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ABSTRACT

A partially distributed team (PDT) consists of two or more subteams that are separated geographically. In a PDT, members of a given subteam are co-located, but they collaborate with members of geographically distant subteams. PDTs are commonplace across diverse IT settings, including outsourcing, off-shoring, and distributed organizations. Often the distance separating subteams spans multiple time zones that encompass diverse cultures and countries, as in the case of global software development teams. Findings are presented from a large-scale international PDT project involving IT students from 13 universities. Quantitative analysis of three emergent communication structures adopted by PDTs show significant differences in terms of both procedural (i.e., awareness and coordination) and socio-emotional (i.e., shared identity and trust) team interaction variables as well as perceptions of team performance. Furthermore, a qualitative analysis shows that inclusive leadership behaviors and the use of inclusive media and software positively impact team interaction processes and performance.

Keywords

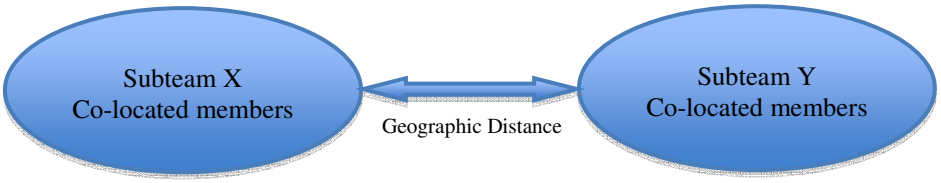
partially distributed teams, virtual teams, distributed teams, communication, shared identity

INTRODUCTION

Information technology (IT) teams are often partially distributed teams (PDTs). A PDT consists of two or more subteams that are separated geographically, as depicted in Figure 1. In a PDT, members of a given subteam are co-located, but they collaborate with members of distant subteams. PDTs are commonplace across diverse IT settings, including outsourcing, off-shoring, and distributed organizations. Often the geographic distance separating subteams spans multiple time zones, that encompass members from diverse cultures and countries, as in the case of global software development teams (Carmel & Abbott, 2007; Herbsleb & Grintner, 1999; Kotlarsky, et al., 2007).

Employers want IT graduates who are "job ready." IT educators are called upon to "ease the transition from academia to the business world by teaching students to work in teams and providing significant project experiences" (The 2008 Information Technology Curriculum Guidelines; Lunt et al., 2008, p. 45). Furthermore, IT education programs need to "provide students with experiences where they can apply international, intercultural, and workplace issues within the context of computing resources, teamwork, and projects" (ibid, p. 45).

Figure 1. Partially Distributed Team (PDT) with two subteams



While many IT students have worked on team projects, our prior work with student PDTs revealed that few if any have experience collaborating in distributed teams in general, and in PDTs specifically. With the goal of preparing IT students to work in a diverse, global workforce, we have developed and fielded a series of PDT projects to provide students with deep learning experiences related to working in PDTs. We have created project procedures and materials, including student learning modules, which we have refined over the field studies (Ocker et al., 2009).

In this paper we discuss findings from a recent PDT project involving over 500 students from a diverse set of 13 US and international universities. Specifically, we report findings related to emergent team communication structures and offer recommendations to improve student training and preparation.

LITERATURE REVIEW

Communication is at the heart of team collaboration. Successful co-located teams communicate effectively, exchanging information predominantly via face-to-face communication. In a virtual context, however, distance precludes the give-and-take of face-to-face interaction and communication occurs primarily via electronic media. PDTs span both face-to-face and virtual communication contexts, which poses particular challenges. For example, research indicates that PDTs are prone to *ingroup team dynamics* – increased communication with and preferential behavior towards members in one's subteam, accompanied by reduced trust and team cohesiveness between subteams. Co-location breeds a strong connectedness to the local subteam as proximate members share the same work context and cultures (both organizational and national), and conduct much of their teamwork via face-to-face communication. This shared context coupled with the rich social cues present in face-to-face communication fosters the development of a shared identity *within* subteams (Armstrong & Cole, 2002; Hinds & Mortensen, 2005). However, ingroup team dynamics *between* subteams threaten team solidarity and maturation, and can have dire consequences on team performance (Huang & Ocker, 2006).

While communication is fundamental to team collaboration, four variables have been shown to be key influencers of both traditional and virtual team interaction and performance; we expect them to be important for partially distributed teams as well. These variables are shared identity, trust, coordination and awareness. The degree of shared team identity and trust are socio-emotional constructs, emphasizing how individuals feel about their team. Shared identification with the team by its members is important in terms of enhancing team cohesion, reducing conflict, and increasing motivation (Jehn et al., 1999; Kramer, 1991). Due to the reduced contact of members in a virtual context, the cohesion that is promoted by shared identification may be especially important to team functioning (Hinds & Mortensen, 2005; Wiesenfeld et al., 2001).

