Leadership in Partially Distributed Emergency Response Software Development Teams

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ABSTRACT

Emergency response and preparedness teams that are inter-organizational or international often work together in partially distributed teams (PDTs). A PDT has at least one collocated subteam and at least two subteams that are geographically distributed. Leadership configuration and behaviors present unique challenges in PDTs. This paper describes preliminary results of an initial field experiment with international student teams undertaken to examine leadership in PDTs working on high-level requirements for an emergency preparedness information system. Leadership is viewed through the lens of what leader behaviors, or roles, are enacted by the leaders. Leadership configuration was varied: some teams had just an overall team leader; others had no team leader but had a leader for each subteam, while others had both team and subteam leaders. The findings suggest that leadership configuration matters and that leaders do enact roles similar to those found in studies of fully distributed or traditional collocated teams.

Keywords

Emergency management information systems (EMIS), partially distributed teams, leadership, in-group/out-group effects, telepresence.

INTRODUCTION

Disasters span national or organizational boundaries, requiring inter-organizational and international collaboration for planning and response, often in the form of partially distributed teams (PDTs). A PDT is a hybrid team that has at least one collocated subteam and at least two subteams that are geographically distributed (Huang and Ocker, 2006). While PDTs share many characteristics with both traditional collocated and fully distributed virtual teams, they also have unique characteristics and issues. This study looks at PDTs working on requirements for an information system to manage large scale emergencies in a "third world" country.

Although leadership in traditional and, to a lesser extent, fully distributed teams has been examined, there is scant research that examines leadership in PDTs. A major issue in PDTs is how to configure leadership to enhance team effectiveness (e.g., is it "best" to have a single leader for the entire team, a leader per subteam, or a combination of the two?). Leaders in PDTs face many challenges. For example, PDT leaders may need to address tensions stemming from strong in-group/out-group effects (Huang and Ocker, 2006) brought about by a distance faultline between subteams. In-group/out-group effects must be overcome by leadership action to create whole team identity or conflict is likely. Different goals can also promote in-group/out-group effects that diminish the ability of an emergency team to act effectively. For example, in the Anthrax contamination scare in the United States in 2001 the FBI had a goal of keeping the investigation secret so that information helpful to those carrying out the threats would not leak out, while the Center for Disease Control had a policy of public disclosure to forewarn the public as a means of minimizing the spread of the outbreak (Plotnick and Turoff, in press). While it seems obvious that effective leadership might help to address such problems, we know little about how leadership should be configured or what leaders should do to address the challenges of PDTs.

LEADERSHIP ROLES

One way of characterizing leadership is by roles enacted. Quinn (1988) identified eight leadership roles that have also been examined in other studies of traditional teams (Denison, Hooijberg, and Quinn, 1995; Hooijberg and Choi, 2000) and in studies of virtual teams (e.g., Carte, Chidambaram, and Becker, 2006). Thus one research question is whether these roles are enacted by leaders in PDTs and, if so, what leader role patterns are present and what are the effects of these behavioral patterns.

The roles identified by Quinn (1988) are the innovator, broker, producer, director, coordinator, monitor, facilitator, and mentor roles. The innovator responds to environmental changes; the broker interacts with external people to advocate for the team and acquire resources; the producer motivates team members to do the things that will bring about team goals; the director sets objectives and expectations and ensures that they are understood by team members; the coordinator handles schedules and other logistical matters and resolves conflict; the monitor monitors team progress to make sure that goals are being met; the facilitator promotes team cohesion and manages interpersonal conflict; and the mentor develops people in a caring, helpful way (Denison et al., 1995).

LEADERSHIP CONFIGURATION

In a PDT leadership configuration can take many forms of team and subteam leaders. There may even be no leader, or leadership can be shared with members and rotated in response to the needs of the group (Rutkowski, Vogel, van Genuschten, Gemelmans, and Favier, 2002). For this research we examine three of the possible configurations: Centralized, Decentralized, and Hierarchical. In the Centralized condition there is a team leader but no subteam leaders. In the Decentralized condition there are subteam leaders but no overall team leader. In the Hierarchical condition there is an overall team leader and leaders for each subteam. These three conditions are likely to be used in emergency planning and response teams working on the design or implementation of EMIS.

