VITAL SIGNS FOR VIRTUAL TEAMS: AN EMPIRICALLY DEVELOPED TRIGGER MODEL FOR TECHNOLOGY ADAPTATION INTERVENTIONS

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Abstract

This study explores how team leaders sense the need for technology adaptation intervention in distributed, computer-mediated (“virtual”) teams. Analysis and coding of critical incident data collected in interviews of practicing leaders produce a five-trigger model including (1) external constraint, (2) internal constraint, (3) information and communication technology (ICT) inadequacy, (4) ICT knowledge, skills, and abilities inadequacy, and (5) trust and relationship inadequacies. The resulting five-trigger model provides several key contributions including (1) a diagnostic tool for examining real, multi-trigger team technology adaptation contexts, enabling better leader training and evaluation as well as improved research on team technology adaptation and interventions and (2) a better understanding of the relationship between the technology structure strength indicators in adaptive structuration theory and the need for team technology adaptation intervention.

Keywords: Virtual teams, leadership, project management, IS development teams, empirical research, critical incident technique

Introduction

“There’s CMM, there’s ISO, and then there’s reality. No firm wants to tell you what’s really going on in their projects, because teamwork is breaking down all the time.”
- Project Manager from a top IT consulting firm

Prior research indicates that one critical enabler of team interaction success consists of effective team technology adaptation during projects (Majchrzak et al. 2000; Malhotra et al. 2001). Consistent with existing literature we define team technology adaptation as a process in which a team changes the way it uses one or more information and communications technology (ICT) for accomplishing its work (DeSanctis and Poole 1994). Given that teams must adapt their technology during work, we can imagine that adaptation management offers team leaders a lever for improving the
success of their projects. For leaders of teams in increasingly common “virtual” settings, reliant on technology-mediated communications among multiple, distributed organizations, direct influence and authority is scarce (Piccoli and Ives 2003). For these leaders, we posit that adaptation management serves as a necessary means to gain needed control and influence over productivity. Given the indications in existing research of the importance of this adaptation role, we sought to understand how a team leader executes it. We began with this study to identify how a team leader may sense the need for technology adaptation intervention. Specifically, we search for what triggers team leaders may watch.

Team leaders intervene when they recognize a need to improve team interaction and believe that their actions could affect such an improvement (Barge 1996; Hackman 2002). In virtual teams (VTs), the core mechanism for interaction is ICTs. It follows that ICT adaptation management interventions would be one critical function of leading a VT. Studies and current theories on the role of ICTs in the effective execution of computer-mediated work emphasize the importance of media choices (e.g., Dennis and Garfield 2003; Dennis and Valacich 1999; Zigurs and Buckland 1998). Several of these latter studies treat ICT choice as an initial problem rather than an ongoing concern because ICT selections are based on their fit with functional needs, which may be predetermined from work tasks. Substantial uncertainty remains as to whether and how media characteristics in isolation from ongoing team interaction explain usage (Massey and Montoya-Weiss 2006).

Existing research focusing on technology adaptation and usage in teams indicates not only that teams will face the need to adapt their ICTs as they work (Majchrzak et al. 2000), but also that these occasions will be important to maintain team productivity (Massey and Montoya-Weiss 2006). That being the case, team leaders managing such technology adaptation occasions would have a need to be able to anticipate and analyze how to craft their interventions based on the needs of any given technology adaptation scenario. Existing literature explaining why people would use technologies, and, therefore, the possible nature of any given technology adaptation occasion, indicates several overlapping and sometimes contradictory explanations. For example, studies, some not strictly examining VTs nor ICTs, have found that technology may be adapted for utilitarian task-fit (Goodhue and Thompson 1995) or expediency (Straub and Karahanna 1998), cultural reasons outside of task needs (Straub 1994), out of habit (Huysman et al. 2003), or due to individual perceptions and experiences (Venkatesh et al. 2003). These theories may explain why a specific technology may get adapted in a controlled environment, but virtual team environments are not controlled because they involve multiple technologies, people, and potential reasons why they may need to adapt. There is a missing layer of understanding that would explain adaptation in different technology adaptation contexts, such as those in VTs. Both practitioners and researchers need to understand this missing layer in order to predict when technology adaptation will occur as well as to analyze different technology adaptation contexts.

We know that technology adaptation is necessary in project teams. Adaptive structuration theory remains silent when it comes to predicting technology adaptation, but it offers a framework that promises to capture all of the elements pertinent to causing technology adaptation. As such, it suggests that we focus on team structures to find out what elements leaders observe when recognizing the need for technology adaptation management. Prior research has documented the idea that the utility of technologies used by groups varies due to factors such as different task needs over time (Massey and Montoya-Weiss 2006; McGrath 1984). Thus, we presume interventions by team leaders to affect technology adaptation would respond to different structural triggers at different points in project teamwork. Our general guiding question was: what signals VT leaders that they need to engage in technology adaptation management to improve team interaction? Our specific research questions follow:

1. How do these triggers relate to team structures: team, task, technology, and organizational context?
2. How do these triggers relate to project stages?

This paper contributes to existing research and practice on technology adaptation in work teams by developing an empirically grounded framework that identifies the vital signs, or key triggers, necessary to watch for recognizing the need to manage technology adaptation in virtual teams. Identifying signs of technology adaptation need is a necessary first step in developing a research stream, which will aid team leaders and researchers attempting to improve team adaptation success. This framework enables future research on better ICT designs for sensing and handling automated adaptations and interventions. It extends our understanding of when technology adaptation will occur. In addition, the findings can be adapted in practice to train and assess VT leaders as well as to design project management and collaboration monitoring systems that support VT leaders.

The first section presents a discussion of relevant existing literature analyzed according to requirements for understanding technology adaptation. The following sections detail the critical incident technique methodology and discuss the data and findings. The final section focuses on implications of this study to research and practice.
Conceptual Development

The first issue in understanding team leader sensing of the need to intervene and manage technology adaptation relates to what may cause members of a virtual team to engage in technology adaptation. To build a framework for understanding how a team leader may better sense and manage technology adaptation events, we must develop a social-temporal theory that, like channel expansion theory (Carlson and Zmud 1999; Massey and Montoya-Weiss 2006), covers why adaptation of a technology will occur in a group over time. It must also, unlike channel expansion theory, define the elements of group context that a team leader must evaluate.

Adaptive structuration theory (AST) provides a starting point for developing such a theory (Poole and DeSanctis 2004). AST identifies elements of a social system that influence technology adaptation. It thereby defines the necessary and sufficient elements to capture from the context surrounding technology adaptation in groups in order to fully describe technology adaptation and causes a leader would be able to perceive.

A second fundamental issue in understanding team leader management of technology adaptation relates to how team leaders view group technologies (ICTs) and their relation to teamwork interventions. While there have been some studies aimed at understanding how to deal with IS project problems once they are communicated to higher management (e.g., Keil 1995; Montealegre and Keil 2000), exactly how a project leader may recognize problems as they are happening and fix them and how she may understand the role of technology in such problems remains largely unknown (Massey and Montoya-Weiss 2006). Prior research on IS-project team leadership recognizes the group-level nature of leadership and ICTs in focusing predominantly on interpersonal conflict and its impact (e.g., Barki and Hartwick 1994, 2001; Gopal et al. 1993; Metiu 2006; Paul et al. 2004) or the value of trust (e.g., Jarvenpaa et al. 1998; Jarvenpaa and Leidner 1999; Paul and McDaniel 2004).

Even if initial ICT choice and usage by individuals are explained, research indicates that corollary behaviors and context must accompany ICT usage to actually get results (Dennis 1996; Dennis et al. 2001), and appropriateness of ICTs for enabling interaction varies over time (Carlson and Zmud 1999; Dennis et al. 2001; Marupping and Agarwal 2004). In order to help leaders facing the on-going need to manage technology adaptation, we cannot separate ICT usage in project teams from its group-level context nor variance over time. We need an integrated view of how factors such as interpersonal conflict and trust relate to media interventions and ICT usage in improving team interaction. AST provides key basic constructs needed to develop a framework capturing the rich context of team structural factors that cause technology adaptation over time.

Adaptive Structuration Theory and Team ICT Adaptation

AST describes how groups use ICTs during interaction (DeSanctis and Poole 1994). Interaction per AST consists of reciprocal causation, alternating cycles of focusing on work with occasional focus on adaptation to change the way technologies are being used to improve interaction. Structures are appropriated based on groups’ usage of technologies. Formed structures become inadequate from time to time, as realized in “discrepant events,” causing further adaptation to take place (Orlikowski and Hofman 1997). The discrepant events are occasions when the structures founded on specific ICTs in a group fail to fill key needs of the group. In a VT context, structures comprise the rules and resources available to a team that result from ongoing interaction through ICTs. Examples of one type of structure identified by AST, a group’s internal system, might include norms for using specific features of technologies. One can count on the norm when needed as a resource but may face difficulty doing something contrary to a norm.

Prior empirical studies have confirmed the basic tenets of AST. We know that teams do encounter discrepant events and adapt their use of ICTs, such as e-mail, collaboration portals, telephoning tools, and many others, during interaction (DeSanctis and Poole 1994; Gopal et al. 1993; Majchrzak et al. 2000). The cycling of change activity with settled patterns of interaction has been described as a punctuated equilibrium pattern, and this phenomenon appears commonly in virtual work (Majchrzak et al. 2000; Maznevski and Chudoba 2000; Montoya-Weiss et al. 2001).

In terms of AST, effective ICT use would be represented by the strength of the technology structure, indicated by three elements: (1) faithfulness toward the intended use of ICT, (2) consensus on how to use the ICT, and (3) attitude of team members regarding how any given ICT is being used (DeSanctis and Poole 1994). The higher the levels of the three constructs (faithful adaptation, team consensus, and positive attitudes), the higher the strength of the technology structure. There is no clear reason, per AST, that low levels of faithfulness, consensus, or attitudes (low strength) would lead to adaptation, only that these indicators tell the state of...
adaptation of a single technology at a given time. Measures exist for these constructs (Salisbury et al. 2002), and they are used in some AST studies to measure the state of adaptation of individual technologies.

If these indicators were both necessary and sufficient to understand adaptation, we would expect VT leaders could assess only these characteristics of the ICTs in their teams in order to understand when to manage technology adaptation. However, AST remains largely silent on the issue of when adaptation will occur, beyond recognizing the importance of the strength of the technology structure and noting that adaptation may be caused by a discrepant event, which can occur at any time. To understand why adaptation occurs, one could observe the structural factors outlined by AST across a number of examples of technology adaptation within a given context of interest to gain insight into the structural triggers of technology adaptation. Such an understanding would be an important step forward for AST. AST has been criticized for its recursive explanation of reciprocal causation, which fails to identify in a deterministic manner when and why technology adaptation will occur and be successful (Poole and DeSanctis 2004).