Trust can be defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer, Davis, and Schoorman, 1995, p. 712). It includes beliefs that the trusted party, for example a distributed subteam, will fulfill its commitments (Luhman, 1979), and that it will behave in an ethical (Hosmer, 1995) and socially appropriate (Zucker, 1986) manner. Perceptions of trustworthiness are developed quickly based on members' communication activity and task follow-through efforts (Zolin et al., 2004). Trusting relationships in any team reduce transaction costs, increase cooperation, promote respect, and lead to better outcomes (Hung, Dennis, and Robert, 2004; Kramer, 1999).

A second pair of variables – degree of awareness and coordination – pertains to procedural aspects of team management. Awareness refers to an understanding of others' activities and provides a context to interpret behavior (Dourish & Bellotti, 1992). Research indicates that the lack of a shared work context in a distributed team reduces the amount of mutually shared knowledge among team members (Cramton, 2001; Mark, 2001) which reduces awareness of member activities and availability, leading to misattributions (Weisband, 2002). This reduction in awareness among team members leads to breakdowns in communication within the team and results in poor team cohesion, missed deadlines and an overall negative team experience.

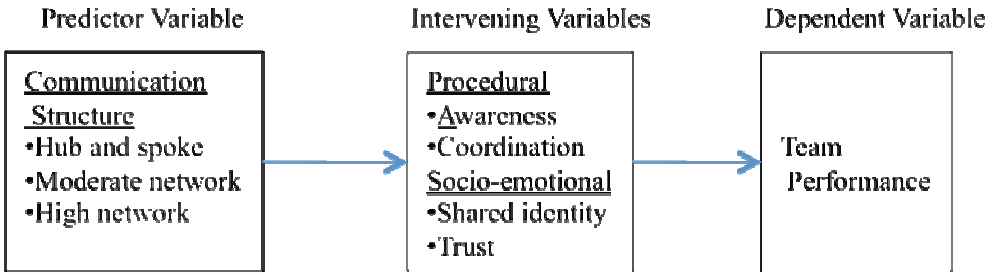
Coordination can be defined as the additional work required when multiple individuals work together to accomplish a goal, compared to individuals working alone (Malone and Crowston, 1994). Time-limited teams must coordinate their efforts temporally (Massey et al., 2003). Temporal coordination mechanisms include milestones, schedule deadlines, time on tasks, and pacing of effort between team members (Ocker et al., 1995-96). Coordinating member efforts across distance is challenging, and becomes more difficult when the team encompasses multiple time zones and/or cultures (Kayworth & Leidner, 2000; Powell et al., 2004; Sarker & Sahay, 2002). Research indicates that teams who establish a temporal rhythm of work (a combination of synchronous and asynchronous communication) and norms for collaborations (e.g. acceptable turn-around time for feedback on work products) have more effective performance (Maznevski & Chudoba, 2000; Massey et al., 2003;).

CONCEPTUAL MODEL

During the PDT project, detailed in the Methods section, we observed that subteams communicated using one of three emergent structures. Some teams adhered to a *hub-and-spoke* communication structure, with interaction occurring between the two subteam leaders who then disseminated information to their respective subteams. The other two structures were variations of a network. In the moderate-network structure, *some* members (less than a majority) within each subteam communicated with their distant counterparts. In the high-network structure, *most* subteam members (a majority) communicated with distant subteam members.

The conceptual model depicting these emergent structures as the predictor variable is shown in Figure 2. We explore the effect that the type of communication structure has on key procedural and socio-emotional team interaction variables (intervening variables), and the resulting differences in team performance (dependent variable).

Figure 2. Conceptual Model



METHOD

Participants

Participants consisted of over 500 students drawn from a diverse set of IT courses in seven US and seven international universities. The domestic universities were: (1) Penn State University, (2) Jacksonville State University (AL), (3) North Carolina Agriculture & Technology State University (NC), (4) Rider University (NJ), (5) Miami University (OH), (6) St. Louis University (MO), and (7) University of Washington (WA). The international universities were: (1) Carlos de Madrid III University (Spain), (2) Hunan University (China), (3) Kaunas University of Technology (Lithuania), (4) Kiel University of Applied Sciences (Germany), (5) Tecnológico de Monterrey (Mexico), (6) Turku University of Applied Sciences, (7) Universidad Carlos III de Madrid (Spain).