INDEPENDENT AND DEPENDENT VARIABLES

The study reported in this paper is part of an extended set of studies in which the independent variables include leadership configuration and distance (cultural, geographic, and temporal) across student teams. In this study distance was held constant but leadership configuration was varied between groups. Dependent variables were developed to assess team outcomes, using a combination of subjective and objective measures.

RESEARCH QUESTIONS AND HYPOTHESES

The possible leadership configurations for a PDT are unique to PDTs – only in a PDT can a team have both an overall leader and separate subteam leaders. It is unknown what effects leadership configuration may have on team outcomes. This is an important issue to address because the findings may be beneficial to consider when designing PDT leadership structure. Therefore, the overarching research questions guiding this research are:

"*Does leadership configuration have an impact on outcomes in PDTs and, if so, through what processes does it have this impact?*

Members of a team need to feel comfortable and capable in order to function well. Therefore our second research question is:

"With which leadership configuration will PDTs be most comfortable, satisfied, and effective?"

It cannot be assumed that leadership in a PDT is the same as leadership in fully distributed or traditional teams: there are unique challenges to leadership in a PDT for leaders such as overcoming in-group/out-group effects that might result from the difference in "presence" s/he has with multiple groups of members. It is plausible that the Quinn (1988) roles are enacted by PDT leaders, but, it is prudent to verify so it is hypothesized that:

H1: Leadership roles as identified by Quinn (1988) are enacted by leaders in PDTs.

In the Hierarchical and Centralized conditions there are team leaders who are distant from at least some of the members of the team. A distant leader needs to develop "telepresence" (Zigurs, 2002), which can be more difficult than the presence that collocation gives a leader. This should affect perception or salience of leadership behavior. We judge a leader role to be salient if it is reported by a team member. Therefore it is hypothesized that:

H2: Leadership configuration will influence role enactment such that subteam leader role behavior (Decentralized and Hierarchical conditions) will be more salient to team members than team leader role enactments (Centralized and Hierarchical conditions).

As role behaviors are intended to promote positive outcomes, it is also hypothesized that:

H3: Role enactment of leader behaviors will be positively associated with perceived team and subteam performance and objective performance.

Being aware of a leader's activities is a plausible antecedent to formulating an opinion of the effectiveness of a leader. Therefore, it is hypothesized that:

H4: Leader role enactment will be associated with perceived leader effectiveness.

Carte (2006) found that certain roles were more evident than others in high-performing teams. Hooijberg and Choi (2000), in a study of traditional teams, found that some roles were positively associated with leader effectiveness while others had a negative association. However, while some roles expressed may be associated with leader, team, and subteam effectiveness in a PDT, it cannot be assumed that the particular roles associated with leader effectiveness are the same for PDTs and for traditional and fully distributed teams. For example, the fact that a team leader is collocated with some members and distant from others may result in members perceiving monitoring behavior as beneficial to ensure that both subteams "pull their weight" although it has been negatively associated with perceptions of leadership effectiveness in traditional teams (Hooijberg and Choi, 2000). However, if a member perceives a team or subteam to be effective, it is likely that they will have ascribed some of that success to the effectiveness of the leader(s). Effective leadership should lead to better outcomes. Therefore, it is hypothesized that:

H5: Perceived leader effectiveness will be positively associated with perceived team and subteam performance.

SUBJECTS

Undergraduate students (N= 365) from three universities in two countries (USA and the Netherlands) were placed into 40 teams of 7 to 11 members each for their course project. Participants were assigned to subteams and teams were formed of two subteams each such that the subteams in a team were from a different university and country.

COMMUNICATION TECHNOLOGY

A customized wiki was configured to be used as the PDT system. Open editing was not allowed, but, each team was given private space where the participants could create new pages, create discussion forums, post discussion messages, and upload files. Subteams could also create private space that would not be accessible to the members of the other subteam in their team. Although the participants were encouraged to use the PDT system for communication, it was not required. They were, however, required to post deliverables on it.