**Virtual Team Leaders Managing Technology Adaptation in AST**

Although any member of a team might initiate an ICT adaptation, formally designated project team leaders, if present, are in the position of responsibility for noticing interaction problems related to ICT usage and making improvements happen, particularly when ineffective ICT use is leading to a drop in team productivity. Thus, this study focused on team leaders.

Recent guidelines for applying AST theory aided this inquiry by helping to map existing literature on virtual teams to the necessary components for understanding virtual team technology adaptation and the role of leaders in that process (Poole and DeSanctis 2004). Application of AST requires the examination of seven elements of a team. Mapping the existing research, especially field research focusing on virtual teams, to these guidelines reveals the importance of looking at how a virtual team leader may sense the need for technology adaptation management (Table 1).

As can be seen from Table 1, this study fills an important gap. We made a distinction between studies that were specific to VTs and those that were empirically drawn from VT field settings because prior literature pointed to a strong need to conduct VT studies in field settings in order to ensure the validity of the results (Fjermestad and Hiltz 1999; Pinsonneault and Caya 2005; Powell et al. 2004). We found a total of 28 VT field studies.

We found only two VT field studies that addressed who the actors are in team ICT adaptation and what moves they may make (rows 3 and 4). These two field studies tangentially addressed the actors. The first examined a single VT leader’s role in researching and writing a governmental business plan (Pauleen 2003), noting the importance of examining adaptation as an on-going concern in teams. It provides a single case from a single perspective. The second looked at the moves any member of a VT can make to improve interaction in knowledge-producing tasks (Kruempel 2000). This study used a content analysis of one discussion using one ICT of a long-standing, voluntary committee and did not focus on causes of leader moves.

Other than these two studies, no study we found has addressed causes of leader moves to manage technology adaptation in virtual teams using empirical, field data. We believe both of these studies are contextually limited if one desires, as we do, to provide insight into common multi-million dollar IS projects, as neither of these involved multiple ICTs and a high-pressure context with a multi-organizational but interdependent team.

Most of the other studies we found were in either the group-support systems or the computer-supported cooperative work literature and were conducted in class or laboratory settings using students. Several of the articles were conceptual papers. Many (27 articles, 29 percent) of these articles took a deterministic view, linking inputs directly to outputs. Others (31 articles, 33 percent) focused on aspects of how teams function using the socio-technical system (row 5). Eight articles mentioned situations in which leader actions critically impacted team interaction, either successfully or unsuccessfully, providing further support that VT leaders may play an important role in team interventions. We use the insights gained from this literature review in the next section to develop our research questions.

**What Triggers VT Leaders to Intervene in Technology Adaptation?**

Because of the complex factors relating to leader intervention in virtual teams, we constructed a conceptual input–process–output model integrating our theoretical understandings. In so doing, we focused on the moment of intervention and how VT
Table 1. Requirements for Applying AST (Adapted from Poole and DeSanctis 2004)

<table>
<thead>
<tr>
<th>AST Focus</th>
<th>Key AST Question</th>
<th>Sample of Relevant Prior Work (VT field studies in italics)</th>
<th>VT, field</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Structures</td>
<td>What are the relevant structures that constitute the system under study?</td>
<td>Team member role, knowledge, and characteristics (Ancona and Caldwell 1992b; Gorla and Lam 2004; Kaiser and Bostrom 1982; Kirkman et al. 2004; Knoll and Jarvenpaa 1998; Sarker and Sahay 2004; Wheeler and Valacich 1996), trust (Paul and McDaniel 2004); tasks and methodologies (Abdel-Hamid et al. 1999; Beise et al. 2004; Glass 2004; Hertel et al. 2004; Marks et al. 2000); technologies and communication channels (Becker et al. 2001; Qureshi and Vobel 2001; Suchan and Hayzak 2001; Te‘eni 2001; Woerner et al. 2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Relationships</td>
<td>How do the relevant structures impact each other?</td>
<td>Technology-task (Dennis et al. 1999a; Huang et al. 2002; Mennecke et al. 2000; Zigurs and Buckland 1998); technology-team (de Vreede and de Brujin 1999; de Vreede et al. 1999; Dennis and Valacich 1999; Zigurs 1993); technology-team-task (Massey and Montoya-Weiss 2006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Actors</td>
<td>Who are the VT members that drive structuration?</td>
<td>Effective leader characteristics (Kayworth and Leidner 2002 VT Leadership; Pauleen 2003); managerial control style (Piccoli and Ives 2003); designated versus emergent or dispersed leadership (Tyran et al. 2003)</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>4 Moves</td>
<td>What are the activities by which VT members produce structures?</td>
<td>Proactive versus reactive strategies (Kelly and Bosrom 1998; Tyre and Orlikowski 1994); automated technology facilitation (Briggs et al. 2003); user adaptation responses (Beaudry and Pinsonneault 2005); knowledge (Kruempel 2000).</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>5 System</td>
<td>What is the socio-technical system setting in which structuration occurs?</td>
<td>Knowledge transfer and communication (Ahn et al. 2004; Ahuja and Galvin 2003; Coppola et al. 2004; den Hengst and de Vreede 2004; Jarvenpaa and Leider 1999; Panteli and Davison 2005; Sarker et al. 2005); appropriation process (Majchrzak et al. 2000); temporal rhythm and group development (Massey et al. 2003; Maznevski and Chudoba 2000; Montoya-Weiss et al. 2001)</td>
<td></td>
<td>12 19</td>
</tr>
<tr>
<td>6 Contextual Impact</td>
<td>How is the VT context shaped by structuration?</td>
<td>Movement to co-sourcing (Kaiser and Hawk 2004); changes in situated learning (Robey et al. 2000); satisfaction (Reinig 2003)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7 Power</td>
<td>How are power dynamics influencing structuration?</td>
<td>Cross-organization boundary issues (Espinosa et al. 2003; Johansson et al. 1999); presence and authority (Dennis and Garfield 2003)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>28</td>
<td>67</td>
</tr>
</tbody>
</table>
leaders act with regard to adaptation in VTs to visualize the expected relationships within team interaction and draw on the model in designing our methods (Figure 1). Because we focus on the moment of intervention, you see no return arrows from the process to the inputs. Across the span of a team’s interaction, one could expect such arrows to exist (e.g., Majchrzak et al. 2000). AST’s basic structures include the internal group system, task, organizational environment, and technology (DeSanctis and Poole 1994).

We appropriately renamed the internal group system structure team as our projects consist of team groups. We treat the organizational environment structure as an encompassing context rather than a resource for leaders to directly manipulate during interventions (Majchrzak et al. 2000). The diagram depicts the leader’s role per AST in intervening to improve team interaction through technology adaptation, and the set of factors, identified through research, that the leader may consider at the time of intervention (Figure 1).

This led us to examine how technology adaptation, specifically, While the structures provide a comprehensive starting point for understanding what a team leader may sense concerning the need for technology adaptation, we recognized the importance of elaborating on the process of interaction from a structural standpoint, because AST indicates that structures are adapted over time. Cally reciprocal causation, might, theoretically, be expected to vary during teamwork. Researchers have described project progress following patterns of either punctuated equilibrium (Gersick 1988) or staged linearity (Tuckman 1965; Wheelan et al. 2003). These views lend insight into reciprocal causation in that they explain when to expect changes in teams’ technology usage.

When fundamental changes in teams occur, we theorize, the nature of technology adaptation and leaders’ abilities to sense cues might also change. Prior empirical VT studies support a stage view (Rutkowski et al. 2002; Suchan and Hayzak 2001), punctuated equilibrium (Jarvenpaa and Leider 1999; Maznevski and Chudoba 2000), and continuous, non-punctuated development (Huysman et al. 2003; Majchrzak et al. 2000). Given the support for the idea of structural adaptation over time in VT research, our framework includes three basic project stages from orientation through production to termination (Figure 1). Overlaying the stages is the punctuated cycle of technology adaptation (intervention focus) settling back into a work focus, which defines our view of team interaction for the purpose of understanding technology adaptation evaluation and intervention. The leaders monitor team interaction, occasionally recognizing triggers, and they intervene when they perceive the need for an intervention focus. Ultimately, the work process results in project outcomes from the team.

**Research Context and Methodology**

Due to the lack of research in the area of group technology adaptation triggers and the difficulty of study, we developed an innovative methodology that integrates the conceptual development presented in the prior section with the goal of
maximizing objectivity of the interpreted results. It enabled looking across many field examples from real teams in a way that could gather enough breadth and depth to analyze the triggers of leader intervention. We describe this method in this section and present its execution in this study as a guide for future work.

**Methods Design**

To successfully understand the variety of possible causes that trigger leaders to engage in technology adaptation management, we had to ensure that we sampled a cross-section of relevant contexts (i.e., multiple examples of leader intervention) within the population of interest (i.e., distributed projects with interdependence among multiple groups in different organizations), a feat difficult to perform with real teams engaged in expensive, sometimes secret, high-pressure work from which they cannot pause to engage with researchers (Dubé and Paré 2003; Fjermestad and Hiltz 1999, 2001).

Further, this study sought to observe technology adaptation. AST observation studies typically apply case research or interpretive methods to study actors’ behavior (Poole and DeSanctis 2004). The richness of its contextual capture has led to AST being applied in observational, field research settings as a descriptive theory for analysis of individual cases (Poole and DeSanctis 2004). Large sets of data have been collected about group context in order to locate and describe the relatively rare events in which technology adaptation occurs (e.g., Majchrzak et al. 2000). This application has limited the usefulness of AST-based findings for generalizing patterns across team technology adaptation contexts because each event has been viewed as idiosyncratic. The lack of ability to generalize across contexts has also contributed to skepticism about the predictive power of AST findings (Poole and DeSanctis 2004). To address this conflict between adequate generalizability and capture of relevant context, we had to apply methods that would enable valid observation of a rare phenomenon involving leaders as actors in the VT interaction and adaptation context.

The critical incident technique (CIT) provided a key solution to this dilemma. Four specific methodological benefits of CIT guided our choice: (1) a narrow focus on intensely examining behavioral requirements of work roles, (2) sampling retrospective data from the individuals enacting those roles, (3) interviews for data collection, and (4) interpretive content analysis as a primary means of data analysis. Since behavioral requirements of a role are gleaned from critical incidents, this study focused on a particular set of critical incidents. These incidents were limited to examples of VT leader technology adaptation intervention nested in ordinary VT interaction that had a clear impact both on how the team used ICTs and on team outcomes.