Students were grouped into 54 teams. Teams consisted of two subteams; each subteam was from a different university. Each subteam consisted of approximately five students drawn from the same collocated class; thus, members within a given subteam were able to meet face-to-face. However, subteams within a given team were geographically distant from one another.

Leaders

Prior studies of leadership in student PDTs indicated that a leadership structure with one leader per subteam may be the most natural fit (blinded-reference); thus, we instructed each subteam to select a subteam leader.

Project Task

Teams worked on the *GRRR project* (Grassroots Regional Resource Repository) where they analyzed and presented the functionality for a self-help regional emergency preparedness information system. The purpose of the system was to provide a way for those living in a given geographic region (e.g., Costa Rica) to locate and manage the resources of that region (e.g., skilled labor, equipment, supplies) so that the resources can be deployed efficiently and effectively in a disaster. Teams worked over a four-week project period. Teams completed weekly activities and deliverables designed to (1) teach them about collaborating across distances in PDTS and (2) lead them through intermediate steps (e.g. brainstorming, outline of functionality). At the end of the project period, teams submitted a written report describing the functional requirements and high-level design for the GRRR system. To increase motivation, the project was a substantial portion of the course grade (generally about 20%).

Communication Media

We developed a custom system to support PDT collaboration. The collaboration system uses Drupal, an open source web-based communication and content management system (see drupel.org), enhanced with extra functionality (via third-party plug-ins) needed by the team activities. Basic features included a threaded discussion board, file sharing repository, shared document creation and editing, and a project calendar. The asynchronous system did not allow for the open-editing often associated with wikis. Each team had its own private space on the system. An important reason for using this centralized open-source approach was to meet the access needs of international students; we could not assume that they would have funding or personnel to purchase, install, or maintain relevant software. All project content materials were posted on the PDT collaboration system. Team "rooms" were created on this system.

Procedure

Subteam and team assignments were completed prior to the start of the project. During the first week, students completed the first of three training modules, the goal of which was to get teams off to a good start by clarifying team expectations and responsibilities, and raising awareness of issues of working in PDTs. Each subteam selected a subteam leader.

Actual work on the GRRR project task began in the second week. Students completed the second training module, the goal of which was to help move teams from "us vs. them" (separate subteam identities) to "we" (whole team identity). Module 2 included a team building exercise in which the students interviewed members of their counterpart subteam and created a team page of member biographies. Teams also completed a brainstorming activity to generate a list of functionality for the proposed GRRR system.

During the third week of the project, students completed Module 3, the goal of which was to establish a positive team trajectory. Two activities were included in Module 3. The team assessment activity was designed to help students assess their team interaction and performance and reach agreement on an action plan for improvement. In the detailed outline activity, teams created a detailed outline of the functional requirements for GRRR, based on the brainstorming list created in week two.

During the fourth and final week, teams completed their final report deliverable using a proposal template. The report included sections on GRRR functionality as well as screen shots of the proposed user interface. There were no team building activities this week.

Data sources and instruments

The post survey was administered at the end of the study, So that we could explore the impact of different communication structures, a question was added to the previously developed instrument (Ocker et al., 2009). Students were asked to indicate how communication *between* subteams typically occurred. Communication structure choices were: (1) *only* through subteam leaders (hub-spoke), (2) between *some* members from each subteam (moderate-network), or (3) between *most* members from each subteam (high-network). The Post survey was also used to collect data pertaining to the the four intervening variables (awareness, coordination, shared identity and trust) and the dependent variable (perception of team performance). Of the four intervening variables, three were adapted from pre-existing scales. Coordination was measured using four items adapted from Faraj and Sambamurthy (2006). *Shared identity* was measured using four items adapted from Mortensen and Hinds (2001). *Trust* was measured by five items adapted from Jarvenpaa and Leidner (1998) and Cummings and Bromily (1996). *Team performance* included six facets (efficiency, quality, creativity, adherence to schedule, coordination, and communication) and was adapted from Mortensen and Hinds (2001). We could not locate any scales on *awareness*, therefore we developed an awareness measure based on a review of awareness literature. The awareness, coordination, and trust ratings gathered judgments about distributed subteams; shared identity and performance were rated with respect to the team as a whole. All items were measured using a 7-point semantic differential response scale. Scale items are contained in the Appendix.

Students also completed four (weekly) personal reflections where they wrote about their experiences during the most recent week of the project, including team dynamics, problems, and concerns.

ANALYSIS

In this section we present findings from a quantitative analysis of post survey responses, followed by an interpretive qualitative analyses based on the personal reflections of members of 12 teams.

