical Analysis

Research Hypotheses	Analytical Technique
1. Psychological safety is positively associated with team learning behavior in a virtual setting	Correlation
2. Team efficacy is positively associated with team learning behaviors in a virtual setting	Correlation
3. TMS is positively associated with team learning behaviors in a virtual setting	Correlation
4. TMS moderates the relationship between psychological safety, team efficacy and virtual team learning?	Multiple Regression

Protection of Subjects

In terms of ethics in research, first, informed consent is important. The research idea, the research procedures, the relationship of the research the specific context, the application of results, and potential benefits of participation was communicated to all subjects.

The proposal with detailed survey questions was submitted to the University of Minnesota Institutional Review Board (IRB) for review. Measures were taken to protect privacy and confidentiality of data. Participants were selected equitably according to stated criteria, and asked to complete participant consent forms prior to administration of the surveys.

The researcher contacted each participant via email to explain the purpose and logistics of the survey and include an embedded Website link for completing the survey on-line.

Second, since respect for privacy and anonymity are at the heart of the conduct of ethical research with human participants (Sales & Folkman, 2000), the participants were told that their responses are confidential and anonymous, that the data will be collected and maintained in an off-site computer system to help guarantee confidentiality, and that management will receive a summary report without individual identification.

Finally, other procedures during data collection may involve gaining the permission of individuals in authority at each member organization to provide access to research participants at research sites. While the researcher was sensitive to the views and influences of individuals in authority, their motivation and interest may be different, and the researcher is obligated to question and decide for oneself what is valid and ethical.

Assumptions

The researcher is employed by the trade association whose members and teams were being studied. The researcher holds the position of Director of Engineering responsible for the management of two divisions (BCD and EPSD) as well as liaison with related trade associations and foreign affiliates. The Director of Engineering reports to

the association Executive Director. The Non-profit organization is located in Texas, but represents manufacturers from across North America.

The researcher organizes and informs ad-hoc work teams. The researcher and ad-hoc work teams chaired by the researcher were not involved in the study. The position of the researcher was disclosed to all participants in an email prior to the start of the research.

Chapter 4

RESULTS AND FINDINGS

This study investigated the development of team learning in ad-hoc work teams in a virtual setting using a survey built from existing measures of psychological safety, team efficacy, transactive memory systems (TMS), and team learning behaviors. This study was developed and conducted to answer the question: does a significant relationship between virtual ad hoc work team interpersonal beliefs, TMS development, and team learning behaviors exist? This study was designed to answer this broad research question and the following specific research questions:

1. Are team learning behaviors and TMS exhibited by teams operating in a primarily technology-mediated, non-collocated environment?

2. Does psychological safety and team efficacy contribute to the development of team learning behaviors in a virtual setting?

3. Does TMS have a relationship to virtual team learning behaviors?

4. Does TMS moderate the relationship between team interpersonal beliefs of psychological safety and team efficacy and team learning behaviors?

The research model shown in Figure 4.1 was used to guide the analysis of the survey data. Psychological safety, team efficacy, and TMS are all hypothesized to impact team learning behaviors. In addition, TMS is hypothesized to moderate the relationship between the interpersonal beliefs of psychological safety, team efficacy and team learning behaviors.

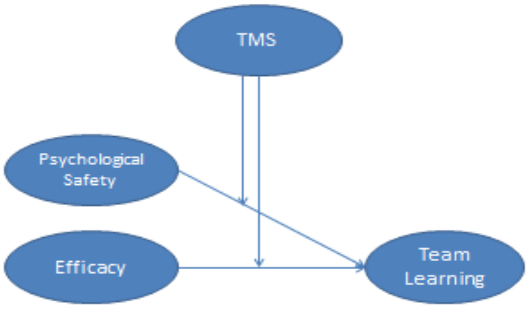

Figure 4.1: Research Model

Quantitative data were collected using Qualtrics© online survey instrument developed from a collection of existing measures of team interpersonal beliefs and team learning behavior that have been found to have a relationship. Responses from 124 individuals that represent 47 individual member companies and 23 distinct teams were gathered. The total of 23 teams only includes teams with at least 3 team members responding, therefore Team 21 shown in Table 4.1 was not included in the results and analysis.

The population consisted of a variety of teams made up of members of a leading North American plastic pipe trade association. The data included teams from each division of the trade association, the Education committee, Umbrella marketing committee, and the Board of Directors. Teams were involved in a range of project and management activities (see Table 5).

Table 4.1: Team Description

#	Answer	Response	%
1	PPI Board of Directors	9	9%
2	PPI Umbrella Marketing	6	6%
3	BCD Management Committee	9	9%
4	Project BC-2010-08 PEX Design Guide	5	5%
5	Project BC-2011-11 R-value of PEX	3	3%
6	Project BC-2013-02 HSB Validation of 0.63 DF	4	4%
7	Conduit Management Committee	5	5%
8	Project CD-2011-04 TR-44 Comparison	3	3%
9	Project CD-2012-02 Guideline for selecting wall t of HDPE Conduit	3	3%
10	CPPA Management Committee	4	4%
11	Project CP-2010-02 Constrained Soil Modulus	3	3%
12	Project CP-2010-04 HDPE Carbon Black	6	6%
13	EPSD Management Committee	6	6%
14	Project FG-2011-01 ASTM D2513 UV Exposure	4	4%