CIT was first used in studies of U.S. Air Force pilot effectiveness in World War II (Flanagan 1954). It has now been successfully applied in thousands of studies, making it one of the most commonly used techniques in the field of industrial and organizational psychology (Butterfield et al. 2005), and it has occasionally been used in information systems studies (e.g., Kelly and Bosrom 1998; Majchrzak et al. 2005). It is particularly suited to the study of real-world phenomena involving human actors performing job roles, especially when there is little known about the role (Bitner et al. 1985; Flanagan 1954), as is the case with leader interventions in interaction involving ICT usage changes in VTs.

**Sample Context and Selection**

The sample for this study was purposeful in that we selected experienced managers currently engaged in IS projects in order to maximize information-rich cases. Such sampling is customary for research in which a very specific phenomenon is studied (Patton 1990). Several strategies enable purposeful selection of information-rich cases. This study employed extreme or deviant case sampling. This strategy targets contexts expected to have plentiful examples of intervention in order to find examples of intervention that are unusual or special in some way, such as ones that are particularly troublesome or successful (Patton 1990). Deviant case sampling provided an ideal fit with the need to find critical incidents.

**Leader Intervention-Rich Context**

Where could we expect to find plentiful examples of leader intervention in VTs? One VT typology aided in this regard; it maintains that increases in task complexity will accompany increases in the need for VT leaders to “create structures and routines” that handle leadership functions, either through technological substitutes or delegation to other team members (Bell and Koslowski 2002, p. 27). Thus, an appropriate sample context for studying VT leaders engaged in interventions to improve interaction would be one in which task complexity is high. This is the case in virtual IS development projects (Walz et al. 1993; Xia and Lee 2004). In addition, IS development projects have lower barriers to ICT appropriation due to increased general familiarity with technology
As a result, we expected that IS development projects would display more ICT usage and adaptation. Teams facing the most interaction challenges would also likely have the greatest need for ICT adaptation. VTs face greater interaction challenges the more virtual—the more temporally and geographically dispersed and the more cross-organizational—they are (Griffith et al. 2003; Jarvenpaa and Leider 1999; Kimble et al. 2000; Knoll and Jarvenpaa 1998; Maznevski and Chudoba 2000; Montoya-Weiss et al. 2001; Riopelle et al. 2003). The more interaction challenges faced by a VT, the more we expected the successful use of ICT would matter. We selected cases where VTs face maximal interaction challenges. Thus, the contexts selected had IS development VTs engaged in projects with at least two organizations and dispersed across at least two countries or time zones.

In sum, our review suggested three key sample criteria:

1. High task complexity
2. ICT usage required and adaptable
3. Interaction challenges present: temporally and geographically dispersed and cross-organizational

Experienced, Effective IS Project VT Leaders

We focused on the VT leaders of successful IS projects because the literature indicates that the success rate even for successful leaders of these types of projects might be quite low (Kappelman et al. 2006) and we wanted to maximize the chance of finding successful critical incidents. We identified 13 subjects who were experienced, successful, and currently involved in virtual teamwork (Table 2). One held a director-level position in a major consulting firm in which he oversees other virtual team leaders (he was the one who self-reported the lowest level of success). Eight held senior-level positions in their firms.

The interviewees represented a range of demographics as well. Ten were citizens of the United States, and three were from other countries. Eleven were male, and two were female. Six had a predominantly technical background, and four had a predominantly business focus. Three had mixed technical-business backgrounds.

The leaders recalled critical incidents from 30 different projects (Table 3). The projects were large both in terms of project members (median 30) and budgets (median $7.5 million). Within a project, the median number of different organizations involved was four. Five projects focused on analysis and assessment, six on major business process re-engineering involving multiple systems and legacy upgrades, six on major package implementations or ERP systems or CRM systems, eleven on developing new systems from scratch, and two were outliers (a year 2000 project and a legacy systems outsourcing project). They reported using twelve ICTs (median) in their projects, distinctly more than have often been researched in the VT context where studies tend to focus on one or at most a few ICTs at a time.

Critical Incident Technique

We applied CIT through structured two-hour interviews with the 13 VT leaders. These interviews followed a survey to collect demographic and experience data. The interview protocol walked the interviewee back through the experiences of specific critical incidents in his/her performance of a job role (see sample in Appendix 1). A critical incident of intervention was defined as one in which the VT leader took action to improve team interaction by affecting the usage of one or more ICT and he/she deemed his/her action either particularly successful or unsuccessful and could point to specific team interaction results. Interviewees received a copy of some of the interview questions in advance to help them prepare, and questions were designed to proceed from general (the project context) to specific incidents in order to cue memory.

For each interview, the interviewer provided the same initial framing. The protocol included standardized guidelines on how to clarify when necessary for implementing CIT methods and ensuring consistency across interviews. For example, incident questions covered several subtopics related to incidents, starting with the basic description, and began with open and proceeded to probing and clarifying questions in the event that certain topical details indicated as important for understanding triggers within the AST lens were not volunteered. Appendix A contains the first two critical incident question topics of the ten covered during the interviews as a sample to illustrate how these questions were presented.

We collected 52 incidents drawn from 30 projects. CIT directs that 50 incidents collected by interview is an adequate number to reach theoretical saturation when studying a sub-role of a job (Flanagan 1954; Hopkins 1987). This requirement of multiple observations of the same phenomenon is often understood as necessary to establish proportionality of an observed phenomenon in a population. Like case method-
### Table 2. Interviewee Summary Data

<table>
<thead>
<tr>
<th>Industry</th>
<th>VT Leadership Experience (years)</th>
<th>Number of VT Projects Led</th>
<th>Non-VT Leadership Experience (Years)</th>
<th>Average Project Duration (Months)*</th>
<th>Self-Reported Success (Out of 10)</th>
<th>Interview Duration (hh:mm)</th>
</tr>
</thead>
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<tr>
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<td>2</td>
<td>15</td>
<td>12</td>
<td>6</td>
<td>2:04</td>
</tr>
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<td>Energy</td>
<td>10</td>
<td>4</td>
<td>10</td>
<td>10.5</td>
<td>8</td>
<td>2:08</td>
</tr>
<tr>
<td>Consulting</td>
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<td>4</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>2:01</td>
</tr>
<tr>
<td>Finance</td>
<td>7</td>
<td>3</td>
<td>12</td>
<td>5</td>
<td>9</td>
<td>2:45</td>
</tr>
<tr>
<td>Health</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>12</td>
<td>9</td>
<td>2:56</td>
</tr>
<tr>
<td>Consulting</td>
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<td>4</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>1:55</td>
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<tr>
<td>Software</td>
<td>4</td>
<td>4</td>
<td>11</td>
<td>4</td>
<td>9</td>
<td>2:10</td>
</tr>
<tr>
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<td>5</td>
<td>4</td>
<td>18</td>
<td>8</td>
<td>2:07</td>
</tr>
<tr>
<td>Consulting</td>
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<td>5</td>
<td>8</td>
<td>7.5</td>
<td>8</td>
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</tr>
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<td>Marketing</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>2:15</td>
</tr>
<tr>
<td>Consulting</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>1.5</td>
<td>8</td>
<td>2:17</td>
</tr>
<tr>
<td>Aero-space</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td>5</td>
<td>2:01</td>
</tr>
<tr>
<td>Consulting</td>
<td>2</td>
<td>6</td>
<td>34</td>
<td>11</td>
<td>7</td>
<td>2:12</td>
</tr>
<tr>
<td>Average</td>
<td>5.00</td>
<td>4.23</td>
<td>10.00</td>
<td>8.50</td>
<td>7.92</td>
<td>2:17</td>
</tr>
<tr>
<td>Median</td>
<td>4.00</td>
<td>4.00</td>
<td>8.00</td>
<td>9.00</td>
<td>8.00</td>
<td>2:10</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.34</td>
<td>1.30</td>
<td>8.12</td>
<td>4.38</td>
<td>1.26</td>
<td>0:20</td>
</tr>
<tr>
<td>Maximum</td>
<td>12</td>
<td>6</td>
<td>34</td>
<td>18</td>
<td>9</td>
<td>2:56</td>
</tr>
<tr>
<td>Minimum</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1.5</td>
<td>5</td>
<td>1:55</td>
</tr>
</tbody>
</table>

*Some interviewees reported duration of stages or phases of longer, multi-year projects.

### Table 3. Descriptive Statistics of Sampled IT Projects

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Type</th>
<th>Length (months)</th>
<th>Budget</th>
<th>Members</th>
<th>Orgs</th>
<th>ICTs Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Analysis/Assessment</td>
<td>9.3</td>
<td>$210,000.00</td>
<td>26</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>BPR</td>
<td>15.8</td>
<td>$11,725,000.00</td>
<td>45</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>Implementation</td>
<td>15.8</td>
<td>$23,866,667.99</td>
<td>121</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>New System</td>
<td>18.6</td>
<td>$12,918,182.00</td>
<td>75</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>Other: Patching</td>
<td>12.0</td>
<td>$10,000,000.00</td>
<td>135</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>1</td>
<td>Other: Outsourcing</td>
<td>12.0</td>
<td>$45,000,000.00</td>
<td>95</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td>13.9</td>
<td>$12,321,591.00</td>
<td>85</td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>
ology, the goal of CIT is not to establish proportionality of sampled phenomena in a population, but to ensure adequate variety of the unit of analysis to observe the major existing types of a phenomenon (Yin 1984), in this case leader interventions, to achieve theoretical saturation. The point of theoretical saturation is indicated when enough data exists so that all major themes are identified and additional cases simply repeat themes already identified (Boyatzis 1998). We found that the incident themes did repeat and no new concepts or types were appearing by the twelfth interview, suggesting we had reached theoretical saturation. Later, during the coding and analysis process, we also found that themes were repeating and no new themes were emerging toward the end, further confirming that we had a sufficient sample.

Data Analysis

The data from the primary interviews were captured in 510 pages of transcribed interview notes. In order to extract major and minor themes, we followed a carefully crafted coding and validation process, presented in Figure 2 and developed in line with recommendations for CIT research (Boyatzis 1998; Butterfield et al. 2005; Flanagan 1954).

