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ABSTRACT

With the availability of round-the-clock labor and inexpensive programming in India and other countries, software development projects increasingly take place in a virtual team setting. Adaptive structuration theory (AST) describes the process by which groups, such as virtual teams, use advanced information technologies. According to AST, people, technology and task structures interact, resulting in virtual team outcomes. Much virtual team research has focused on the people and other input factors. Technology as it relates to interaction processes remains under-examined in relation to virtual team leadership and should be explored. This paper applies AST and relevant current research on virtual teams to develop a framework and propositions regarding virtual team leader actions supporting technology appropriation.

Keywords

Virtual teams, leadership, project management.

INTRODUCTION

Virtual team (VT) leadership offers a critical under-studied lever for improving virtual team effectiveness (Zigurs, 2003, Gibson and Cohen, 2003). This dynamic needs to be studied in relation to technology in teamwork processes (Bell and Kozlowski, 2002). This paper focuses on how and when virtual team leaders use what technology to improve VT interaction mid-process.

Virtual group and team research has examined a range of issues including effectiveness relative to social-psychological inputs (Furst et al., 1999), critical success factors in cross-organizational ad hoc virtual teams (Lipnack and Stamps, 1999), project management and success (Paré and Dubé, 1999), knowledge transfer (Griffith et al., 2003), teams dynamics, communication, and outcomes (Maznevski and Chudoba, 2000), technology choices, specifically media stickiness (Huysman et al., 2003), trust (Jarvenpaa and Leidner, 1999, Piccoli and Ives, 2003), learning in cross-functional virtual teams (Robey et al., 2000), socialization in virtual groups (Ahuja and Galvin, 2003), and leadership effectiveness (Kayworth and Leidner, 2002).

We know that a primary team leader function is monitoring and mediating team interaction (Barge, 1996) and that traditional team monitoring and control mechanisms do not seem directly applicable to the VT setting (Piccoli and Ives, 2003). Early evidence on VTs suggests that multiple VT members can share leadership (Avolio and Kahai, 2003) and that leaders are likely to emerge even when they are not designated (Tyran et al., 2003, Yoo and Alavi, 2004, Sarker et al., 2002), suggesting an innate need for leaders. Virtual team anecdotes also confirm this need for a leader (Geber, 1995). Virtual teams face a critical daily problem of planning their use of information and communication technology (ICT) (Suchan and Hayzak, 2001), and VT leaders can probably influence that planning toward success or failure (Kayworth and Leidner, 2002). VT leader effectiveness increases as leaders assume more of a facilitative role than an authoritative one (Piccoli and Ives, 2003, Piccoli et al., 2004). Indeed, facilitators of virtual group work must plan how and when to use ICT (Niederman et al., 1996). This ICT role will likely become even more important as effective VTs must fit their communication patterns to their task (Maznevski and Chudoba, 2000), though some contradictory evidence exists about the value of a VT leader having technological proficiency (Tyran et al., 2003) or not (Sarker et al., 2002), suggesting a need for closer examination.

In a VT context, we do not know exactly how technology can support leadership roles and how leaders will use it to influence performance (Zigurs, 2003). This should especially be studied in relation to ICT choice over time in VTs (Montoya-Weiss et al., 2001). This paper takes a first step in this direction, conceptually exploring how VT leader actions to initiate technology structuration can improve technology appropriation. The first three sections review the current literature on virtual team leadership and interaction in relation to adaptive structuration theory, producing a conceptual model. The

final section develops some propositions based on a piece of the model as an example of how the model may be used to guide research.

VIRTUAL TEAM LEADERSHIP

What is a Virtual Team?

Virtual teams operate as a social unit, have one or more interdependent tasks, are somehow separated physically, and communicate predominantly through computer-mediated means (Gibson and Cohen, 2003, Hackman, 2002). They are likely to face tight deadlines for their tasks/projects (Powell et al., 2004) and be accountable for their project outcome (Gibson and Cohen, 2003). In addition to these conditions, VTs face a whole new environment in terms of information acquisition, storage, interpretation, and dissemination, leading to increased difficulties and distinct challenges relative to traditional teams (Avolio and Kahai, 2003). As a result, means for improving their effectiveness, such as how to better employ technology and improve virtual team leadership, need to be studied, especially since leader roles can change fundamentally in a virtual team (Majchrzak et al., 2000).