	Qualification		
15	Project FG-2011-03 Adoption of 0.4 DF for PE	0	0%
16	Project FG-2011-05 TN-30 Update	3	3%
17	M&I Management Committee	3	3%
18	Project MI-2010-02 Belleau Project	5	5%
19	Project MI-2011-02 Design Formula for Mitre Bend Elbow	3	3%
20	Project MI-2012-01 PPI Pipe Design Software	3	3%
21	Project BC-2012-03 Revise TN-17	2	2%
22	Project TC-2010-05 Cyclic Pressure Testing	5	5%
23	Project TC-2011-03 Butt fusion Joint Structure	3	3%
43	Education Committee	4	4%
	Total	**101**	**100%**

An overview of the analysis is shown in Table 4.2 to provide a better understanding of the process used to address each research hypothesis. As part of the survey demographic data were collected for background information purposes, but not included as part of the analysis.

Table 4.2: Statistical Analysis

Research Hypotheses	Analytical Technique
1. **Psychological safety is positively associated with team learning behavior in a virtual setting**	Correlation
Team efficacy is positively associated with team learning behaviors in a virtual setting	Correlation
2. **TMS is positively associated with team learning behaviors in a virtual setting**	Correlation
3. **TMS moderates the relationship between psychological safety, team efficacy and virtual team learning?**	Multiple Regression

Descriptive statistics, correlations, inferential statistics (i.e., ANOVA), and regression analysis was conducted using Statistical Package for Social Sciences (SPSS version 23). When the p-value was less than .05, it was considered statistically significant. Since this study sought to answer questions related to the team-level constructs of psychological safety, team efficacy, TMS, and team learning behavior, the

survey results were coded to identify respondents by team rather than individually. Results of the survey were aggregated based on averaging of individual responses at the team level. The variables were coded as VTLBmean, PSmean, TEmean, and TMSmean respectively.

The first step in the analysis was to compute descriptive statistics (Table 4.3) and correlations between input variables to test for collinearity. The inter-correlations between group-level survey variables, and correlations of team belief factors, TMS, and learning behavioral factors were computed at the group level of analysis to measure each variable.

Table 4.3: Descriptive Statistics

	Mean	Std. Deviation	N
VTLB_mean	4.8177	.41152	23
PS_mean	5.0259	.49372	23
TE_mean	5.4234	.57389	23
TMS_mean	3.4872	.25862	23

To test the first research question, correlation analysis was used. The correlation coefficients among psychological safety, team efficacy, TMS, and team learning behavior were computed. The inter-correlations among the variables are reported in Table 4.4.

The correlation matrix provides a rough idea of the relationship between predictor variables and the outcome (Field, 2005), and provides a preliminary look at multicollinearity. A high level of collinearity increases the probability that a good

predictor will be found non-significant, or a type II error. As noted by Field (2005) if there is no multicollinearity in the data then predictor variables should not correlate very highly (R > .9).. The matrix in Table 4.4 indicates no correlation greater than R = 0.762 between variables indicating the predictors are likely measuring different things.

Table 4.4: Item Correlations

		PS_mean	TE_mean	TMS_mean	VTLB_mean
PS_mean	Pearson Correlation	1	.613**	.762**	.562**
	Sig. (1-tailed)		.001	.000	.003
	N	23	23	23	23
TE_mean	Pearson Correlation	.613**	1	.627**	.301
	Sig. (1-tailed)	.001		.001	.082
	N	23	23	23	23
TMS_mean	Pearson Correlation	.762**	.627**	1	.570**
	Sig. (1-tailed)	.000	.001		.002
	N	23	23	23	23
VTLB_mean	Pearson Correlation	.562**	.301	.570**	1
	Sig. (1-tailed)	.003	.082	.002	
	N	23	23	23	23

**. Correlation is significant at the 0.01 level (1-tailed).

According to McMillan (2000), correlations between predictor variables and the outcome variable of .10 to .30 indicate small or weak positive relationships, correlations between .40 and .60 are moderate positive relationships, and .70 and above are high positive relationships.

Table 4.4 indicates that TMS had the highest Pearson correlation coefficient ($r = 0.570$) indicating a moderately positive relationship to virtual team learning behavior supporting hypothesis H3. Psychological safety also correlated moderately to virtual team learning behaviors ($r = 0.562$) and was significant at the $p < 0.01$ level supporting research hypothesis H2. This result is consistent with existing literature that asserts that the development of TMS will motivate a team to learn (Lewis, 2003 and London et al., 2005).

Team efficacy showed a weak correlation to virtual team learning behavior, but still supports research hypothesis H2. Team efficacy did correlated strongly to psychological safety ($r = 0.613$) and TMS ($r = 0.627$), and is somewhat consistent with the past research by Edmondson (1999) and Van den Bossche et al. (2006) that showed a positive correlation between team efficacy, group potency and team learning behaviors and team learning beliefs respectively. This may be attributed to the fact that this study used virtual teams instead of collocated teams. It should be noted that all of the teams exhibited a high degree of efficacy (mean of 5.42 ± 0.57).

Regression Analysis and Assumptions

To address research hypothesis H4 a multiple regression analysis was conducted to assess the predictive ability of independent variables (psychological safety, team efficacy, and TMS) on the dependent variable, virtual team learning behavior. The model for the first regression analysis is: VTLB = PS + Efficacy + TMS and is noted as regression Model 1.

Table 4.5 provides a summary of the regression analysis of Model 1. The regression shows that 38% of the variability in VTLB is explained by the model.