We based the coding scheme design on a prior managerial facilitation role study conducted using CIT (Ellinger et al. 1999). We defined triggers as a general a priori category for the judges in a coding scheme. This coding scheme was subjected to two successive rounds of refinement using other judges until we reached 86 percent inter-rater reliability for agreement on presence of triggers, an adequate level for exploratory research (greater than 70 percent, Boyatzis 1998). The coding scheme and validation process formed the first of three stages of the coding process. This three-stage coding process with multiple refinement and validation substages yielded 65 trigger themes (out of 439 total themes) with 5 major trigger categories (groups of themes) representing the reasons virtual team leaders take action to improve interaction.

Thirteen of the themes related to general knowledge and awareness of leaders. We classified these as leader trait themes rather than triggering conditions and withheld them from our trigger analysis. These trait themes broadly supported the notion that leaders need to be trained on ICT features and availability, to be aware of the risks and opportunities that changes in ICT usage may represent for improving interaction, and to be sensitive to the possible risks of intervening in varying interaction contexts.

Counts of code presence by interviews and incidents provided a more accurate picture. Since no interviewees worked on the same projects and multiple, different organizations were involved in each project, we concluded that the number of interviews would give an approximation of prevalence of a code across IT project organizational boundaries and settings. The number of incidents in which a theme was represented provided a correction in case particular themes were represented in multiple incidents within the same interview.

After the coding was complete, in order to get a sense of the prevalence of the themes in the five trigger categories to ensure that they were cross-sectionally representative and not based on organizational or individual bias in the sample, we analyzed each theme code and category to identify how many interviews and how many incidents it appeared. Although quotation counts are often used to analyze the level of external validity or prevalence of an item in content analysis such as this (Neuendorf 2002), we found these counts alone contained bias, as some interviewees had multiple quotations in a single incident interview relating to the same occurrence of a theme, thus misrepresenting one occurrence of the theme as multiple occurrences.

We used the interview and incident counts to create a joint statistic to see if it might help yield better insight into overall prevalence. We conceived this weight as a combination between the number of incidents and interviews associated with each theme code and dimension. The formula for the weight was

$$\frac{\alpha + \alpha + \beta}{3} \times 100$$

Alpha represents the number of discrete interviews in which a theme code or dimension was present. Beta represents the number of discrete incidents in which a theme code or dimension was present. The range of this weight is 5.77 for codes appearing in only one incident and one interview to 100 for codes appearing in all incidents and interviews. We arbitrarily weighted the interview ratio twice to increase its influence in the weight as interview counts represented broader prevalence. The theme codes are ordered by this weight in the table in Appendix B, which lists the subdimensions and themes for each trigger. We determined that this weight provided the best determinant and represented a good balance between the two measures after comparing it with quotation-, interview-, and incident-count-based data representation.
In this section, we present our findings in relation to our research questions, namely: (1) what are the triggers of technology adaptation management in relation to structural dimensions of virtual teams and (2) how do these triggers vary across stages of projects. Our analysis confirmed prevalence of five major triggers in the data. We roughly divided them into constraints and inadequacies to distinguish triggers that appear more associated with the organizational context of a project and, therefore, more outside of direct VT leader authority and autonomy (constraints) (Majchrzak et al. 2000), and triggers more associated with structures the VT leader may manipulate in order to manage them (inadequacies). These five are (1) external constraint, (2) internal constraint, (3) ICT inadequacy, (4) trust and relationship inadequacy, and (5) ICT knowledge, skills, and abilities (KSAs) inadequacy (see Table 4).

Each of the triggers was broadly represented across project contexts and leaders interviewed, indicating to us that our resulting model was generalizable to the broader context of
Table 4. Intervention Triggers

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Interview Count</th>
<th>Incident Count</th>
<th>Weight</th>
<th>Trigger Sources (Structures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>External constraint</td>
<td>13</td>
<td>31</td>
<td>100%</td>
<td>60% 86.54 Task &amp; org. context</td>
</tr>
<tr>
<td>ICT inadequacy</td>
<td>12</td>
<td>37</td>
<td>92%</td>
<td>71% 85.26 Technology &amp; Task</td>
</tr>
<tr>
<td>Trust and relationship</td>
<td>12</td>
<td>25</td>
<td>92%</td>
<td>48% 77.56 Task &amp; Team</td>
</tr>
<tr>
<td>inadequacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal constraint</td>
<td>10</td>
<td>16</td>
<td>77%</td>
<td>31% 61.54 Technology, Task, &amp; Team</td>
</tr>
<tr>
<td>ICT KSA inadequacy</td>
<td>9</td>
<td>17</td>
<td>69%</td>
<td>33% 57.05 Technology &amp; Team</td>
</tr>
<tr>
<td>Maximum</td>
<td>13</td>
<td>52</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

virtual team leadership at a minimum. The least-represented trigger with the lowest weight value (57.05) (calculated for ICT KSA Inadequacy triggers) appeared in 9 interviews (69 percent) and 17 incidents (30 percent)—a majority of the leaders and a third of the incidents. The most prevalent triggers were external constraint and ICT inadequacies, with very high weights (greater than 80).

During the final consensus stage of coding when the judges met, the judges were asked to evaluate the triggers and their dimensions in terms of which of the four root structures the team leader was seeing. Table 4 lists the triggers, their prevalence data, and the AST structure roots associated with each trigger.

Each of the triggers contained at least two subdimensions, which help to define them and which will enable researchers to reapply the trigger model in examining other contexts of group technology adaptation management. We present the triggers, along with details of their subdimensions, the apparent root causes we found associated with each, and an example from a critical incident in Table 5. In brief, external constraint consists of external conditions imposed on a team such as mandated changes to overall scope, time line, budget, leader authority, or organizational authority. Internal constraint consists of internal characteristics of the project team such as dispersion among members, number of members, and organizational or cultural differences among members. ICT inadequacy consists of team ICTs lacking technical operation or lacking needed features. Trust and relationship inadequacy consists of team members not communicating when expected and necessary, personal conflict between team members, or team members not trusting other team members’ personal capabilities or beneficence. ICT KSA inadequacy consists of ICTs being workable but not useful in a way that members were using them or members lacking the knowledge and experience to be able to use one or more ICT.

While the mix of root structures associated with each trigger is different, all four AST structures do appear in the triggers, which we take as an affirmation of the value of our approach using AST. According to AST, any of the structures can cause a need for adaptation if, in combination with a specific technology, team interaction is somehow not fully supported. The lack of support would cause decreases in the strength of the technology structure. Thus, we would expect the technology structure to be associated with every trigger. Surprisingly, this was not the case. External constraints and trust and relationship inadequacies both lacked a technology root. On closer examination of some of the incidents dominated by these triggers, we found leaders sometimes engaged in technology adaptation as a proactive means for addressing issues originating outside of a discrepant event directly involving a technology.

For example, in one case of external constraint, a leader faced changed scope requirements (organizational context). He decided to instigate technology adaptation in order to enable the team to handle the new requirements (task structure). Perhaps he was trying to bolster their information processing capability. In another example when trust and relationship inadequacy was the trigger, a leader changed the usage of the phone conferencing and e-mail tools due to cross-cultural relationship breakdowns between teams in the United States and Japan. Ultimately, he saw a means for addressing the dispersion of members (team structure) and pressing schedule (task structure) through a technology adaptation. As in the previous example, he was not initially triggered by noticing a problem with the technology structure. Contrary to some prior thinking on technology change and adaptation, these examples imply either that discrepant events need not include direct awareness of technology structure or that something outside of discrepant events or discovery of new opportunities due to ICT features (Tyre and Orlikowski 1994) may trigger technology adaptation. Further, it appears that adaptation of
<table>
<thead>
<tr>
<th>Trigger</th>
<th>Subdimension</th>
<th>Apparent Root Causes</th>
<th>Example from a Critical Incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Constraint</td>
<td>Time-Schedule (Scope Change)</td>
<td>Some ICT related structures appear to not allow enough flexibility in reinforcing or representing time line and additional scope information to a team.</td>
<td>A project sponsor moves up a deadline for external reasons. The team scrambles to figure out how they could meet the needs of the new time line. The leader recognizes a need for different ICTs that will enable the team to jointly see their tasks, resources, and interdependencies.</td>
</tr>
<tr>
<td>Organizational Policy</td>
<td></td>
<td>Many ICTs lack access policy transparency across organizations, leading to conflicts that emerge due to misunderstanding or not knowing relevant policies that impact interaction.</td>
<td>A participating organization has policies that limit team members from other organizations on team from accessing needed ICT systems/resources. The leader realizes it will be impossible to get the policy set in the way he needs to enable the team members.</td>
</tr>
<tr>
<td>Upper Management Intervention</td>
<td></td>
<td>New leaders may have personal biases against existing ICT structures and decide to change them.</td>
<td>A project sponsor pulls an existing project manager and installs a new one due to project problems. The new leader enters with a mandate to improve the project. The new one enforces Microsoft Project in place of existing Excel usage, though Excel was apparently working for the team’s needs.</td>
</tr>
<tr>
<td>Internal Constraint</td>
<td>Dispersion</td>
<td>Many ICTs offer communication support without aiding in coordinating members to connect, leading to complications when members are dispersed.</td>
<td>The team members are physically distributed among multiple locations in two countries on two continents. Leader recognized existing ICT structures around audio conferencing were not working and needed more structure and a better tool.</td>
</tr>
<tr>
<td></td>
<td>Team Size</td>
<td>ICT structures that worked for smaller teams do not scale to larger team settings due to lack of persistent, organized archives, message filtering and controls, or other tools for handling larger groups of people.</td>
<td>The team exceeds 7 members, and the size changes over the span of the project, reaching 300 members. E-mail becomes impossible to coordinate, new members have no access to archives referenced by existing team members, and many members lack clear understanding of what is happening and what they need to do.</td>
</tr>
<tr>
<td></td>
<td>Demographics</td>
<td>One organizational or national culture within a team has/develops preferences for ICT structures to the exclusion of other options preferred or suggested by other team members.</td>
<td>The team skill-sets and cultures vary among groups. One technical group strongly prefers instant messaging and refuses to respond to any e-mail or other ICTs used for simple, normal communications.</td>
</tr>
<tr>
<td>ICT KSA Inadequacy</td>
<td>ICT Used Ineffectively</td>
<td>Members understand how to use a feature/tool but lack enough understanding of the structure around the tool and why it is a necessary resource/constraint in the team.</td>
<td>Members are supposed to use a feature/tool but do not due to comfort using something else or failure to understand the need for using the feature/tool. In one case, members continued sending updated code via e-mail rather than using the content versioning system.</td>
</tr>
<tr>
<td></td>
<td>Lack of ICT Knowledge</td>
<td>Members do not fully understand how to operate a feature/tool or perceive that they lack understanding.</td>
<td>Members do not know how to use a feature/tool that is expected to be used, in two cases, instant messaging. Leader recognizes need for training in one case. In other case, mandates usage without training (failure to recognize this trigger). The first case succeeds.</td>
</tr>
<tr>
<td>ICT Inadequacy</td>
<td>Not Operating</td>
<td>ICTs or some subset of their features are unreliable or completely fail to operate.</td>
<td>In several cases, a desired feature/tool was not working or was unreliable. In one team spread between Mexico and the U.S. e-mail was unreliable, causing the leader to take action to setup an alternative communication means.</td>
</tr>
<tr>
<td></td>
<td>Feature/Tool Missing</td>
<td>Based on prior experience or knowledge, one or more team members know of an alternate ICT-enabled structure the team could be using to improve its work.</td>
<td>A desired feature/tool does not exist among the features/tools available to the team. One team member suggests to the leader that the team try a synchronous meeting tool and explains why it would be a better resource that would remove an existing constraint on the team’s work.</td>
</tr>
</tbody>
</table>
Table 5. Trigger Details (Continued)