TASK

The primary task was to prepare a written team report in response to a posted Request for Proposal (RFP) for a Grassroots Regional Resource Repository (GRRR) which was to be an emergency preparedness information system for a specified country. The participants took the role of analysts in a multi-national consulting company that was bidding on the RFP. The report was to specify the functional requirements of the GRRR as well as who the users would be and what the policies to manage it would be. The teams were given a project template to guide them in writing the report, which was due at the end of the four week project. Intermediate deliverables were designed to help the participants work effectively in a PDT and guide them in the process of developing the final report. The grades for the final report were determined by a designee of the research team using a rubric to insure consistency across all reports.

The GRRR system was to be a "self-help" emergency preparedness information system to provide a way for citizens and organizations in a geographic region to assess and deploy resources quickly and effectively. In an emergency, citizens are often the first to respond (Palen,, Hiltz, and Liu, 2007) and continue, together with government and NGOs, to play an important role in the response. Therefore, a system such as the GRRR would be invaluable. Developing and populating the database of such a system with available resources, before an incident is critical. In a case study of a large snowstorm in Western New York in 2006, Chen, Sharman, Rao, Upadhyay, and Cook-Cottone (in press) describe how not having a list of available resources pre-loaded into the emergency system database

adversely affected the ability to respond to the emergency. Thus, the task used in this study mirrors tasks that are important in preparation for large scale emergencies.

PROCEDURES

Teams were assigned to one of three leadership conditions: Centralized, Hierarchical, and Decentralized. In each team's private PDT system space were links to a set of instructions, calendar with deliverable dates, and links to templates and surveys needed for the deliverables. The participants received class credit for the task and those who chose to voluntarily participate in the experiment (e.g., complete surveys), received extra credit.

The first week of the project was used to acquaint the participants with the PDT system by having them complete a tutorial, to introduce them to their remote teammates, and to complete the first of three other tutorial modules. The goals of this module were to clarify team expectations and responsibilities, to raise awareness of issues of working in PDTs, and to select their leaders. As part of the process of preparing a team "contract," the participants read a description of leader responsibilities for the leadership they were requested to choose (e.g., responsibilities for an overall team leader were described for teams assigned to the Centralized condition). They also completed a background survey and personal reflection. Personal reflections had an open-ended question for the participants to reflect on their experiences in their team the week before and survey question items as well.

Active work on the final deliverable began in week 2. There were two activities in the second tutorial module, a team building exercise and a brainstorming activity in which the teams generated and shared ideas regarding the GRRR. The participants in the experiment also completed a personal reflection.

Week 3 included a team assessment activity in which the participants evaluated their team performance and planned for how to improve it, and continued work on the GRRR proposal. Participants in the experiment completed another personal reflection.

During the final week of the project, the teams completed their final deliverable using a proposal template. Experiment participants completed a final personal reflection and the post survey.

TEAM STRUCTURE

Teams were requested to choose leaders that put them in one of three leadership conditions: Centralized, Hierarchical, and Decentralized as described above. Although each team was requested to enact a particular leadership structure, this was a field experiment in which the teams chose their leaders, so the teams could ignore the suggestion and select leaders that placed them in a structure that they believed would be more comfortable and effective. A check was done by examining the team contracts. These contracts revealed that for the most part the teams *did not* follow the suggestions and did not select only the types of leaders they were requested to choose. Instead, for all requested conditions, the teams tended to create leadership structures that were examples of the Decentralized condition, or some variation of that. Thus one finding is that the participants in these student teams seemed to be most comfortable in the Decentralized condition.

For the purposes of analysis, teams were assumed to be instances of the condition indicated by their team contract (i.e., when this differed from their requested condition). In cases where two subteam leaders were chosen for a single subteam (co-leaders), we could not identify which leader was the referent for rating scales responses, so scores were averaged to arrive at a subteam leader score.