The varying situations virtual teams face have prompted their differentiation, in terms of task complexity (Bell and Kozlowski, 2002), type of group whether temporary (*ad hoc*) or permanent (Jarvenpaa and Leidner, 1999, Paré and Dubé, 1999), context judged by cultural-geographic similarity of the members (Jarvenpaa and Leidner, 1999), interaction mode on a graduated scale from face-to-face (FtF) to purely virtual (Jarvenpaa and Leidner, 1999, Griffith et al., 2003), interaction mode in terms of synchronicity and collocation issues (Kimble et al., 2000), and same versus cross-organizational composition (Kimble et al., 2000). For understanding technology choice and leader actions during interaction, Bell and Kozlowski's typology offers the best fit since it applies to the interaction process at the task-event level in relation to effective leadership rather than the inputs prior to team interaction. It holds 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 (p.27, 2002). This paper focuses on this leader-influenced structuration. To better understand how leaders may be useful, the virtual team interaction process must be understood.

VIRTUAL TEAM INTERACTION

Adaptive Structuration: the Process of Team Interaction

Adaptive structuration theory (AST) describes appropriation, the interaction process in which a group adapts technology to its work (DeSanctis and Poole, 1994). Appropriation, collectively as a process, describes the transition into use of interaction inputs as groups settle on ways of interacting (Figure 1). Appropriations are the on-going changes to structures, where structures are the ways of interacting. Technologies have two structural characteristics that guide their design and use: their deliberate features and overall spirit. These characteristics may be interpreted in unintended ways (unfaithfully appropriated) or abandoned in favor of alternative technologies. When appropriation does occur, groups will pick and choose the features of the technology that suit their task needs.

In addition to technology, AST positions people factors, factors relating to demographics and relationships, organizational factors, those relating to organizational environment and support, and task factors, those things dealing with work goals and methodology, as inputs to the structuration process (DeSanctis and Poole, 1994). These additional inputs temper the way technology will be appropriated and used during interaction and deserve further research attention (Powell et al., 2004); however, they are precursors to the interaction process itself, and *ceteris paribas*, we will forego their examination here in order to focus on the specific effects leader actions within team interaction may have on technology appropriation. Similarly, outputs from the process might include project completion and learning at individual, team and organizational levels but must be set aside in this paper due to space limits, leaving the focus of this paper shown in bold areas in Figure 1.

Recent evidence shows that the virtual team technology appropriation process surfaces in "discrepant" events (Majchrzak et al., 2000) or an "episode of project dissonance" (Rutkowski et al., 2002, p.225). These "discrepant events" can indicate situations in which available technologies in use–those appropriated into the team's structures–fail to fulfill the team's needs. Discrepant events might also indicate failure of other interaction inputs, organizational context, work process or people to meet team needs, herein we focus on the technology discrepant events. Viewed in terms of activity theory, which poses a central group task of "overcoming *contradictions* between elements within an activity" (Andriessen et al., 2003, p.374), appropriation must solve the contradictions apparent in team interaction, often surfaced by discrepant events, in order to proceed with work, further clarifying our research question: how can virtual team leaders positively affect structure using