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Subdimension</th>
<th>Apparent Root Causes</th>
<th>Example from a Critical Incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust and Relationship Inadequacy</td>
<td>Communication Failure</td>
<td>Statements, files or other communications are not transferred between a sender and receiver in a manner that enables proper encoding and decoding for transfer of meaning, due to sender and receiver not cooperating on communication protocol (ICT structure).</td>
<td>A team has a standard for exchanging systems models, but members do not follow them, leading to members unable to read and view each others’ models and workarounds involving screenshots of models, effectively removing the productivity (resource) promised by exchanging interactive model objects (ICT feature).</td>
</tr>
<tr>
<td>Intra-team Conflict</td>
<td>Members of different sub-groups on a</td>
<td>Members of different sub-groups on a team are in conflict over task responsibilities or duties.</td>
<td>Creative team members believe they can get their work done whenever it will be completely correct, while technical team members are stuck waiting for the interface designs in order to add the coding to them. The leader recognizes the need for an ICT structure that will clarify the interdependency between the roles and highlight the shared needs.</td>
</tr>
<tr>
<td>Trust Failure</td>
<td>One or more team members distrusts</td>
<td>One or more team members distrusts one or more other team members.</td>
<td>A content expert in the U.K. stops interacting over e-mail after disagreeing with the team’s scope and publically accusing the leader (based in the U.S.) of failing to respond to necessary changes. Leader recognizes a need to make change processes more accessible and to have traceable communications.</td>
</tr>
</tbody>
</table>

Technology may occur in order to restructure other structures (team and task) in a team, even if the existing technology structure exhibits faithful usage, consensus on how to use it, and positive attitudes about using it.

In the following subsections we describe the nature of each of the five triggers in turn. These discussions draw on the details presented in Tables 4 and 5 as well as the coding results obtained after data analysis and presented in Appendix B. The trigger sections are presented in order of prevalence, divided broadly into the two types of triggers identified earlier, constraints and inadequacies.

**Trigger: External Constraint**

Constraints are the triggers that originate from conditions imposed on a team from the beginning and that are somewhat beyond the authority of the team and leader to manipulate. The external constraints represent the external conditions that are imposed on a project, such as its global time line, its budget, its basic scope, the assignment of the overall leader(s), and the policies of the core organizations that are working together. External factors affecting a team often interfered and triggered leader interventions. External constraint occurred more than any other trigger, exhibiting itself in all of the interviews and 60 percent of the incidents. This prevalence suggests that external constraints are a key ingredient in signaling technology adaptation intervention need. At the same time, external constraints did not always accompany triggers related to technology structure as noted earlier. Perhaps a shared external constraint visible to the team helps a VT leader to gather the necessary authority, motivation, and resources for change, and technology adaptation management provides a means for achieving that change.

The presence of external constraint had three subdimensions: (1) time limits or project schedule imposed on the team, (2) interference by organizational and larger policy issues, and (3) intentional efforts by upper management to influence change in the project (e.g., changing the basic scope or the interjection of a new leader, as exemplified above). Time limits and project schedules were changed mid-project, causing teams to need to reorganize work and goals, leading to interaction trouble. Organizational policies also limited critical interactions needed to accomplish project tasks, such as limiting information sharing and system access as in the following example:

We were trying to get this large set of documents to someone else at the client. There [are] two organizations. Sure, my company has FTP servers, and the organization has its own ways to share files. But, e-mail between the two will not allow these large files to go between the two servers. So, now we’re away, and we need to get these large documents to
the client. Hence, that’s what’s triggering the incident, our inability to communicate the document. Pretty basic.

In this incident, an organizational IT capacity policy imposed by one organization constrained the ability of the team to work. The leader had to engage in technology adaptation management in order to work around the external constraint. Project leaders dealing with external constraints appear to face the critical role identified by Ancona and Caldwell (1992a) of being a “boundary spanner” who must work out cross-organizational and project internal-external relationships.

**Trigger: Internal Constraint**

Internal constraint consists of internal project conditions required to implement the project as defined by the core scope and organizations involved. As could be expected by reading the wide variety of discussions on the difficulty of setting up distributed collaboration in the research and practice literature, we found that the distributed, global project design choices implemented in projects also interfered with successful interaction, triggering leader technology adaptation intervention (Table 4). This trigger mirrored much of the existing discussion in virtual team research about difficulties due to virtuality and distributed, global composition of teams (Powell et al. 2004). The main subdimensions of the constraint of internal team project design were (1) time and space dispersion, (2) team size, and (3) team member cultural differences.

Technology structure appears as a root cause in this trigger. Some incidents with internal constraints involved members from different teams or cultures (team structure) with low consensus on how to use given tools (technology structure). In such cases, it would seem leaders failed to adequately develop the strong technology structure needed given the team’s internal constraints.

The internal constraint results indicated that VT leaders would benefit from better guidance on how to assess the impact of team size, dispersion, and cross-cultural issues on technology requirements. It also suggests that such evaluations need to be performed as an on-going concern, perhaps monthly or more frequently, with an eye to which technology adaptation interventions may be needed as the size, dispersion, and composition of teams varies over time. While external constraints may emerge by surprise due to forces outside the project, the internal constraints are visible as a project proceeds and should be easier to predict and avoid through proactive project planning and management.

**Trigger: ICT Inadequacy**

ICT inadequacies consist of emergent understandings of how a given technology either partially or completely fails to serve a task-related need during team interaction. ICTs were frequently inadequate at supporting virtual team interaction, with ICT inadequacy triggers occurring in 92 percent of the interviews and 71 percent of the incidents (Table 4). Like external constraint, the high prevalence of this trigger suggests that it serves a critical function in the leader’s awareness for recognizing and executing a technology adaptation intervention. Perhaps a shared experience of a technology failing helps congeal team motivation around technology structure change, and the leader seizes the “window of opportunity” (Tyre and Orlikowski 1994) to intervene. This trigger had two subdimensions: (1) an ICT was not working, perhaps because of availability or reliability issues, not enough capacity, or lack of interoperability, and (2) an ICT feature or whole tool was missing and could not be handled by existing ICTs.

Surprisingly, e-mail provided several examples of the second subdimension, although our data and research indicated it to be a commonly accepted basic and robust tool. Our data pointed to project managers regularly struggling with getting their team members to convert to alternatives with better shared archiving and search features than are provided in e-mail, as in the following example:

As a project manager, I would send out…important e-mails with information that people needed, specs, schedules and status, and plans and things like that. I thought that I was communicating everything that everyone needed to know, but the problem we recognized was that there was too much information going across e-mail. People are either ignoring e-mails to begin with or unable to find the appropriate e-mail when they needed it down the road. So, we saw the WIKI as a tool to help with that—a central place that people could go to get current information on the project.

The first subdimension, an ICT not working, appeared across a wide variety of ICTs from scheduling software that lost events or file sharing servers that regularly went down to personal productivity software document interchange failures such as UML-modeling packages that did not properly interchange XMI documents. The interoperability between technologies was a critical reason for ICTs not working, especially considering that these projects involved, on average, more than 11 discrete ICTs (minimum of 7 and maximum of 18; see Table 3, which lists the median number by project type). This is a very surprising finding, considering that most prior research has examined only one or a few technologies at
a time. Three ICTs (phone, e-mail, and audio conferencing) were used in 100 percent of the projects and appear to be the common denominator tools for VT work. The other most common tools reported in at least 20 projects (66 percent) were project management tools, development environment tools (such as the UML tools mentioned above), document versioning tools, file repositories, instant messaging, and team spaces.

The leaders indicated that integration or interoperability across systems and across versions of the same software was a major problem. Teams could not rely on their tools exchanging files and interpreting them properly. Different subgroups within teams often had different versions of tools or different packages claiming to handle the same functionalities but failing do so. Similarly, tool availability faltered frequently, disabling task work. We found ICT inadequacy problems even among the three common denominator tools, suggesting to us that much design work remains to make ICT integration with knowledge work more effective.

Our results provide a deep criticism of the current state of ICTs in that the inadequacy of tools, even of the most common and accepted ones such as e-mail, often causes team interaction problems. One might argue, as an example, that the use of e-mail for content archiving and search (task structure) is not the intent of e-mail (therefore teams would be unfaithfully using the technology, indicating a weak technology structure foundation); however, this is how some teams are attempting and expecting to use it (indicating a strong technology structure in terms of faithfulness, consensus, and attitude). The tool regularly fails at this task (task–technology structure misfit).

Teams make the mistake of building a strong ICT structure on a weak foundation. There is a large opportunity to improve the tools to include the usage patterns needed and expected in group work. To do so, researchers may apply our framework to differentiate the contexts in which technologies are failing and having to be adapted. Such research will aid improvements by helping to define the distinct use cases in which different features increase or decrease in value for teams. We believe these applications of the framework will also locate key problems of standards integration for file descriptions and communications protocols to focus on for improving ICTs so that VT leaders will less frequently observe and more easily address this trigger.

**Trigger: Trust and Relationship Inadequacy**

Trust and relationship inadequacies consist of interpersonal misunderstandings and attitude problems among team members. Trust and relationship breakdowns proved common, providing evidence in some critical incidents supporting assertion of the central importance of trust in virtual work (Paul and McDaniel 2004). This trigger had three subdimensions: (1) communication was not working in general, (2) intra-team conflict arose and could not be solved by members on their own, and (3) trust between members soured and damaged relations.