Table 4.5: Model 1 regression analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.616[a]	.380	.282	.34868	.380	3.882	3	19	.025	2.239

a. Predictors: (Constant), TMS_mean, TE_mean, PS_mean

b. Dependent Variable: VTLB_mean

The ANOVA analysis of Model 1 is provided in Table 4.6. The F = 3.882 statistic is significant at the $p < 0.05$ level indicating that Model 1 is significant. The regression coefficients are reported in Table 4.7.

Table 4.6: ANOVA of Hypothesized Model 1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.416	3	.472	3.882	.025[b]
	Residual	2.310	19	.122		
	Total	3.726	22			

a. Dependent Variable: VTLB_mean

b. Predictors: (Constant), TMS_mean, TE_mean, PS_mean

Table 4.7: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	T	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.743	1.010		1.725	.101					
	PS_mean	.300	.241	.360	1.242	.229	.562	.274	.224	.389	2.572
	TE_mean	-.124	.173	-.173	-.718	.482	.301	-.163	-.130	.563	1.775
	TMS_mean	.642	.467	.404	1.374	.185	.570	.301	.248	.378	2.645

a. Dependent Variable: VTLB_mean

To address hypothesis H4, the hypothesized interaction effects between team efficacy and transactive memory system (TE*TMS) and team psychological safety and transactive memory system (PS*TMS) were calculated using SPSS. These were coded for analysis as TETMS and PSTMS respectively.

A second multiple regression analysis including the interaction effects was conducted to analyze if TMS moderated the relationship between psychological safety, team efficacy and team learning. Model 2 is expressed as VTLB = PS + Efficacy + TMS + (PS*TMS) + (Efficacy *TMS). Because respondents belonging to the same team are not independent, a regression analysis of the team-level data was performed so as not to violate the regression assumption of independence (Edmondson, 1999).

Table 4.8 provides a summary of the regression analysis of model 2. The model, including the interaction effects of TMS, explained 41.4% of the variability in VTLB. This is a slight increase from the 38% variability explained by model 1. Based on the

regression analysis it is not clear that the moderating effect of TMS is present in this model, therefor H4 was not fully supported.

Table 4.8: Model 2 regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.616[a]	.380	.282	.34868	.380	3.882	3	19	.025	
2	.644[b]	.414	.242	.35826	.034	.498	2	17	.616	2.079

a. Predictors: (Constant), TMS_mean, TE_mean, PS_mean

b. Predictors: (Constant), TMS_mean, TE_mean, PS_mean, TETMS, PSTMS

c. Dependent Variable: VTLB_mean

Demographic Data

Demographic data were not expected to impact results, but were included in the study to provide added background information. Demographic information reported includes: team diversity (country of origin), team gender, and age range. Although the demographic data were not expected to impact results, they may provide additional insight to help describe the results.

Respondents included members from China, Columbia, Germany, Canada, and the United States. Team type was also reported and included: management, project, and Board of Directors.

Table 4.9 is a summary of a self-reported measure of team diversity as indicated by the broad categories. In this case diversity was intended to indicate roughly how many team members were from different cultural backgrounds. As shown in Table 4.9 the majority of teams (53%) reported little diversity.

Table 4.9: Team Diversity

#	Answer	Response	%
1	None	10	10%
2	Little	51	53%
3	Somewhat	34	35%
4	Very	2	2%
	Total	**97**	**100%**

The majority (54%) of respondents were above the age of 50 years of age and 38% were between the ages of 35 and 50 (Table 4.10).

Table 4.10: Age range of Respondents

#	Answer	Response	%
1	21 - 34	8	7%
2	35 - 50	43	38%
3	50 +	61	54%
	Total	**112**	**100%**

The vast majority (81%) of respondents were male (Table 4.11).

Table 4.11: Gender

#	Answer	Response	%
1	Male	97	81%
2	Female	23	19%
	Total	**120**	**100%**

The responsibility or position of respondents on their respective teams is indicated in Table 4.12. The table shows that 16% reported to be the chair or vice-chair of their teams.

Table 4.12: Position on Team

#	Answer	Response	%
1	Project Chair/Vice-Chair	15	16%
2	Project Team Member	80	84%
	Total	**95**	**100%**

Summary

This chapter provided an overview of the research questions, analysis methodology, results, and a description of demographic characteristics of the sample population including identification of the teams by type. The hypothesized regression models indicate a relationship between team interpersonal beliefs, TMS, and team learning behaviors, and may indicate that TMS plays a moderating role in that relationship.

The insights gained in this research will contribute to the understanding of the influences that impact team learning behaviors in a virtual setting. Chapter 5 will provide further interpretation of the data, conclusions, and recommendations for future research that extends current knowledge base discussed in the literature review.

Chapter 5

INTERPRETATIONS, CONCLUSIONS AND RECOMMENDATIONS

Summary

Teams have become the basic organizational unit for getting work done, and virtual teams are increasingly used as an organizational tool to take advantage of diverse human resources and skills as well as improved technological resources. Yet a gap exists in our understanding of how shared interpersonal beliefs and learning behaviors develop in virtual teams. "Much of our understanding of how such teams function, particularly extant work teams, is still at a very rudimentary stage, and more research clearly needs to be directed at identifying how to design and support highly virtual teams" (Cordery & Soo, 2008, p. 498). Teams are used to draw on a variety of expertise that needs to be coordinated and applied to accomplish work. Such groups or teams may be consulting teams, product development teams, research teams, or other cross-functional, or ad-hoc project teams (Lewis, 2003).