Quantitative Analysis

Three hundred and eighty-one (381) students completed the post survey, for a response rate of ~ 73%. A reliability analysis was conducted for each measurement scale. All scales achieved a Cronbach's alpha coefficient of .05 or better, indicating that the scales were reliable.

We conducted an ANOVA to explore the relationship between team communication structure and the intervening and outcome variables. Based on a communication structure question in the post survey, 134 students indicated that their team used a hub-spoke communication structure, 183 indicated a moderate-network communication structure and 64 indicated a high-network communication structure. The scale descriptive results are presented in Table 1; significance levels of pairwise comparisons of communication structures are presented in Table 2.

Table 1. Scale Means and Standard Deviations

Communication Structure	Awareness	Coordination	Shared Identity	Trust	Performance
(1) Hub-spoke	3.89 (1.82)	4.22 (1.43)	4.75 (1.83)	4.81 (1.56)	4.70 (1.50)
(2) Moderate network	4.14 (1.73)	4.52 (1.320	5.21 (1.70)	4.94 (1.55)	4.98 (1.35)
(3) High network	5.15 (1.74)	5.21 (1.43)	5.61 (1.62)	5.36 (1.40)	5.47 (1.28)

Table 2. Significance levels of pairwise comparisons of communication structures

Communication Structure	Awareness	Coordination	Shared Identity	Trust	Performance
Hub-spoke vs moderate-network	.20	.06	.02	.44	.07
Hub-spoke vs high-network	.00	.00	.00	.02	.00
Moderate-network vs high-network	.00	.00	.11	.07	.02

The contrast between hub-and-spoke, moderate-network, and high-network communication structure revealed increased ratings for all five variables. The spread between high-network and hub-and-spoke structures were the greatest, with significant differences across all variables. The contrast between high- and moderate-network was less broad-spread, with significant differences occurring for awareness, coordination, and performance. Comparing hub-and-spoke and moderate-network structures, shared identity showed a significant difference.

These data suggest that perceptions of team interaction – both socio-emotional and procedural aspects of team management – as well as team performance are tied to the communication structures adopted between subteams.

Qualitative Analysis

To further explore the quantitative findings, we conducted a qualitative analysis of the weekly personal reflections on a subset of teams. To select teams, we first formed a pool of teams where there was strong agreement among members on type of communication structure (i.e., the majority of team members selected the same response for the communication structure question on the post survey). From this pool, we segregated teams into the three types of communication structures. We then reviewed the response rates across team member personal reflections. Based on this data, we selected three teams from each structure with the highest and most consistent number of member personal reflections across the four week project period. The selected teams are shown in Table 3.

Table 3. Teams used in the Qualitative Analysis

Communication Structure	Teams
hub-and-spoke	10,18, 39
moderate-network	38, 41, 46
high-network	12, 15, 16

Team member personal reflections were coded with respect to communication practices. Inclusiveness, both in terms of media use and leadership behaviors, emerged as a key distinguishing characteristic in understanding how team interaction and performance differed among the three communication structures.

Findings

High network teams adopted communication media and software that promoted inclusion of team members. It was common for these teams to use a variety of inclusive media including group chat, googledocs, and skype. For example,

> "We created googledocs so that everyone would be able to see the changes to documents as we were going through them." (member Team 12)

High network team leaders adopted inclusive between-subteam communication behaviors. They encouraged (and sometimes demanded) that distant members interact with one another. The use of chat was important in lessening the divide between subteams, as evidenced by the following leader's reflection:

> "Team dynamics-things definitely picked up. We became friends. This was mostly due to me (as a leader) enforcing the member interviews via synchronous communication (aim). We learned a lot about each other and had a blast doing it. Now we talk to each other whenever we are online - just to check in about what is going on and if there are any news/updates.)" (subteam leader Team 12)

Below, the reflection of a moderate-network team member points to the importance of establishing a one-on-one relationship with the leader of the distant subteam.