Figure 1: Conceptual Model of Virtual Team Leader Actions for Appropriation
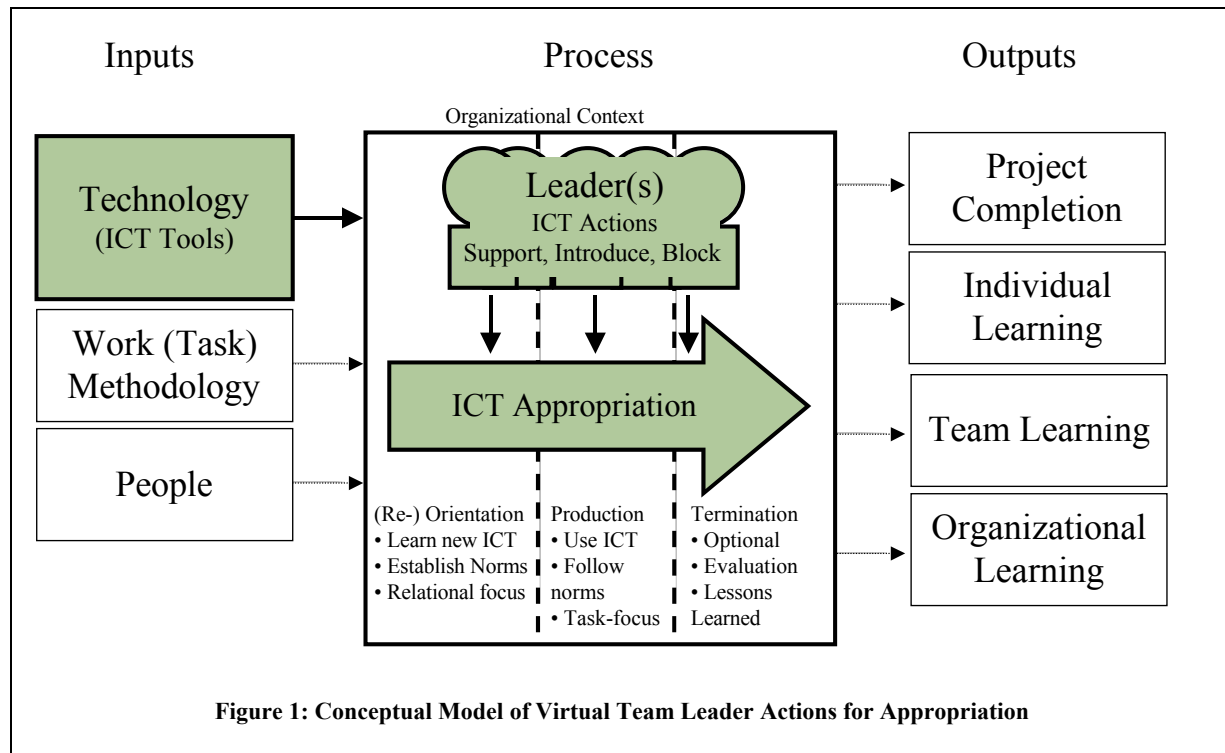
technology to solve team contradictions, and what role do discrepant events play in this process?

Structuration Over Time

Understanding VT interaction requires time. Studies of groups and technology often fail to allow adequate time for interaction to develop and display time effects (Fjermestad and Hiltz, 1999). The impact of time has to do with a team's on-going development, or appropriation in AST terms. Group studies have long postulated that stages characterize group development (Tuckman, 1965). More recently, research has suggested that only two stages exist in a punctuated equilibrium pattern (Gersick, 1988), and alternately, that prior stage research still applies (Wheelan et al., 2003). Virtual team studies have offered partial support for stages (Rutkowski et al., 2002, Suchan and Hayzak, 2001), punctuated equilibrium (Jarvenpaa and Leidner, 1999, Maznevski and Chudoba, 2000), and continuous, non-punctuated development (Huysman et al., 2003, Majchrzak et al., 2000). A simple three-stage model captures the necessary detail from the literature for team leader action (Hackman, 2002). We term the three stages: (re-)orientation, production, and termination. In VTs, the need for initial group development focused on initial introductions to all of the interaction inputs (people, technology, organizational context, and work methodology) to make sure shared understanding and shared language is clear (Powell et al., 2004). We term this stage orientation.