Given the proliferation of virtual and geographically dispersed teams, understanding the factors that help or hinder team learning is critical to their success. Much of the research related to team learning and virtual team learning has been based on student teams or teams within a single organization. To my knowledge, no prior studies have explored the development of transactive memory systems and team learning using virtual ad-hoc knowledge-work teams. The purpose of this study was to provide an

analysis of the relationship between psychological safety, team efficacy, transactive memory system (TMS) development, and learning behaviors of virtual teams.

This study was developed and conducted to answer the question: does a significant relationship between virtual ad hoc work team interpersonal beliefs, TMS development, and team learning behaviors exist? This study was designed to address this broad research question and the following specific research questions:

1. Are team learning behaviors and TMS exhibited by teams operating in a primarily technology-mediated, non-collocated environment?

2. Does psychological safety and team efficacy contribute to the development of team learning behaviors in a virtual setting?

3. Does TMS have a relationship to virtual team learning behaviors?

4. Does TMS moderate the relationship between team interpersonal beliefs of psychological safety and team efficacy and team learning behaviors?

This study attempted to integrate theory of interpersonal team beliefs, transactive memory system development, and team learning behaviors. Interpersonal belief factors are complementary in that they were all hypothesized to be positively associated with team learning in a virtual setting. The results of the study indicate that the team interpersonal beliefs of psychological safety and team efficacy were all positively associated with team learning behaviors. In addition, it was demonstrated that TMS was also positively associated with team learning behaviors.

The study by Gibson and Gibbs (2006) explored the role of psychological safety in virtual teams, and found that a psychologically safe communication climate helped mitigate many of the potential process losses associated with virtual team working. Increased psychological safety was expected to facilitate team learning behaviors regardless of the context since it facilitates the appropriate environment for learning behaviors. This hypothesis was supported by the results of this study. Psychological safety correlated moderately to virtual team learning behaviors ($r = 0.562$) and was significant at the $p < 0.01$ level. This result is consistent with past research on team learning by Edmondson (1999) and Van den Bossche et al. (2006) that demonstrated a strong positive relationship between team learning behaviors and psychological safety.

This study measured virtual team efficacy of non-collocated ad hoc work teams. It has been argued that the sense of confidence generated by high group potency may help teams persevere in the face of adversity and influence how teams regulate their processes and share information (Gully et al., 2002). This study hypothesized a similar positive relationship between virtual team efficacy and team learning behavior. The results indicate support for the positive relationship between virtual team efficacy and virtual team learning behavior, but the relationship was weak. Although not hypothesized in this study, it was noted that team efficacy correlated strongly to psychological safety ($r = 0.613$) and TMS ($r = 0.627$) at the $p< 0.01$ level.

It has been noted by London et al. (2005) that a mature, well-developed transactive memory system may provide group members with a way to draw on broad knowledge, communicate among themselves more easily, and have a means for new knowledge related to the task thus improving group performance. The processes and

behaviors associated with TMS were hypothesized to have a positive relationship to team learning behaviors. The results of this study support that hypothesis and indicate that TMS had a Pearson correlation coefficient ($r = 0.570$) and was significant at the $p < 0.01$ level indicating a moderately positive relationship to virtual team learning behavior. This is consistent with the work of Lewis et al. (2003) who argued that TMS enable individual level and team level learning that transfers to other similar tasks.

The main research hypothesis of this study was that the relationship between team psychological safety, team efficacy, and team learning behaviors are moderated by TMS. The hypothesized model that placed TMS as a moderator did show a slight increase in the variation explained in virtual team learning behaviors versus the model with no moderating effect included. This result may indicate a potential moderating effect of TMS, but is not strong enough to make an unequivocal statement. Additional research with a larger sampling of virtual teams may help to improve the significance and validity of these results.

All hypotheses proposed in this study were supported at varying levels. Conclusions, interpretations, and recommendations based on these findings and past research will be further explored in following sections.

Conclusions

Consistent with findings by Edmondson (1999), van den Bossche et al. (2006), and Ortega (2010), psychological safety was shown to influence team learning behaviors positively. The study by Gibson and Gibbs (2006) explored the role of psychological

safety in virtual teams, and found that a psychologically safe communication climate helped mitigate many of the potential process losses associated with virtual team work. Ortega et al. (2010) study showed that psychological safety stimulates interactions oriented toward learning in project teams that operate virtually. My study demonstrated once again that psychological safety has a positive influence on team learning behaviors. As noted by Knapp (2010) team learning requires a team to practice critical reflection, routinely review basis assumptions, assess their motivation, and look for signs of defensive reasoning. A psychologically safe team environment allows for risk taking and experimentation that allows teams to collaborate, explore new ideas, test group processes, learn, and grow.

The difficulties posed by virtual team environments may affect the development of group efficacy. Both the lack of collocation and the need to use sophisticated information technology are factors that add complexity to team interactions (Lipnack & Stamps, 2000) and consequently may affect the efficacy beliefs related to those interactions (Hardin, 2006). Ortega's (2010) study of student project teams found that collective efficacy was positively related to virtual team learning, but no such result existed for virtual ad-hoc work teams.