> "Because I have been chatting with their team leader on MSN, I did damage control by smoothing out the tenor of the message our leader sent. I sent out an email to our team suggesting that we reach out to the distant team member that we interview and try to develop an online personal relationship so that we would be able to smooth out any misunderstandings such as the one that took place." (member Team 46)

As some high-network teams got to know each other and developed coherence over the life of the project, trust developed; subteam leaders reduced time-consuming synchronous team meetings, dividing the work between subteams and relying on asynchronous communication to maintain contact:

> "The leadership is becoming more effective and smooth. We have decided this week to split up the work and rely less on face-to-face or instant communication. This allowed us to be much more productive and efficient. It also allowed us to get our work done sooner so that each subteam had time to review each others' work. I think this was a much more effective strategy for completing the assignment in the PDT." (member Team 16)

In contrast, leaders of hub-and-spoke teams focused on efficient coordination between subteams *from the very beginning* of the project. They took on a command-and-control style of leadership whereby the only communication between subteams occurred through the leaders and the leaders divided tasks between subteams. Typical member comments include:

> "Leaders were once again great on dividing activities and tasks. I think we had no problems -- each subteam did its job. I think we could have gotten to know each other better. But I think we did a good job." (member Team 39)

> "Both of our subteams are working very well together. We were all issued tasks by the leaders of both subteams and we all executed them without any issues." (member Team 18)

> "The team leaders seem to communicate well between one another, but communication between the other team members is minimal." (member Team 39)

This led to a feeling of separateness, rather than a shared team identity, as described below:

> "It still seems that we are working as two separate teams sometimes as we do separate parts of the deliverables. In the end tasks still get done but it just seems separated instead of a conjoined team." (member Team 39)

Members in moderate-network teams also felt that the leaders were effective in terms of "getting the job done," but that communication and coordination between distant subteam members was lacking.

> "Our subteam's leader is very effective, she knows how to handle deliverables and activities. We needed more communication between subteams…We shared our daily schedules last week, we should have done that the first week." (member Team 46)

Because of the lack of interaction across subteams, there was little need to utilize inclusive technology such as googledocs. Similarly, there were no team meetings, so inclusive media such as group chat was not utilized.

SUMMARY AND CONCLUSION

In the PDT study described in this paper, results from an ANOVA indicated that students from high-network teams reported significantly higher degrees of procedural awareness and coordination as well as team performance compared to both hub-and-spoke and moderate-network teams. In terms of socio-emotional aspects, high-network teams reported significantly higher levels of trust compared to hub-and-spoke teams, while both high- and moderate-network teams reported significantly higher levels of shared identity.

An analysis of personal reflections across 12 teams, three from each communication structure, revealed stark contrasts in terms of aspects of inclusiveness, especially between high-network and hub-and-spoke teams. Leaders in hub-and-spoke teams took a command-and-control approach to leadership, often thwarting the between-subteam interaction of distant members. While this eased coordination challenges, it effectively cut off distant team members from each other, resulting in perceptions of lower team performance. In contrast, high-network leaders initiated and "enforced" both team-level interaction as well as one-on-one between-subteam member interactions. Thus, inclusivity, in terms of both media use and leadership behaviors, increased awareness of procedural aspects of team management and strengthened the feelings of shared team identity and trust, resulting in perceptions of increased team performance.

As educators, we find these insights into inclusiveness both surprising and intriguing. While we have developed and refined PDT project processes, procedures and materials, including student learning modules, to provide rich "real world" learning experiences for students, clearly more work needs to be done. To this end, we plan to add a learning module on communication structures, which emphasizes the importance of inclusive leadership and media use. We intend to develop scenarios with associated activities and deliverables for student PDTs to work through, which will guide them through the pitfalls of exclusivity and the benefits of inclusivity. As with our other PDT materials, we will make these materials freely available via the web, to other educators who are interested in increasing the diversity of their students' experiences through partially distributed teams.

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Appendix: Constructs and Associated Scale Items

AWARENESS

- I was aware when members were available to meet (either electronically or face to face in) the other subteam
- I was aware of the activities members were working on in the other subteam.
- I was aware of what needed to be done next in the other subteam.

Response scale:

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

COORDINATION

To coordinate member effort *between subgroups,* there were*:*

- procedures for coordinating work
- project milestones and delivery schedules
- project documents and memos
- regularly scheduled team meetings (face-to-face and/or electronic)

Response scale:

To a small extent	1	2	3	4	5	6	7	To a great extent

SHARED IDENTITY

- I feel loyal towards my team.
- I see myself as a member of my team.
- I am proud to think of myself as a member of my team.

Response scale:

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

TRUST

- I felt that members negotiated joint expectations fairly in the other subteam
- I felt that members were honest with me in the other subteam
- I felt that members kept their word the other subteam
- Even if I could not monitor them, I was comfortable giving a critical task or problem to other members in the other subteam.
- I was comfortable when other members worked on a critical task or problem in the other subteam

Response scale:

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

PERFORMANCE

Compared with other teams you have worked on, use the following dimensions to rate the performance of your team.

- Efficiency
- Quality
- Creativity
- Adherence to schedule
- Coordination between subteams
- Communication between subteams

Response scale:

Low	1	2	3	4	5	6	7	High