Following orientation, VTs enter production. In production, the VT leader facilitates team interaction to guide its direction and maintain momentum. A final stage for project termination and closure on lessons learned seems optional but offers opportunity for increased learning and improved quality (Rutkowski et al., 2002). We term this termination. The VT leader can guide the reflection and learning when this stage occurs. Adaptive structuration theory holds that adaptation recurs throughout the life of a group when structures are inadequate (DeSanctis and Poole, 1994), representing emergent patterns of team interaction punctuated by process shifts (DeSanctis and Poole, 1997). We argue that from a VT leader's standpoint vis-à-vis technology, this cycling of settled structures and adaptations represents two possible patterns in terms of the core production activity of the VT. First, it can be linear, establishing structures in orientation and tweaking settled structures to maintain momentum during production and termination. Second, it can be circular, revisiting the orientation stage when momentum flags in order to introduce major structural revision if a team is already in production or termination.

From this latter perspective, (re)orientation, production, and termination do not strictly correspond to sequential stages and might also be termed interaction modes as in production modes in TIP theory (McGrath, 1991). We consider mode and stage interchange.

ICT Appropriation

Virtual team interaction involves team members using available ICT to accomplish their project. As they work, team members may find that certain ICTs do not offer what they need, and they will then try to adapt and compensate for their missing or unfamiliar features (Huysman et al., 2003). This might lead to scrapping a given ICT in favor of an alternative, adding a new one, or perhaps sticking with an ill-fitting ICT and adapting other structures to accommodate it (Huysman et al., 2003).

A VT's initial ICT may be carefully developed to be effective for the team's given work situation–work process, organizational context and people. Nonetheless, as discrepant events arise, needs make themselves known, raising questions for VT leader action: What interaction needs merit action to manipulate appropriation? What actions can a VT leader take to affect appropriation? What are the critical factors for a successful VT leader action choice? Some research suggests the VT leader weigh task appropriateness of the additional ICT against the added confusion and complexity of its introduction in deciding on a course of action (Pauleen and Yoong, 2001). Thus, the choice and subsequent structural adaptation impact of VT leader actions depend on the team interaction needs at the time of action in relation to the VT leader's understanding of ICT available. Team interaction needs have been addressed in terms of team development stages. The subsections below link team interaction needs to VT leader understanding of ICT.

Team Interaction Needs: Role of ICT in Communication

Virtual team interaction takes place predominantly through communication (Powell et al., 2004, DeSanctis and Poole, 1997). Communication is the interactive process underlying all human social activity and is critical for the accomplishment of collaborative work (Winograd and Flores, 1986). Most technologies that support communicative interaction are advanced information technologies (DeSanctis and Poole, 1994). In the realm of VT process, maintaining effective team communication becomes a chief responsibility of leadership (Zaccaro and Bader, 2003), flowing through the motivation role during orientation, the consultation role during production and the education role during termination. The roles change because the communication needs corresponding to the nature of the team tasks change with team development over time. Research suggests that effective VTs adapt their available technologies to meet the communication needs of their day-to-day tasks (Maznevski and Chudoba, 2000). This adaptation evidences differing communicative value of ICT options for changing tasks, requiring that the VT leader know the differing ICT options.

VT Leader Understanding of Available ICT for VT Communication

Virtual teams communicate through numerous ICT including audio conferencing, email, personal communications devices such as phones, scheduling/calendaring systems, groupware, and document management systems (Becker and Lee, 1999), aptly termed a VT technology "toolkit" (Suchan and Hayzak, 2001). These ICTs differ in their capacity to enable different communicative goals (Dennis and Valacich, 1999, Te'eni, 2001, Scott, 1999). These two observations draw attention to a potential pitfall of understanding ICT. Knowing the technical specificities of an ICT does not necessarily correlate to knowing the communicative value humans will derive from it. Many ICTs may share the same "spirit", potentially satisfying the same core group communication needs though the specific features differ. Inability to understand the specific features might lead to choosing an overly complex and confusing option. Two types of ICT knowledge result, one conceptual and framed in terms of group communication, the "spirit" of the ICT and another technical and more focused on the particular features. VT leaders draw on both conceptual and technical knowledge of ICT when acting.