This study showed that although teams developed a high level of team efficacy, there was only a somewhat weak, but positive relationship between team efficacy and team learning behaviors. This result may be attributed to the fact that this study used virtual teams instead of collocated teams. As noted by Hardin, Fuller & Valacich (2006), virtual teams may not develop efficacy the same way as collocated teams, and efficacy may not play an important role in a virtual environment.

TMS, as anticipated, had a positive impact on virtual team learning behaviors. Teams of experts with known areas of specialization are a common structure. TMS provides the metacognitive process used by teams to organize and utilize the strengths of each team member, and may provide the efficacy needed to execute. Individual credibility is built on the process of sustained development of trust between parties. Teams develop similar credibility by successfully performing their expected roles. Once that credibility and trust are established teams feel empowered to coordinate actions based on the knowledge, and efficacy belief, that the team can accomplish the task at hand.

The moderating effect of TMS was very small, and this study could not conclude that TMS moderates the relationship between team interpersonal beliefs and team leaning behaviors. However, the study found a high degree of correlation between TMS and virtual team learning behaviors, which may indicate that TMS plays an important role in team learning. The relationship between TMS and team learning behavior should be explored further in future research.

A TMS is comprised of three substructures: (1) specialization of knowledge; (2) cognitive trust of other's knowledge, and (3) an ability to coordinate knowledge according to the task structure and members' unevenly distributed knowledge (Lewis, 2004). While the team understands that knowledge may be unevenly distributed, efficacy remains high since members learn to rely on other member's knowledge thereby increasing their team efficacy.

It has been noted by Yoo and Kanawattanachi (2001) that the volume of communication in virtual teams decreases over time as TMS develops. In this study it was known that teams had many members with a high degree of familiarity with other team members which may explain a highly developed TMS and a strong correlation between TMS and team efficacy. It may follow that a well-developed TMS may positively impact team efficacy since there is a sense of confidence developed when employees believe that they belong to a strong team and understand how to access those strengths.

Although teams were formed based on interest, many team members were well aware of the expertise of other team members based on past experience in other common trade areas and meetings, as well as through reputation. This may help explain the high level of TMS developed in most teams.

Team learning is an abstract concept of how the collective group processes information and works together. Knapp (2010) proposed that team learning could be explained as a combination of metacognition and reflective practice, and that teams are complex adaptive systems. The results of this study further support the role of psychological safety, team efficacy, and TMS in the development of team learning behaviors.

TMS may help further develop the model of team learning proposed by Knapp (2010). TMS and the concepts that make up TMS - specialization, credibility, and coordination - may replace metacognition as a central element in the process of team learning as shown in Figure 5.1. Psychological safety and group efficacy have been shown to be necessary in the development of effective team learning behaviors. Although

TMS was not shown to clearly moderate the relationship between interpersonal beliefs and team learning in this study, TMS was shown to strongly influence the development of team learning behaviors. Placing TMS in the center of the proposed model of team learning denotes the concept that it influences all aspects of team learning, structure, and performance. The ability of the team to understand its' individual and collective knowledge and the ability to access and retrieve that information for use in solving problems is central in a team's function, learning, and performance. The results of this study and past studies of TMS indicate that TMS should be part of any model of team learning.

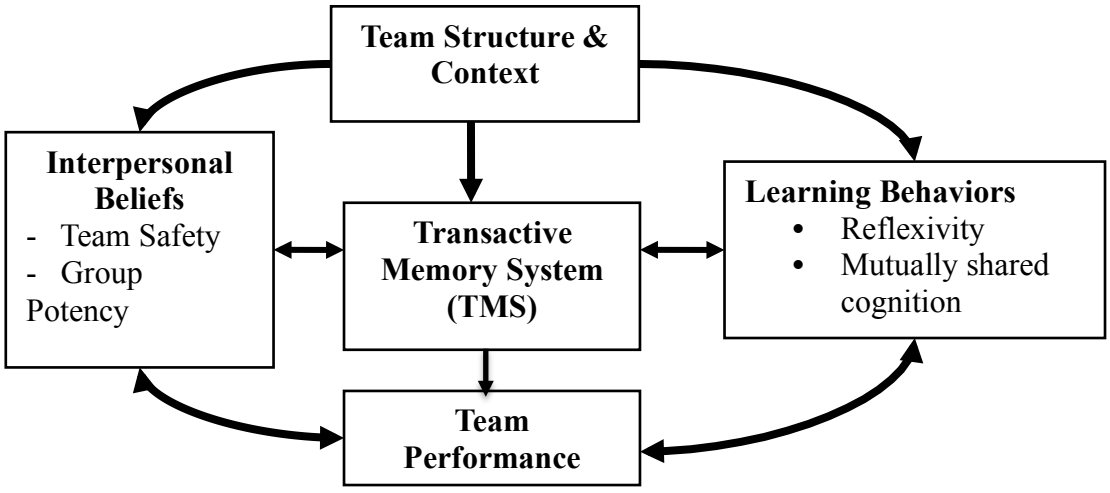

Figure 5.1: Team Learning Model with TMS

The ad hoc teams studied in this research fit the definition of a virtual team provided by Kirkman et al. (2002) as "groups of people that work interdependently with shared purpose across space, time and organizational boundaries using technology to communicate and collaborate" (p. 67). The ad hoc work teams were also well characterized by Gibson and Gibbs' (2006) dimensions of geographic dispersion, electronic dependence, dynamic structure, and national diversity. Team members were dispersed throughout North America and Europe, relied almost completely on electronic communication, had a limited lifespan indicating a dynamic structure, and in some cases, were nationally diverse.