Like external constraint, this trigger seemed to originate independent of the technology structure. The configuration of the ICTs, how they were being used, and how members felt about using them (technology structure) mattered only indirectly in that people had to interact virtually. Exactly which ICTs were used or how well they were understood did not seem inherent in this trigger. Data on incidents involving these triggers reveal examples in which members took advantage of dislocation and asynchronicity to “go dark” or stop interacting, as in the following example displaying the first subtheme:

This was originally scoped as a six-month project, and the model was supposed to be done at the end of the second month. The people who were supposed to be doing the model just went dark, didn’t respond. They took full advantage of the lack of ability of technology to find them if they didn’t want to be found.

In a way, one could argue that the individuals going dark in this example are not faithfully using the technology to communicate (technology structure). This would be a mistaken interpretation. They are not communicating (team structure) and refusing to respond to task needs (task structure), regardless of multiple ICTs available to them with adequate capacity, reliability, etc.

In several cases where leaders reported their interventions ultimately failing, conflict short-circuited all other co-work and led to a complete breakdown in distance interaction, requiring collocation at extraordinary costs. Two examples involved cross-cultural (national) misunderstandings spiraling out of control. Another involved organizational culture, and two derived from the divide between professional skill sets across dispersed groups, where the business team did not trust the technical team and vice versa. These examples led us to believe that the trust and relationship breakdowns have a special place in terms of the difficulty of resolution when triggering leader intervention for adaptation management.

Existing findings regarding virtual collaboration performance (Paul and McDaniel 2004) and interpersonal conflict resolution in IS development teams (Barki and Hartwick 2001) lend
support to the broader existence of this trust issue as a prevalent and difficult problem in IS development VTs. The fact that leaders chose to engage in technology adaptation management in order to address trust and relationship inadequacies was somewhat surprising. We observed incidents, such as one in which a leader had the teams switch collaboration portals, in which the technology structure was fine and the ICT was reliable and had adequate capacity. The adaptation of a new ICT served as a vehicle for the leader to rebuild trust.

**Trigger: ICT Knowledge, Skills, and Abilities Inadequacy**

The final trigger involved team members’ ICT knowledge or lack thereof and consequent use or disuse of tools (Table 4). The inadequacy of ICT knowledge, skills, and abilities represents the degree to which team members know how to use various ICTs and their preferences in using the ICTs available. Two subdimensions indicated this trigger: (1) a tool was workable but not effective in the way members were understanding it or using it, and (2) evidence that team members lacked knowledge or experience to use a tool. In the first theme, team members were found failing to follow critical ICT usage procedures due to ignorance, apathy, or inability, resulting in major problems. For instance,

What basically happened was the release failed the test. And again, we were very, very structured in terms of what our testing approach was. So, specifically, what we did was we tracked it back. People were not using the tools properly. There were two people, one of whom happened to be my chief database guy, one of whom was not updating the document versioning system properly. They had an old version of the database that we were testing against, so the code was blowing up all over the place, because the database was wrong. So, in this case, it was one of those things, we had all the structure in place, everyone knew the procedures, and he knew but simply didn’t follow it.

The leader acted on the triggers by making the individuals aware of how many problems they had caused and why what they did had led to problems. This motivated the two members to use the ICT in concert with the rest of the team (consensus; technology structure). Once the leader had taken this step, the team’s error rate sunk dramatically and interaction improved. The individuals had to gain knowledge of how other workers were dependent (team structure) on their proper usage of ICTs. Unfortunately, this problem only appeared after a major failure. The other aspect of member ICT KSA inadequacy dealt with capability to actually operate an ICT. Teams were assigned to use specific tools, but some members did not know how or were unaware of the actual features, as in this example where automatic archiving was assumed:

> It turned out that that e-mail was just shared amongst the members and somebody just thought it was archived. But, it was a critical e-mail, because it described how to set up the software... I just spun around for a week trying to find it and [gave up].”

In the preceding example, as part of his intervention, the leader introduced a new ICT to solve the lacking feature (ICT inadequacy trigger) and enable the team to have the capabilities that some of them assumed that they already had (ICT KSA trigger).

**Triggers Across Project Stages**

We also sought to understand how recognition of triggers relates to project stages. To examine this question, we calculated the frequency of each trigger in each incident. For this analysis, frequencies derive from the total possible number of indicators (theme codes) of triggers for each incident (n = 52, the sum of external constraint = 11, internal constraint = 9, ICT KSA inadequacy = 8, ICT inadequacy = 16, and trust and relationship inadequacy = 8; see Appendix B for the specific theme codes) summed as binary presence or absence of each theme code in each incident for each stage. The total number of trigger indicators possible in the dataset equals the number of incidents multiplied by the number of trigger theme codes or 52^2 = 2704. The total number actually observed was 507.

Table 6 displays the results of our trigger frequency analysis by project stage when intervention occurred. Proportions of each trigger in each project stage are given in parentheses. For example, we can see that there were 15 external constraint theme codes present during interventions occurring at project start-up, and these 15 accounted for 24 percent of the triggers found in the start-up stage. The middle stage of projects tended to have the most triggers overall, which probably relates to the long span of the middle stage being defined as incidents occurring after the first month and prior to the last two months of any project (Table 6). Start-up incidents are incidents that occurred during group formation, prior to beginning the actual main content work of the project.
We wanted to know if the trigger frequencies statistically varied from stage to stage, because if they did, it would indicate differing issues related to technology adaptation at different points in the life of a virtual project team. To test the difference between the levels of the triggers from stage to stage we calculated a specialized chi-square test, capable of handling our special case of binomial data (Krishnamurthy et al. 2004; Rohatgi and Saleh 2000). Unfortunately, derivation of an expected value for the chi-square test can only be approximated in this sample, as no independent benchmark exists to guide us on what would be a normal level of each trigger, an issue suitable for future research. Substituting the rate of prevalence of each trigger in each stage as an expected value for each incident, we calculated this chi-square for the difference in actual levels of triggers found in each stage. The results (see Table 6) indicate that the levels of external constraint and ICT KSA inadequacy significantly differ by project stage (P < .05), while internal constraint and trust and relationship inadequacy are not significant, but show signs of variation in our 52-incident sample (P < .1).

External constraint relates to the imposition of new project conditions by managers or clients above and outside of the project team. The recognition of these triggers remains fairly constant, trailing off in the last stage of a project. This makes sense. Project managers or sponsors may realize when a project is near its end that changes will cause delays or substantial reworking, leading them to decide not to interfere.

Leader recognition of ICT inadequacies jumps in the early stage of the projects and is lowest prior to starting work. Overall, in fewer than one-third of the projects did leaders report taking steps to define the technology and communications plan used by their teams (7 out of 30 projects). We believe this partly explains the pattern of tool inadequacies. Leaders initially thought the ICTs were going to work and did not focus on them or test them. Once teams began working, inadequacies of specific ICTs became more apparent, causing early stoppages of work to focus on intervention. A second plausible explanation is that people must adapt their ICTs to their work, no matter how much preparation takes place, because when they start using the ICTs, they discover fits and misfits with their work.

This finding is somewhat surprising given the amount of vendor, practitioner, and research literature that has emphasized the importance of having the right tools for communicating from the start and recent research deemphasizing understanding and setting up ICTs correctly to enable success (Paul and McDaniel 2004). Emphasis needs to be placed on preparing for technology adaptation. Better technology-toolkit design and team-interaction planning would likely increase the success rate of incidents involving this trigger, thereby leading to fewer stoppages during interaction. This is an area where research continues to struggle to define the fits between ICTs and group needs and how to select the ICTs and get groups to use them.

Trust and relationship inadequacies and team member ICT KSA inadequacies both started low and rose, with ICT KSA inadequacy spiking in the late stage to 20 percent of triggers (Table 6). This general upward trend and late spike suggests problem emergence through interaction and experiences during virtual collaboration, supporting the idea that when

---

**Table 6. Trigger Frequencies (Proportions) by Project Stage**

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Start-up</th>
<th>Early</th>
<th>Middle</th>
<th>Late</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>External constraint*</td>
<td>15 (.24)</td>
<td>21 (.23)</td>
<td>70 (.24)</td>
<td>8 (.15)</td>
<td>114</td>
</tr>
<tr>
<td>(χ² = 8.71, df = 3, Cramer’s V = .85)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal constraint†</td>
<td>14 (.22)</td>
<td>12 (.13)</td>
<td>33 (.11)</td>
<td>4 (.07)</td>
<td>63</td>
</tr>
<tr>
<td>(χ² = 7.09, df = 3, Cramer’s V = .77)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT KSA inadequacy*</td>
<td>4 (.06)</td>
<td>6 (.06)</td>
<td>12 (.04)</td>
<td>11 (.20)</td>
<td>33</td>
</tr>
<tr>
<td>(χ² = 9.11, df = 3, Cramer’s V = .87)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT inadequacy</td>
<td>23 (.37)</td>
<td>44 (.47)</td>
<td>129 (.44)</td>
<td>23 (.42)</td>
<td>219</td>
</tr>
<tr>
<td>Trust and relationship inadequacy †</td>
<td>7 (.11)</td>
<td>10 (.11)</td>
<td>52 (.18)</td>
<td>9 (.16)</td>
<td>78</td>
</tr>
<tr>
<td>(χ² = 6.96, df = 3, Cramer’s V = .76)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>93</td>
<td>296</td>
<td>55</td>
<td>507</td>
</tr>
</tbody>
</table>

*Denotes a trigger with P > .05, where P is the probability of this level of variability occurring in the sample purely by chance if the underlying frequencies are actually the same.
†Denotes a trigger with P > .1.
such people-related problems exist, they present an emergent risk and challenge to team interaction that can catch leaders by surprise. It may also be interpreted as an indication that leaders do not initially want to blame others personally for interaction breakdown and would like to focus on task, technology, and organizational structures. We echo calls that future research should extend prior work on participation and conflict resolution in IS projects (Barki and Hartwick 1994; He and King 2008; Markus and Mao 2004) to look at the conditions leading to such incidents during interaction and how to ameliorate their likelihood through project design.

The late stage sharp spike in ICT KSA inadequacy recognition highlights a serious problem for VT leaders. How could they better know the capabilities of their team members from a distance? How could they anticipate and ameliorate such inadequacies at a distance, earlier in the project, or prior to starting work? These questions form another area for future research that would benefit virtual leadership scholarship.