MEASURES

In the post survey the participants were asked about the extent to which their leaders (subteam and/or team) enacted each of the eight leadership roles identified by Quinn (1988). Scale items were derived from Denison et al. (1995) with two 7-point semantic differential scale items per role and an additional two new items, one each for the director and monitor roles.

Perceived leader effectiveness was measured on the post survey by one item per leader which asked the participant to rate the performance of the leader on a 10-point semantic differential scale.

Perceived performance was measured in the post survey by six 7-point semantic differential scale items each for the participant's subteam and the team. The items were adapted from Mortensen and Hinds (2001). For analysis, the aggregate of the six scores is used. Objective performance for the team was measured by the team grade on the final deliverable as assigned by a researcher.

RELIABILITY AND VALIDITY

Cronbach's alpha showed adequate reliability for all multi-item scales. The items used to measure role enactments were modified from a previously validated scale (Denison, Hooijberg, and Quinn, 1995) with the addition of two new items. Cronbach's alphas were also calculated for the items by role to measure reliability of the subscales as shown below:

	Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
Team Leader	.923	.899	.944	.936	.909	.880	.847	.897
Subteam Leader	.934	.854	.951	.938	.910	.891	.736	.915

Table 1. Cronbach's alpha reliability measures for leader role enactment

Perceptions of team and subteam performance were measured by six items each. Reliability was good with Cronbach's alphas of .920 for items measuring perceptions of subteam performance, and .912 for items measuring perceptions of team performance. Factor analysis resulted in loadings on one factor each for perceptions of subteam and team performance with all loadings greater than .80.

ANALYSIS AND RESULTS

For each of the leader roles (innovator, broker, producer, director, coordinator, monitor, facilitator, mentor), the values of the scale items that measured the roles were averaged to arrive at a score (from 1 to 7) for the salience of that role enactment to members. A total of 217 participants completed the items regarding subteam leaders; 65 participants completed the team leader role questions. The table below shows the means of the role enactment scores for each subteam and team leaders. Standard deviations are in parentheses. For both subteam and team leaders, the mean scores for each role had a value greater than 5 (out of a possible 7), with a low of 5.15 for team leader as facilitator, to a high of 5.61 for subteam leader as broker. The generally positive ratings suggest that both subteam and team leaders did enact the leadership roles identified by Quinn (1988) thus supporting Hypothesis 1. The average values for team leaders tend to be lower than those for subteam leaders; this is not surprising given the greater availability of evidence regarding the behavior of collocated leaders (see Table 2)..

	Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
Subteam Leader	5.32 (1.26)	5.61 (1.26)	5.59 (1.30)	5.52 (1.30)	5.67 (1.28)	5.33 (1.29)	5.25 (1.39)	5.48 (1.34)
Team Leader	5.30 (1.28)	5.57 (1.24)	5.48 (1.34)	5.42 (1.29)	5.42 (1.28)	5.31 (1.24)	5.15 (1.32)	5.36 (1.29)

Table 2. Means and standard deviations of leader role enactments scores

To test whether or not leader role enactment varied by condition, a nonparametric test (Kruskall-Wallis) was performed. A nonparametric test was performed because leader role enactment was not normally distributed for any role and various attempts at transforming them to normal distributions failed. The results, shown below, suggest that the innovator, broker, and facilitator role enactments vary by leadership configuration while the broker, producer, director, coordinator, monitor, and mentor roles do not. (N=237: Centralized (11); Decentralized (130); Hierarchical (96)) This suggests that leadership condition matters for the expression of some roles, but not others.

	Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
Centralized Mean	4.09	4.45	4.59	4.64	4.82	4.61	4.00	4.68
Decentralized Mean	5.29	5.59	5.60	5.53	5.66	5.33	5.24	5.47
Hierarchical Mean	5.50	5.76	5.63	5.56	5.63	5.40	5.35	5.51
Chi-Square	8.391	6.288	3.519	2.172	2.309	2.820	6.791	2.138
Pr>Chi-Square	.0151*	.0431*	.1721	.3376	.3152	.2442	.0306*	.3434

Table 3. Results of Kruskall-Wallis test for effects of configuration on leader role enactments

To analyze the data for Hypothesis 2, nonparametric tests (Kruskall-Wallis) are performed to compare subteam leader role enactments to team leader role enactments. The results indicate there is not a significant difference for any role between team leader and subteam leader role enactments of that role; thus Hypothesis 2 is not supported. The results are shown below in Table 4 (N=237: team leaders (59); subteam leaders (178)):

	Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
Subteam Leader Mean	5.32	5.61	5.59	5.52	5.67	5.33	5.25	5.48
Team Leader Mean	5.30	5.57	5.48	5.42	5.42	5.31	5.15	5.36
Chi-Square	.0077	.1096	.3149	.4945	2.2891	.0561	.4990	.4755
Pr>Chi-Square	.9301	.7405	.5747	.4819	.1303	.8129	.4799	.4905

Table 4. Kruskall-Wallis results – Leader role enactment did not vary by leader type

We hypothesized (H3) that leader role enactments would be positively associated with perceived team and subteam performance and objective performance. Participants rated their perception of subteam and team performance along the dimensions of efficiency, quality, creativity, adherence to schedule, coordination of efforts, and communication. An aggregate score from 1 to 7 was used as the perceived performance score in the analysis. Objective performance was measured by the team's grade on the final report. Subteam leader role enactments and team leader role enactments were separately correlated with perceived team performance for team and for subteam as shown below in Tables 5 and 6. (Subteam leader N=209; team leader N = 61) All roles for both subteam leaders and team leaders are positively correlated with perceived team performance and all subteam leader roles and some team leader roles are correlated with perceived subteam performance.

	Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
Perceived Subteam Performance	.3364 <.0001*	.32172 <.0001*	.39747 <.0001*	.3544 <.0001*	.3475 <.0001*	.3380 <.0001*	.2668 .0004*	.3466 <.0001*
Perceived Team Performance	.3567 <.0001*	.3108 <.0001*	.3167 <.0001*	.3289 <.0001*	.3441 <.0001*	.3381 <.0001*	.2389 .0003*	.2974 <.0001*

Table 5. Subteam leader role enactment vs. perceived performance (Pearson's r p)

	Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
Perceived Subteam Performance	.1508 .2717	.1896 .1655	.3363 .0121*	.3927 .0030*	.3327 .0131*	.2710 .0454*	.1372 .3179	.2673 .0485*
Perceived Team Performance	.3257 .0152*	.3039 .0241*	.5029 <.0001*	.5763 <.0001*	.5046 <.0001*	.4217 .0013*	.2680 .0479*	.4390 .0008*

Table 6. Team leader role enactment vs. perceived performance (Pearson's r p)

Objective performance is measured at the team level. Therefore, team scores are calculated for the team leadership role enactment and subteam leadership role enactment to compare them to objective performance in correlation tests. Thirty five teams provided usable data to compare subteam leader role enactments to objective performance and ten teams were used in the correlation of team leader role enactments to objective performance. There were no statistically significant correlations between leader role enactment and objective performance. Thus, Hypothesis 3 was supported for perceived performance but not supported for objective performance.

To examine whether leader role enactment was associated with perceived leader effectiveness, correlations for each of the eight leader roles and perceived leader performance were computed. The results, shown in Table 7 indicate that for all roles, there is a significant correlation between enactment of that role and perceptions of leader effectiveness (N=220). Thus, Hypothesis 4 was supported.

Innovator	Broker	Producer	Director	Coordinator	Monitor	Facilitator	Mentor
.6833 <.0001*	.6629 <.0001*	.6660 <.0001*	.6710 <.0001*	.6746 <.0001*	.6367 <.0001*	.5454 <.0001*	.5865 <.0001*

Table 7. Leader role enactment vs. perceived leader effectiveness (Pearson's r p)

To test hypothesis 5, perceived leader performance was compared to both perceived subteam performance and perceived team performance by running correlation tests (N=221). In both cases the correlations were positive and significant at the .05 level of significance: leader performance vs. perceived team performance (r=.41544, p<.0001) and leader performance vs. perceived subteam performance (r=.46681, p<.0001); results thus supported hypothesis 5.