Recommendations and Limitations

This study has direct implications for the development of teams that work in a technology mediated, non-collocated environment. This type of work structure is increasingly used across industries. While this study examined the relationship between the variables in a limited number of ad hoc work teams of a trade association, the results may be useful for understanding structures and processes of other types of temporary teams working in a primarily virtual environment. The study of additional teams with a larger sample size would improve the reliability of the results.

The trade association and teams in this study were primarily made up of experienced engineers that are generally comfortable with technology. Teams of engineers exhibit a high level of comfort with technical tasks, but may not be so adept at other types of tasks such as management or marketing. Since this study did not look at team learning in relation to specific team tasks it is difficult to determine if task may have an impact on the results. If time allowed, it may be worthwhile to include many types of

teams with varying membership and tasks to assess the applicability to a broader range of teams.

The need to have a psychological safe environment to facilitate learning behaviors was demonstrated in this study and is well established in the research literature for a variety of team types. In the research population used in this study team members may have been more familiar with one another than in other types of temporal or ad hoc work teams. This provided a relatively high degree of psychological safety for team interactions. Additional research that examines virtual teams with less familiarity among group members may provide additional insights on the development of psychological safety and the relationship to team learning.

While the work of Bandura (1997, 1999) indicates that efficacy can be a team-level construct, additional research is needed to determine if efficacy is an important team-level construct in relation to the development of team learning. This study did not establish a strong relationship between team efficacy and team learning behaviors in a virtual environment. Additional studies using virtual teams may help identify a relationship between the constructs similar to that found for collocated teams.

A relationship between team efficacy and TMS was noted in this study and is worthy of further exploration. It is possible that there is conceptual overlap between the two team-level constructs that led to a high degree of correlation.

The results of this study indicated that TMS was positively associated with the development of team learning behaviors. This is an important finding that extends the TMS literature where Yoo & Kanawattanachai (2001) noted that there has been limited empirical research on how TMS specifically develops in virtual teams. Clearly TMS

plays an important role in the development of team learning and team performance. The concepts of specialization, credibility, and coordination that make up TMS are all important components of explaining how teams work together to accomplish their goals. Further empirical research is needed on the role of TMS in other types of teams.

This study utilized individual responses to group level questions and analysis due to lack of time and resources. While the aggregation of data from individual to group level is relatively common in the quantitative study of teams it can have issues with construct validity. Since all measures used in this study showed strong within-group agreement and meaning at the team level of analysis they were aggregated to the team level from individual responses by averaging responses by team. Directly collecting data through other techniques and instruments at the team level could prove to be more powerful in future studies. For example, focus groups or team observations would provide for the interaction of team members and allow the researcher to assess the development of specific interpersonal beliefs and team learning behaviors.

Due to time and access constraints only quantitative data was collected in this study. The collection of qualitative data through interviews and focus groups would provide more insight into why team members and teams act as they do.

Additional research on the model shown in Figure 5.1 using a variety of teams in various settings is necessary to further understand the proposed relationships between interpersonal team beliefs, TMS, team learning behaviors, and team performance. This study utilized correlation analysis and multiple regression analysis methods to help establish that there is a relationship between psychological safety, team efficacy, TMS, and virtual team learning behaviors. The use of more powerful statistical techniques such

as structural equation modeling (SEM) is needed to determine the strength of the causal relationships between the constructs presented in the proposed model of team learning. SEM would improve the validity and reliability of measures and is a more powerful test of causal relationships specified in the model of team learning (Gall, Gall & Borg, 2007).

Virtual teams have become an important organizational phenomenon in today's workplace. The results of this research have shown that there is a positive correlation between team interpersonal beliefs of psychological safety and team efficacy, TMS, and team learning behaviors in a virtual work setting. The finding that TMS is positively related to team learning behavior helps fill the void of empirical research on the development of TMS in virtual teams, and demonstrates it's important role in the development of team learning. Although the moderating effect of TMS was not shown to be conclusive, the concept is important in the development of future models of team learning and is worthy of additional research. It is worth noting that although there may be some conceptual overlap between team efficacy and TMS, both play an important role in team learning and development. Additional research on the interaction of these constructs is needed to clarify what specific role they play in the development of team learning beliefs and behaviors.

The results of this research may be generalizable to other types of teams that work in a virtual environment. Additional research on virtual teams is needed to explain how people work and learn in this interpersonally complicated environment that has become an important organizational tool.

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Appendix A

Research Information Sheet

INFORMATION SHEET FOR RESEARCH

The Effects of Psychological Safety, Team Efficacy, and Transactive Memory System Development on Team Learning Behavior in Virtual Work Teams

You are invited to be in a research study of virtual team interpersonal beliefs and learning behaviors. You were selected as a possible participant because you are a member of the Plastics Pipe Institute (PPI) and have been involved in teams that conduct the majority of their work virtually at PPI. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by the principal investigator: Randall Knapp, Department of Organizational Leadership, Policy, and Development of the University of Minnesota. The PI is also employed by the Plastics Pipe Institute.