Implications

Researchers and practitioners can adapt the trigger model with its dimensions and their indicators, listed in Table 5 and Appendix B, as a diagnostic tool in order to monitor and identify technology adaptation contexts and target more accurate interventions. This primary contribution enables a standardized approach to typifying team technology adaptation conditions and characterizing the needs for intervention.

The model could be used in training VT leaders and helping them reflect on critical incidents experienced in their work. Understanding the relevant contextual bounds of interventions will help leaders to narrow their focus to the important control signs they need to monitor. It will also help them to understand additional technology adaptation factors that may be important as they work. For example, leaders who may have a tendency to see technology adaptation contexts from a task-technology fit perspective will have the opportunity to identify and see the relationships between technology inadequacies and the other triggers. This would hopefully enable them to craft more effective interventions by seeing all of the root causes when they intervene. Avoiding assumptions of the solution will meet a fundamental problem-solving need (Polya 1945) while also allowing them to more quickly diagnose the contexts they encounter. This latter benefit will yield better attention management by helping them avoid monitoring spurious issues while ensuring they do not monitor too little. The leaders reported to us that their attention is usually spread very thin among many competing work tasks. Improved attention management should enable them to improve their project outcomes.

The model will be useful in investigating the connections between specific leader actions or interventions relative to incident triggers. Future research will be able to take this foundational model and refine it, identifying a typology of intervention contexts based on the most common combinations of triggers for specific contexts. For specific intervention contexts, researchers will be able to identify the relative fit and overlap among differing theories explaining technology adaptation and usage. This will help ensure that they apply explanations that address all of the relevant context in a team technology adaptation scenario.

Overall, leaders often recognized two or three trigger types during incidents. This seems to indicate the need for awareness that a given technology usage context involving one trigger will likely also involve another. There has been an implicit underlying assumption in past research on leading teams that isolation of one area such as trust and relationships (Druskat and Wheeler 2003), external constraint (Ancona and Caldwell 1992a; Guinan et al. 1998), or ICT inadequacies (Dennis and Valacich 19999) could occur with little explanation of how to recognize and handle multiple triggers occurring simultaneously. Future IS research on VT leadership and technology adaptation needs to address the simultaneous presence of multiple triggers. As we gather an understanding of the most prevalent types of technology adaptation intervention contexts using the trigger model, we believe more effective multi-trigger integration theories for intervention will become possible. Such theories might substantially decrease the difficulty of distance leadership by guiding leader actions as well as improving ICT designs, thereby improving the effectiveness of VTs. This brings us to implications for using the model itself.

We have developed a five-trigger model that characterizes the status—the “vital signs”—of team interaction for the purpose of an observer, such as a leader or researcher, understanding technology adaptation intervention. In this regard, it addresses a problem-solving principle in the medical community known as Occam’s Razor (entia non sunt multiplicanda praeter necessitatem—“don’t multiply the explanations without necessity”). This principle was instrumental in ensuring that medical practitioners and researchers capture necessary context when dealing with sick patients so that they do not do harm by jumping to diagnoses too quickly while also catching major potential root causes before illnesses kill patients. This was particularly important in medicine because multiple diagnoses could be found for many individual symptoms. Diagnoses are based on particular combinations of symptoms.
IS research on technology adaptation intervention has lacked such a model of vital signs describing the complete conditions of a team relevant to understanding interventions. The triggers indicate that there are several salient combinations of root structures from AST that may cause adaptation. We can see task and technology fit in the ICT inadequacy trigger. Computer self-efficacy of individual team members shows up in ICT KSA inadequacy. In fact, several IS theories related to adoption and effective usage of ICTs can be seen in relation to the root structures represented by each of the triggers. As a third contribution, the model helps identify relevant theories to apply to treat or deepen research on a given intervention context.

For example, a leader or researcher encountering scenarios dominated by external interference might apply work analyzing organizational context and task structure such as strategic alignment (Henderson and Venkatraman 1999), project escalation (Keil 1995), outsourcing and interorganizational arrangements (Kaiser and Hawk 2004; Karimi and Konsynski 1991), and boundary spanning (Ancona and Caldwell 1992a). To understand a context characterized by internal constraints (technology–task–team fits), one can look to work on demographic/cultural diversity (Ancona and Caldwell 1992b; Carte and Chidambaram 2004), setting up virtual teams (Gibson and Cohen 2003), understanding dispersion and team size (Hare 1992; Kayworth and Leidner 2002), power and status impacts (Jasperson et al. 2002), cultural issues (Leidner and Kayworth 2006; Watson et al. 1994), and general project design and management (Abdel-Hamid et al. 1999; Hackman 2002; Piccoli and Ives 2003).

ICT inadequacy triggers represent the classic IS example of task-technology fit issues (Goodhue and Thompson 1995; Zigurs and Buckland 1998). These triggers involve design of complex adaptive systems in that integrating standards and interoperability among multiple ICTs simultaneously proves to be a “wicked problem” deserving further attention (Hervner et al. 2004; Markus et al. 2002). Future design research should focus on the wicked problem of enabling dynamic, smooth adaptation of ICT features during interaction involving heterogeneous mixes of ICTs such as the ones we found in this study (e.g., teams using, on average, more than 11 ICTs). Characteristics of ICTs such as richness (Daft and Lengel 1986) and synchronicity (Dennis et al. 2008) and design theories directing how such characteristics may be applied to task settings such as knowledge conversion (Massey and Montoya-Weiss 2006), emergent knowledge processes (Markus et al. 2002), or task closure (Straub and Karahanna 1998) provide insight into how one might intervene when ICT inadequacy is a major issue.

We believe this is where studies of technology adaptation in groups will also need to focus.

As a fourth contribution, our work extends AST concerning how to characterize the structural conditions that lead to technology adaptation. Current research indicates that there are discrepant events (Majchrzak et al. 2000) or that technology gets adapted in repair events when its utility is low (Massey and Montoya-Weiss 2006). These fundamental studies point VT leaders toward team interaction and direct them to observe how team members are using ICTs in order to understand adaptation needs. AST holds that the technology structure embodies the state of technology usage in interaction. AST indicates the strength of a technology structure based on three group-level indicators: (1) faithfulness of usage in accordance with the design of an ICT, (2) consensus on how an ICT is used and for what, and (3) attitudes toward the use of an ICT (DeSanctis and Poole 1994). Up to now, these indicators would be the best guidance for a team leader watching team interaction and ICT usage with the goal of understanding when to intervene, but our data indicate watching only the technology structure strength indicators of AST would be incomplete and potentially misleading.

Our results indicate that reasons for technology adaptation include but also go beyond the strength of the technology structure. Effective VT leaders focus on the five triggers in our model, sometimes intervening to manage technology adaptation even when technology structure is not a primary cause. We found technology adaptation occurring due to external constraints and trust and relationship inadequacies, even when the technology structure appeared strong based on the three group-level indicators. The three indicators of technology structure strength seem best suited to understanding the state of usage of a single ICT at any given time. This was not our concern, nor does it appear to be the root concern of a VT leader attempting to maximize team productivity enabled by effective ICT usage. They cannot afford to continuously evaluate the state of each ICT, as there are too many, and their reasons for intervening and managing tech-
nology adaptation may include occasions in which the specifics of an ICT and its structural strength are incidental to trust and relationship or external constraint issues.

Limitations

Some limitations should be considered in interpreting our findings in this study. Our pilot survey indicated that critical incidents might not occur in every project, making it necessary to collect retrospective data that may be biased through memory error. The CIT methodology followed a highly structured and delineated process to ensure accuracy and objectivity, and studies of CIT methodology have shown its methods produce very high levels of agreement when self-reported, retrospective data are compared with data from outside observation so long as the information provided is “full, clear, and detailed” (Butterfield et al. 2005, p. 481). We believe we successfully collected such data. Still, it is possible some bias has been introduced due to memory error.

In that our sample derives predominantly from 13 interviews, we cannot say it provides a statistically representative sample of the population of possible virtual interaction in IS projects. However, on its face, this sample does derive from a varied set of IS projects across multiple organizational experiences. Further, our analysis indicates that we reached theoretical saturation within our 52-incident sample, suggesting we did sample the full variety of possible intervention triggers.

The triggers do not appear to vary by project type, leader, organization, project size, nor any other factor we attempted to correlate with their frequency, and broad prevalence appeared in our analysis of codings. Thus, our data indicate that this five-factor model of VT leader intervention triggers is robust across contexts within IS projects, but we caution that due to our limited, nonrandom sample, there may be bias in this analysis and caution should be exercised in generalizing the findings beyond virtual IS projects.

Conclusion

Taking a critical incident method approach, this study identifies five triggers necessary and sufficient for characterizing the state of team interaction as it relates to the need for technology adaptation management. This approach entailed carefully analyzing existing literature based on requirements for understanding technology adaptation and framing this literature using AST. The trigger model enables future research on technology adaptation to focus on the five triggers and use them as a bridge between existing IS studies and complex global, distributed team contexts. It also extends our understanding of the causes of group technology adaptation to encompass structural causes beyond the three aspects of technology structure strength outlined in AST, and it offers an empirically and behaviorally anchored diagnostic tool for understanding team technology adaptation that may be used by researchers and practitioners to improve theories and effectiveness of leaders, teams, and ICTs.


Supported Inter-Organizational Virtual Team,” *MIS Quarterly* (24:4), pp. 569-600.


Thomas & Bostrom/A Trigger Model for Technology Adaptation Interventions

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References


Appendix A

Sample Interview Protocol Documents

Interview Frame from the Researcher Guidelines

[FRAME] “Think of virtual team projects in which you had to take action to improve your team’s information and communication technology (technology) use. Each time you took action was a technology facilitation incident. Please focus on significant, critical incidents that demonstrate particularly effective or ineffective technology facilitation. To help you understand the context of the events I seek, know that they can occur for any number of reasons… new technologies may become available, available technologies may not get used to their full potential, technologies in use may become somehow inadequate, people may react unpredictably to using technologies, tasks may not fit with technologies. In any one of these ordinary situations, there may be an opportunity to improve the team’s communication and performance through improved technology use. These are just a few examples. There may be other situations that would prompt you to facilitate technology. Think of those occasions when you took action and your action led to changes which impacted the team’s technology use and project performance.”

[optional clarification: TECHNOLOGY FACILITATION] “Technology facilitation is what you are doing when you intervene during your team’s project to improve your team’s technology use.”

[optional clarification: CRITICAL INCIDENT of TECHNOLOGY FACILITATION] “A critical incident of technology facilitation is an occasion when you acted and your action or actions made a big impact, either unusually positive or even unusually negative, on your team’s use of technology. This change in technology use in turn led to real changes in the team’s performance on the project. In terms of context, a critical incident takes place during a normal or ordinary day-to-day situation.”