VIRTUAL TEAM LEADER APPROPRIATION ACTIONS

Virtual team leaders must move their teams toward project goals. Discrepant events point out moments of flagging progress due to ill fit between ICT and communication needs. In response to these events, VT leaders can try to manipulate the ICT for a better fit. To do so, they introduce, support, or block ICT use across the stages of team development (Figure 1). VT leaders can *support* ICT appropriation through working around blocks using available options in the extant ICT and encouraging use of existing ICT (Archer, 1990, Kayworth and Leidner, 2002, Sarker and Sahay, 2003), *introduce* new ICT, making it physically available, initiating initial use and training (Bell and Kozlowski, 2002, Kayworth and Leidner, 2002, Sarker and Sahay, 2003), or *block* ICT appropriation by discouraging use and making it physically unavailable (Kayworth and Leidner, 2002). These actions vary in ease of implementation and can directly impact their VT's technology

appropriation process, positively or negatively. For example, we can expect that the VT leader ICT support actions will be the most common and least invasive, requiring the least cost in diverted team energy once a team passes out of orientation, while introduction and blocking will be more invasive, requiring greater team energy to be diverted from task-accomplishment. This first look at critical factors for positive VT leader impact emphasizes two items for further examination: 1) VT leader action with sensitivity to the team's stage; and 2) VT leader action with knowledge of ICT options. This section develops propositions for team stages and VT leader ICT knowledge in relation to actions.

How and When to Act

ICT structuration actions by VT leaders – supporting a current ICT, introducing a new ICT, or blocking a current ICT– form but one aspect of the very behaviorally complex VT leader job (Kayworth and Leidner, 2002). Choosing how and when to take these actions will be tempered by a kind of cost-benefit analysis based on the gravity of the discrepant event trigger, the available ICT capabilities, the team communication needs at the time, and the current team development stage. A couple hypothetical scenarios help illustrate how these factors might impact a VT leader. The first scenario is our combination of a common theme found in our literature review. The second derives from our literature review and current data we are processing from a survey of VT leaders and participants. We present them as two of many possibilities.

Scenario 1: The VT has completed initial training, establishing relationships and roles, some norms of conduct and initial structure for working, leading it into the production stage. One or more members complained about the ICT being used. Perhaps it is not prompting adequate responses from all members or it does not allow transfer and manipulation or the needed information as desired.   This is a discrepant event. The VT leader notices this complaint and considers the available ICT in the team's toolkit, realizing that it lacks the needed application sharing or large-file transfer capability, for example. The team leader consults a member who has used the technology in a similar project and discovers a potential work-around using tools in the toolkit. The VT leader also knows of tools outside the toolkit that would solve the problem but would require major restructuring of the team's ICT use. The VT leader pursues the work-around, a supporting action.

Scenario 2: The VT is in the middle of its orientation stage, doing some early project work but still establishing norms for ICT use. The VT leader observes the on-going work, realizing that the members are trying to transfer huge files over email and keep track of the various versions of the revisions. This seems to be working, but the VT leader thinks the members will be more accurate and productive using a content versioning system. He introduces it, making it physically available, training members on its use and suggesting a context in the VT's work.

A VT leader may act in response to a discrepant event (scenario 1) or proactively prior to any discrepancy arising (scenario 2). Future research needs to more fully examine the nature of discrepant events. We suspect variance in their nature, but lacking a current model from the literature, we treat them as all equal. Nonetheless, some ICT action may be taken without a discrepant event trigger when the other costs and benefits convince the VT leader of the need. This can only happen if the VT leader has a well-rounded understanding of the costs and benefits of ICT structuration, which, according to our model, primarily depend on four elements: the discrepant event's nature if any, the communication needs, the team development stage, and the available ICT capabilities. Following the scenarios mentioned earlier, VT leaders will have to pay attention to their team's communication needs, sometimes evidenced in discrepant events, in order to be effective at choosing and implementing ICT structuration. We consider effectiveness here as a black box, such that given a generalized measure of VT leader effectiveness differentiating any set of VT leaders, we would expect to see the patterns outlined. We generalize that VT leader ICT structuration action capability will feed overall success of the VT and depend on our first proposition:

P1: More effective VT leaders will actively monitor their team's communication for discrepant events and emerging communication needs.