Procedures:

If you agree to be in this study, we would ask you to do the following things:
Complete an online survey for the virtual teams that you have been or are currently participated on over the past 12 months. Each survey requires approximately 15 – 20 minutes to complete. You are being asked to complete one survey for each team experience.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota or with PPI. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher(s) conducting this study is (are): Randall Knapp. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact the researcher at rknapp@plasticpipe.org, knap0109@umn.edu or by phone at 763-691-3312. Otherwise please contact the researcher's adviser, Alexandre Ardichvili, at ardic001@umn.edu or by phone at (612) 626-4529.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Appendix B

Letter to Survey Participants

Letter to Survey Participants

PPI conducts itself and accomplishes its goals through the use of teams. Many, if not all, of the teams do the majority of their work virtually … meaning that team members are not in the same location and must rely on technology for their interaction and communication.

Randy Knapp (PPI staff) is conducting his doctoral research project entitled "The effects of psychological safety, team efficacy, and transactive memory system development on team learning behavior in virtual work teams" utilizing PPI teams. You are being asked to participate in a short survey that assesses team interpersonal beliefs and learning behaviors based on your experience on teams at PPI.

The Institutional Review Board (IRB) of the University of Minnesota has approved this doctoral dissertation research project. Results from individual surveys will be aggregated to the team level and no individual responses will be included in the survey results. Your participation is highly encouraged, but voluntary. You may opt out of the research at any time without repercussion.

I encourage you to participate in this research project being conducted by Randy in pursuit of his Ph.D. in Organization Development. We believe that beyond assisting Randy in his doctoral dissertation efforts, this research can inform PPI and member

companies on how virtual teams work and learn. As an added benefit of your participation, Randy will present the findings of the study at either the Fall 2014 or Spring 2015 PPI meeting.

In a few days you will receive an email with a link and instructions for completing the survey. If you have any questions, please contact Randy Knapp directly at rknapp@plasticpipe.org.

Thank you for your support of PPI!

Appendix C

Virtual Team Learning Beliefs and Behaviors Questionnaire

Virtual Team Learning Beliefs and Behaviors - Survey Instrument

Purpose

The purpose of this research is to gather information regarding the virtual team(s) of which you have most recently been or are a current member through your involvement with the Plastics Pipe Institute (PPI) trade association. It is hoped that this research will help improve our understanding of how virtual team interpersonal beliefs of psychological safety and team efficacy along with transactive memory system development affects team learning behaviors.

This research is being conducted as part of a doctoral dissertation.

Your Participation

In order to accomplish the goals of the research we need your complete and honest participation. We ensure complete confidentiality for everyone who completes this survey. Individual responses will be aggregated to the team level and no individual can be identified. Please identify a current or recent (within the past 12 months) virtual team experience through your work at PPI to respond to this survey. Please note that you are being asked to fill out a separate survey for each team that you were involved in or led during that time.

Survey Results

The results of the survey will be aggregated to the team level and summarized in a final report upon completion of this dissertation research project. The report will be shared with all participants in this process in an effort to inform all involved and further the learning for individuals, teams, and organizations involved.

Directions for completing the Survey

The Virtual team beliefs and behaviors survey will take approximately 15 – 20 minutes to complete. If you participated on more than one team, you will need to complete a separate survey for each team experience. Please follow the instructions for each sub-section and indicate your responses accordingly.

EXAMPLE	Very Inaccurate	Inaccurate	Somewhat inaccurate	Neither Accurate or Inaccurate	Somewhat Accurate	Accurate	Very Accurate
This was the best team experience I ever had	☐	☐	☐	☐	✓	☐	☐

Section #1 - Team efficacy

This survey asks you about your beliefs regarding the team's efficacy, or their belief in the ability of the team to compete the work effectively. Please use the rating scale below to indicate how accurately each statement describes your virtual team experience. Please read each statement carefully, and then mark the bubble that corresponds to your reply.

	Very Inaccurate	Inaccurate	Somewhat inaccurate	Neither Accurate	Somewhat Accurate	Accurate	Very Accurate

				or Inaccurate			
1. Achieving this team's goals is well within our reach	☐	☐	☐	☐	☐	☐	☐
2. This team can achieve its task without requiring us to put in unreasonable time or effort	☐	☐	☐	☐	☐	☐	☐
3. With focus and effort, this team can do anything we set out to accomplish	☐	☐	☐	☐	☐	☐	☐

Section #2 - Team psychological safety

This survey asks you about your beliefs regarding the team's psychological safety or trust. Please use the rating scale below to indicate how accurately each statement describes your virtual team experience. Please read each statement carefully, and then mark the bubble that corresponds to your reply.

	Very Inaccurate	Inaccurate	Somewhat inaccurate	Neither Accurate or Inaccurate	Somewhat Accurate	Accurate	Very Accurate
1. If you make a mistake on this team, it is often held against you	☐	☐	☐	☐	☐	☐	☐
2. Members of this team are able to bring up problems and tough issues	☐	☐	☐	☐	☐	☐	☐
3. People on this team sometimes reject others for being different	☐	☐	☐	☐	☐	☐	☐

4. It is safe to take a risk on this team	☐	☐	☐	☐	☐	☐	☐
5. It is difficult to ask other members of this team for help	☐	☐	☐	☐	☐	☐	☐
6. No one on this team would deliberately act in a way that undermines my efforts	☐	☐	☐	☐	☐	☐	☐
7. Working with members of this team, my unique skills and talents are valued and utilized	☐	☐	☐	☐	☐	☐	☐

Section #3 - Team learning behavior

This survey asks you about your beliefs regarding the team's learning behavior. Please use the rating scale below to indicate how accurately each statement describes your virtual team experience. Please read each statement carefully, and then mark the bubble that corresponds to your reply.