The results of the analysis suggest that leadership configuration does matter to some extent but the more significant factor is the presence or telepresence a leader is able to establish. In order for members to believe that their leaders are effective, they must be aware of their activities and view them positively. While further research and analysis would need to be done, the fact that perceived leader effectiveness and leader role behaviors affect perceptions of performance but not the objective measures of performance suggests that perceptions of performance may be more indicative, given our findings, of a satisfaction with team than it is indicative of actual performance. This may be important for reducing potential conflict that can arise in a PDT from in-group/out-group effects resulting from geographic or organizational (e.g., police vs. fire) faultlines. That is, leaders must take care to develop presence and telepresence so that even their remote members are aware of their activities and see them in a positive light.

Additionally, the nonconformance to our recommendations for leadership structure is informative. Emergency preparedness or response teams may be ad hoc teams. There is little time to build structure into the team. It is important to recognize that subteams may feel more comfortable having a local leader. If the need arises for other leadership configurations, it is important to be explicit about the leadership structure and responsibilities at the start so that the subteams do not ignore the prescribed leadership condition. Other leadership configurations than the Decentralized condition may, in fact, be beneficial. For example, having an overall team leader (Centralized and Hierarchical conditions) may help build whole team identity which could reduce conflict. Further research is needed to investigate this.

METHODOLOGICAL NOTES

The results of this study must be considered in light of the standard caveats about research that uses students as participants. While the team-based work was a significant element in the participating courses, most of these subjects were not members of the workforce which may limit generalizability. Because most teams chose to enact a Decentralized structure, the statistical power of the leadership contrasts was reduced. Finally, the experimental task

took four weeks, whereas the tasks of a real world emergency planning team may take place over longer periods of time, perhaps also limiting the generalizability of the results.

This paper has presented results based on quantitative data only. Analysis is still in progress for qualitative data such as the coding of the four sets of participants' personal reflections for satisfaction with team and leader, and evidence of emergent leadership.

FUTURE RESEARCH AND CONTRIBUTIONS

This study has suggested that the roles identified by Quinn (1988) and studied in traditional and fully distributed virtual teams are also enacted in PDTs. Results also suggest that leadership condition matters for the expression of some roles, but not others. Results indicated that while perceived performance is associated with leader role enactments, objective performance was not. This disparity warrants further investigation to explore the reasons for it. The nonconformance to recommendations for leadership structure is also informative as the majority of the teams chose to be in the Decentralized condition. This has implications for leadership management, especially if further analysis and study reveals that the Decentralized configuration is not the best configuration for all tasks.

This study is a first step toward the specification and manipulation of leadership variations in PDTs. Although it has produced a set of intriguing preliminary results, further study and analysis will be conducted. In the next study (to occur in spring 2008) a more tightly controlled manipulation of leadership configuration will be used, and the study will include distance between subteams as a second independent variable. A field study of global corporate PDTs and field experiments involving training of leaders and participants are planned; these should address some of the generalizability concerns associated with university student teams.

This study contributes to the literature by increasing the understanding of leaders and leader issues in PDTs, particularly in the domain of collaborative work on EMIS. It is hoped that the results will provide insights that can guide future research and for practitioners who are forming or working in PDTs. We validated for use in PDTs, scales used to measure leader roles (Denison et al. 1995) and perceived performance (Mortensen and Hinds 2001) that have been previously validated and used in traditional and/or fully distributed virtual teams.

This study brings to light some issues that face modern day multi-national or multi-organizational emergency response and preparedness teams. Information systems for crisis response and management, and the often-formed PDTs that create and use them, form an interdependent socio-technical system. In order to improve emergency management, we must improve our understanding of the dynamics of PDTs in this context. This study contributes to understanding leadership of PDTs in this context and how leadership role behavior is related to team effectiveness.

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