Sample Question Protocol from the Critical Incident Questions

1. Project Context. [If this is not the first incident covered, ask if this incident comes from a project already discussed in this interview. Give the interviewee a Project Description Guide (PDG) to follow and guide the interviewee through the Project Context Form (PCF) unless this incident’s project has already been covered in another PCF. For phone interviews, have the interviewee navigate to [URL where forms are available] to see a PDG. For FtF, hand the interviewee a PDG. NOTE: a project may have multiple phases that are fully contained, including complete deliverables that get implemented and used. In such a case, a phase can be considered a project. Make a note on this form if the context of this incident is a phase of a larger project.]

   Write the project reference name here: ______________________


   I want to know what you did. Imagine that you have been placed back in time into that episode. What was the incident and what exactly did you do or say? [Note: Go for actual actions… Tell me exactly what happened, what you said or did at that time. Clarification: And you, what did you do? What did you say? Probe (as necessary): Did you modify any goals or methodology steps in acting? Did the members have to have additional ICT knowledge? Did you sanction or reward any of the members? Did the members’ roles within the team change in any way?]

   What were team member related issues in this incident? [Probe (as necessary): Did the members have to have additional ICT knowledge? Did you sanction or reward any of the members? Did the members’ roles within the team change in any way?]

   What were project task related issues in this incident? [Probe (as necessary): Did you modify any team goals? Did you change or rearrange any of the work process or methodology steps?]

   How did you use members’ ICT knowledge in this incident, if at all?

   When during the project did this incident happen? [Note: Interviewee must give enough answer to at least distinguish between the beginning, mid-project, and end of project.]
Appendix B

Analysis of Trigger Dimensions

These “raw results” are raw in that the theme codes derive directly from transcript quotations. On the first occurrence of each theme, the theme code or name was taken as directly as possible from the interview transcript and added to a coding list. Later, if the same theme appeared, the original quote was associated with the subsequent occurrence. The appendix lists these theme codes and their prevalence data (number of interviews, incidents and quotations containing them and the weight statistic). Among these theme codes you can see some duplication of themes. For example, external constraint contains “Time pressure …” as well as “Project delays create ripple effect ….” Both themes refer to the pressure created due to a hard timeline imposed on a project externally.

During the last stage of coding, the 8 to 16 themes within each trigger were grouped into the 2 to 3 subdimensions, major themes, representing each trigger (in bold below each trigger).

<table>
<thead>
<tr>
<th>Theme Code</th>
<th>Weight</th>
<th>Interviews</th>
<th>Incidents</th>
<th>Quotations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External Constraint Trigger</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time-Schedule Subdimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time pressure/lack of time to complete</td>
<td>56.41</td>
<td>9</td>
<td>69%</td>
<td>16 31%</td>
</tr>
<tr>
<td>Pressure to complete this project right</td>
<td>29.49</td>
<td>5</td>
<td>38%</td>
<td>6 12%</td>
</tr>
<tr>
<td>Project delays created ripple effect/rework</td>
<td>17.95</td>
<td>3</td>
<td>23%</td>
<td>4 8%</td>
</tr>
<tr>
<td>Cost as choice factor in tool selection or usage</td>
<td>17.31</td>
<td>3</td>
<td>23%</td>
<td>3 6%</td>
</tr>
<tr>
<td>Project timeline/production constraints</td>
<td>5.77</td>
<td>1</td>
<td>8%</td>
<td>1 2%</td>
</tr>
<tr>
<td><strong>Organizational Policy Subdimension</strong></td>
<td></td>
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</tr>
<tr>
<td>Organizational policy restricted tool choice and usage</td>
<td>46.15</td>
<td>8</td>
<td>62%</td>
<td>8 15%</td>
</tr>
<tr>
<td>Permissions/Access problem</td>
<td>41.03</td>
<td>7</td>
<td>54%</td>
<td>8 15%</td>
</tr>
<tr>
<td><strong>Upper Management Intervention Subdimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leader hired to affect change</td>
<td>34.62</td>
<td>6</td>
<td>46%</td>
<td>6 12%</td>
</tr>
<tr>
<td>Escalation of work performance problems cause higher management intervention</td>
<td>17.31</td>
<td>3</td>
<td>23%</td>
<td>3 6%</td>
</tr>
<tr>
<td>Client requested that team use a new tool to try it out</td>
<td>11.54</td>
<td>2</td>
<td>15%</td>
<td>2 4%</td>
</tr>
<tr>
<td>Leader promoted to enable change</td>
<td>11.54</td>
<td>2</td>
<td>15%</td>
<td>2 4%</td>
</tr>
<tr>
<td><strong>ICT Inadequacy Trigger</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Not Operating Subdimension</strong></td>
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</tr>
<tr>
<td>Clear evidence visible to all that current tool(s) ineffective</td>
<td>58.33</td>
<td>9</td>
<td>69%</td>
<td>19 37%</td>
</tr>
<tr>
<td>Tool not accessible and/or reliable enough</td>
<td>35.26</td>
<td>6</td>
<td>46%</td>
<td>7 13%</td>
</tr>
<tr>
<td>Team members had different versions of tool(s)</td>
<td>17.31</td>
<td>3</td>
<td>23%</td>
<td>3 6%</td>
</tr>
<tr>
<td>Existing tools not interoperable/interconnected</td>
<td>12.18</td>
<td>2</td>
<td>15%</td>
<td>3 6%</td>
</tr>
<tr>
<td>Tool poorly implemented/configured</td>
<td>11.54</td>
<td>2</td>
<td>15%</td>
<td>2 4%</td>
</tr>
<tr>
<td>Tool features poorly designed/inefficient</td>
<td>5.77</td>
<td>1</td>
<td>8%</td>
<td>1 2%</td>
</tr>
<tr>
<td><strong>Feature/Tool Missing Subdimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A tool feature was needed but missing</td>
<td>50.64</td>
<td>8</td>
<td>62%</td>
<td>15 29%</td>
</tr>
<tr>
<td>No common repository/shared information space existed</td>
<td>35.26</td>
<td>6</td>
<td>46%</td>
<td>7 13%</td>
</tr>
<tr>
<td>Email overload, too many</td>
<td>23.08</td>
<td>4</td>
<td>31%</td>
<td>4 8%</td>
</tr>
<tr>
<td>File sharing not possible with existing tool(s)</td>
<td>23.08</td>
<td>4</td>
<td>31%</td>
<td>4 8%</td>
</tr>
<tr>
<td>Leader needed synchronous meeting tool with visual control</td>
<td>23.08</td>
<td>4</td>
<td>31%</td>
<td>4 8%</td>
</tr>
<tr>
<td>Information was inaccurate without correction means to handle versions</td>
<td>12.18</td>
<td>2</td>
<td>15%</td>
<td>3 6%</td>
</tr>
<tr>
<td>Email unable to handle conflict resolution between individuals</td>
<td>11.54</td>
<td>2</td>
<td>15%</td>
<td>2 4%</td>
</tr>
<tr>
<td>Theme Code</td>
<td>Weight</td>
<td>Interviews</td>
<td>Incidents</td>
<td>Quotas</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>--------</td>
<td>------------</td>
<td>-----------</td>
<td>--------</td>
</tr>
<tr>
<td>Email was unable to keep track of different document/code versions</td>
<td>11.54</td>
<td>2</td>
<td>15%</td>
<td>2</td>
</tr>
<tr>
<td>Needed verbal channel</td>
<td>5.77</td>
<td>1</td>
<td>8%</td>
<td>1</td>
</tr>
<tr>
<td>Needed visual control of other’s screens</td>
<td>5.77</td>
<td>1</td>
<td>8%</td>
<td>1</td>
</tr>
</tbody>
</table>

**Trust and Relationship Inadequacy Trigger**

**Communication Failure Subdimension**
- Leader noticed that communication was not working: 48.08, 8, 62%, 11, 21%, 14
- Private communications among team members disabled collaboration: 23.08, 4, 31%, 4, 8%, 4
- One or more team members didn’t respond, went dark: 11.54, 2, 15%, 2, 4%, 5
- No regular communication/interaction: 5.77, 1, 8%, 1, 2%, 1

**Intra-Team Conflict Subdimension**
- Members of different groups had conflicting data and opinions: 41.67, 7, 54%, 9, 17%, 15
- Team members had interpersonal conflict: 17.31, 3, 23%, 3, 6%, 8
- One group shirks responsibility to another due to interaction virtuality: 5.77, 1, 8%, 1, 2%, 3

**Trust Failure Subdimension**
- Lack of trust in professional skills between individuals in different subgroups: 30.13, 5, 38%, 7, 13%, 10

**Internal Constraint Trigger**

**Dispersion Subdimension**
- Members were physically distant from one another: 34.62, 6, 46%, 6, 12%, 7
- Multiple team member locations: 12.18, 2, 15%, 3, 6%, 3
- Time differences among members disable an option: 11.54, 2, 15%, 2, 4%, 2
- Inability to coordinate: 6.41, 1, 8%, 2, 4%, 2
- Needed to enable multi-tasking and member accessibility: 5.77, 1, 8%, 1, 2%, 1

**Team Size Subdimension**
- Team size grew: 23.08, 4, 31%, 4, 8%, 4
- Team size bigger than usual tools and ways of using them could handle: 17.95, 3, 23%, 4, 8%, 4

**Team Demographics Subdimension**
- Language/Cultural misunderstanding: 17.31, 3, 23%, 3, 6%, 3
- Had to work across multiple organizations: 12.18, 2, 15%, 3, 6%, 3

**ICT KSA Inadequacy Trigger**

**ICT Used Ineffectively Subdimension**
- People not able to be corralled/convinced using existing tools: 28.85, 5, 38%, 5, 10%, 6
- People were not using the tools properly/professionally: 17.31, 3, 23%, 3, 6%, 4
- Team members using tool features in an unacceptable way: 11.54, 2, 15%, 2, 4%, 3

**Lack of ICT Knowledge Subdimension**
- Team members had inadequate task knowledge: 17.31, 3, 23%, 3, 6%, 3
- Team members’ lack of experience: 11.54, 2, 15%, 2, 4%, 3
- Tool assigned but not getting used: 11.54, 2, 15%, 2, 4%, 3
- Key team members had inadequate knowledge of the tool: 6.41, 1, 8%, 2, 4%, 2
- Some team members had not used the new tool before: 5.77, 1, 8%, 1, 2%, 1