	Very Inaccurate	Inaccurate	Somewhat inaccurate	Neither Accurate or Inaccurate	Somewhat Accurate	Accurate	Very Accurate
1. We regularly take time to figure out ways to improve our team's work processes	☐	☐	☐	☐	☐	☐	☐
2. This team tends to handle differences of opinion privately or off-line, rather than	☐	☐	☐	☐	☐	☐	☐

addressing them directly as a group							
3. Team members go out and get all the information they possibly can from others-such as customers, or other parts of the organization	☐	☐	☐	☐	☐	☐	☐
4. This team frequently seeks new information that leads us to make important changes	☐	☐	☐	☐	☐	☐	☐
5. In this team, someone always makes sure that we stop to reflect on the team's work process	☐	☐	☐	☐	☐	☐	☐
6. People in this team often speak up to test assumptions about issues under discussion	☐	☐	☐	☐	☐	☐	☐
7. We invite people from outside the team to present information or have discussions with us	☐	☐	☐	☐	☐	☐	☐

Section #4 - Transactive Memory System Development

This survey asks you about your beliefs regarding the team's development of transactive memory system. This section is divided into three sub-scales. Please use the rating scale below to indicate how accurately each statement describes your virtual team experience. Please read each statement carefully, and then mark the bubble that corresponds to your reply.

Specialization:

	Strongly disagree	disagree	Neutral	Agree	Strongly agree
1. Each team member has specialized knowledge of some aspect of our project	☐	☐	☐	☐	☐
2. I have knowledge about an aspect of the project that no other team member has	☐	☐	☐	☐	☐
3. Different team members are responsible for expertise in different areas	☐	☐	☐	☐	☐
4. The specialized knowledge of several different team members was needed to complete the project deliverables	☐	☐	☐	☐	☐
5. I know which team members have expertise in specific areas	☐	☐	☐	☐	☐

Credibility:

	Strongly disagree	disagree	Neutral	Agree	Strongly agree
1. I was comfortable accepting procedural suggestions from other team members	☐	☐	☐	☐	☐
2. I trusted that other members' knowledge about the project was credible	☐	☐	☐	☐	☐
3. I was confident relying on the information that other team members brought to the discussion	☐	☐	☐	☐	☐
4. When other members gave information, I wanted to double-check it for myself	☐	☐	☐	☐	☐
5. I did not have much faith in other members' "expertise"	☐	☐	☐	☐	☐

Coordination:

	Strongly disagree	disagree	Neutral	Agree	Strongly agree
1. Our team worked together in a well-coordinated fashion	☐	☐	☐	☐	☐
2. Our team had very few misunderstandings about what to do	☐	☐	☐	☐	☐
3. Our team needed to backtrack and start over a lot	☐	☐	☐	☐	☐

4. We accomplished the task smoothly and efficiently	☐	☐	☐	☐	☐
5. There was much confusion about how we would accomplish the task	☐	☐	☐	☐	☐

Section #6 – General Team Information

This survey asks you to provide general information regarding the team that you participated on and used to complete this survey, as well as some individual demographic data. Please read each statement carefully, and then respond accordingly in the area provided.

	Response
1. Identify the team by project number, or if not known by Division and Title	
2. Indicate the primary task of your team 1) Management 2) Technical 3) Process	
3. Indicate the total number of members on your team	
4. Indicate how long your team was or has been in existence by selecting one of the categories 1) 6 months or less 2) 6 to 12 months 3) 12 – 18 months 4)18 months +	
5. How diverse is your virtual team? Members from different states, countries, cultural backgrounds, etc. 1) very diverse 2) diverse 3) very little diversity 4) not diverse at all	
6. Indicate your role on the virtual team 1) Chair 2)Member	
7. Indicate your age (in years)	
8. Indicate your gender (M or F)	

Appendix D

Institutional Review Board Approval

From: IRB

Date: Tuesday, November 5, 2013

Subject: 1310E45047 - PI Knapp - IRB - Exempt Study Notification

To: knap0109@umn.edu

TO : ardic001@umn.edu, knap0109@umn.edu,

The IRB: Human Subjects Committee determined that the referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2 SURVEYS/INTERVIEWS; STANDARDIZED EDUCATIONAL TESTS; OBSERVATION OF PUBLIC BEHAVIOR.

Study Number: 1310E45047

Principal Investigator: Randall Knapp

Title(s):

The effects of psychological safety, team efficacy, and transactive memory system development on team learning behavior in virtual work teams

This e-mail confirmation is your official University of Minnesota HRPP notification of exemption from full committee review. You will not receive a hard copy or letter.

This secure electronic notification between password protected authentications has been deemed by the University of Minnesota to constitute a legal signature.

The study number above is assigned to your research. That number and the title of your study must be used in all communication with the IRB office.

Research that involves observation can be approved under this category without obtaining consent.

SURVEY OR INTERVIEW RESEARCH APPROVED AS EXEMPT UNDER THIS CATEGORY IS LIMITED TO ADULT SUBJECTS.

This exemption is valid for five years from the date of this correspondence and will be filed inactive at that time. You will receive a notification prior to inactivation. If this research will extend beyond five years, you must submit a new application to the IRB before the study?s expiration date.

Upon receipt of this email, you may begin your research. If you have questions, please call the IRB office at (612) 626-5654.

You may go to the View Completed section of eResearch Central at http://eresearch.umn.edu/ to view further details on your study.

The IRB wishes you success with this research.