Leader ICT Actions and Team Interaction Stages

Consistent with research on the context of VT leadership (Piccoli, 1999, Kayworth and Leidner, 2002), our team interaction model represents a complex overall situation for VT leader interpretation and action. It assumes that VT design targeted positive initial ICT structure. The team interaction stages, (re)orientation, production and termination present differing opportunities for leader ICT action once a team begins interacting. In the orientation stage, team members are establishing momentum. Orientation guides team members to focus on trying different ICT to establish structures that will enable the communication necessary for production. Thus, trial of new technologies and attempts to use more complex technologies complement orientation's characteristics.

Once orientation ends, actions to require the introduction of a new ICT or the blocking of an old ICT will be more costly in team energy, since evidence points to VT tendencies to stick to the ICT they initially use (Huysman et al., 2003). While

discrepant events during the production stage indicate important needs unsatisfied by the initial design, supporting actions such as work-arounds, training, or initiating use offer less disruptive means for addressing the needs. At some point during production or termination, the discrepant event(s) can indicate ICT within structures causing a major obstruction of team progress. In such a case, introduction and blocking become more viable as the discrepant event provides concrete rationale for the increased team energy expense. We posit that increased energy demands of introduction and blocking in latter stages makes a re-orientation stage more appealing and therefore more successful as it focuses a team jointly and explicitly on adapting and appropriating new structures vis-à-vis ICT.

P2: More effective VT leaders will use introduction actions primarily in response to discrepant events during the orientation stage.

P3: During the production or termination stage, more effective VT leaders will accompany any introduction action with a re-orientation stage, even if brief, to encourage the new ICT structure's appropriation.

Leader ICT Actions and Knowledge of ICT Capabilities

In order to take appropriate action for ICT structuration, VT leaders must have a working understanding of the capabilities of the different ICT in their toolkit and how they relate to team communication needs (Tyran et al., 2003). It seems contradictory that VT members with the highest levels of tech knowledge relative to their teams do not tend to become the leaders (Sarker et al., 2002). Our model suggests a resolution in that VT leaders must have two types of ICT knowledge: conceptual and technical. The most technically knowledgeable VT leaders might get lost in the technical details of the ICT forgetting other important elements in their behaviorally complex role, or they might introduce ICT that cannot be readily appropriated. While team members can be found to explain details of complex ICT and conduct training when necessary, VT leaders with the highest levels of technical knowledge relative to their teammates can get lost in the minutia, thus likely experiencing difficulty balancing all of the other complexities influencing the value of ICT actions for improved team communication and therefore team interaction. On the other hand, those VT leaders with a clear conceptual knowledge of ICT features in terms of team communication needs should become more and more effective as they can choose appropriate ICT structuration actions to fill team communication needs with increased accuracy. Thus, there will likely be a sweet spot indicated in a curvilinear relationship between VT leader effectiveness and technical ICT knowledge when judged relative to other team members' technical knowledge.

P4: There will be a curvilinear relationship between VT leader technical ICT knowledge relative to the team members' and effectiveness. VT leaders in the middle range of knowledge relative to their team will be more effective than those with relatively very little or very much knowledge.

P5: VT leaders will be more effective the more conceptual knowledge they have of ICT in terms of team communication needs and ability to fill them.

CONCLUSION

This paper has presented a framework for understanding technology appropriation in virtual teams as it relates to how and when virtual team leaders act. Virtual team leader research has shown that this appropriation process and the context for leader action involve substantial complexity and need to be examined. This paper offers researchers three valuable contributions for addressing this topic. First, the model of virtual team interaction developed here provides an ordered perspective. Second, six propositions presented may guide future research. Third, an extensive literature review and bibliography of sources related to virtual team interaction processes present material for related studies.

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