Boundary Issues in Global Virtual Teams

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Boundary issues in global virtual teams

By

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The purpose of this dissertation is to develop a better understanding of boundary issues in global virtual teams, especially in higher education settings. Although previous research in the past decade has studied various aspects of global virtual teams, there is no comprehensive review of boundary issues and their impact. This dissertation addresses these limitations in previous research through a systematic investigation of boundaries issues in global virtual teams. First, it surveys previous research to draw a comprehensive picture of how global virtual teams have been studied and builds a classification system of boundary issues. The relationship between boundary issues and team performance is then investigated in a quantitative study of China-US virtual teams in engineering education. Boundaries and the interaction among them are further described in a multi-perspective qualitative case study of engineering students participating in global virtual teams. The findings indicate that boundary issues were present individually and concurrently, and also interacted among one another to impact team collaborative learning. The dissertation also informs recommendations on team set up and team project design to enhance collaborative learning practice in higher education at a time when the engineering sector is becoming increasingly global. This dissertation provides a foundation for future research of the boundaries that affect virtual team performance in a global education environment.
CHAPTER 1. GENERAL INTRODUCTION

Introduction

Global virtual teams, almost unheard of two decades ago, serve today as a critical mechanism for integrating information, making decisions, and implementing actions around the world, and these teams reach beyond traditional boundaries to play an increasingly important role in the industrial workplace and in education. In particular, global virtual teams are useful because they bridge boundaries of geography, technology, organization, function, time, and culture (Kock & Nosek, 2005; Pauleen & Yoong, 2001). The unique characteristics of global virtual teams both pose challenges to collaborators and offer extraordinary opportunities to expand collaborators’ perspectives, approaches, and expertise.

In this dissertation, the notion of “boundary” is deployed to define the challenges and opportunities that most global virtual teams encounter. Researchers (Watson-Manheim, Chudoba & Crowston, 2002; Chudoba, Wynn, Lu, & Watson-Manheim, 2002) described the incoherence or a gap in aspects of the team’s work, such as the work setting, task, and the relationships with others. In the present dissertation, the use of the term “boundary” means an edge, discontinuity, or other dividing characteristic present in the work context of a virtual team.

Boundary issues that have been highlighted and investigated include the following: technological boundary by Maznevski and Chudoca (2000), cultural boundary by Sosik and Jung (2002), temporal boundary by Espinosa and Carmel (2003, 2004), geographic boundary by O’Leary and Cumming (2002), organizational boundary by Espinosa, Cummings, Wilson,

Boundary issues have been found by researchers to have an impact on global virtual team performance individually and through interaction (Jarvenpaa, Knoll & Leidner, 1998; Espinosa & Carmel, 2003, 2004; Espinosa et al., 2003; Earley & Christopher, 1993; Hiltz, Coppola, Rotter, & Turoff, 2000; Jarvenpaa & Leidner, 1999).

In education, the growth of information and communication technology in schools has paved the way for the development of teaching and learning in a global environment. One goal of globalization of education is to raise students' awareness and understanding of the variety and relevance of all cultures, and global virtual teams have become a key strategy to fulfill the goal. One of the benefits of using student global virtual teams is the acquisition of intercultural competence, which is the capacity to change one's knowledge, attitudes and behaviors so as to be open and flexible to other cultures (Davis & Cho, 2005). The popularity of global virtual teams has inspired parallel research interests examining various aspects of virtual teams. A review of recent studies on virtual teams indicates researchers have acknowledged the importance of articulating boundary issues and the importance of examining boundary issues on team collaboration.

Previous research shed lights on the presence and role of boundary issues in global virtual teams; these researches are, nevertheless without limitations. Despite the fact that many researchers have carried out empirical studies and theoretical discussions (e.g. Jarvenpaa, et al., 1998; Espinosa et al., 2003; Powell, Piccoli & Ives, 2004), there is no literature review up to date to capture the current trends of global virtual teams. In addition, although many global virtual teams have several boundaries at play at the same time,
previous researchers have tried to examine only one or two boundary issues encountered by a group of peculiar global virtual teams. Finally, despite the fact that student global virtual teams are popularly adopted in higher education, little effort has been made to examine the complex pedagogical issues of the computer-supported global virtual teams in the context of international education (Bonk & Cunningham, 1998, cited by Solem et al., 2003).

**Research Questions**

This dissertation centers on boundary issues in global virtual teams with particular attention to the potential effects of boundary issues on team collaboration. It aims to provide theoretical and empirical foundations of global virtual teams for educators and organizational administrators when they deploy such teams in their classrooms and in their institutions. It also aims to advance higher education pedagogy that adopts global virtual teams, a classroom strategy that empowers students to be competitive and collaborative through globalized education. In particular, this dissertation seeks answers to three research questions:

1) *What is the extent of knowledge or conceptual understanding among researchers with regards to boundary issues in global virtual teams?*

2) *To what extent do boundary issues affect global virtual team performance, and to what extent do boundary issues interact with other factors to affect team performance?*

3) *What boundary issues have been found present in student global virtual teams, and how do boundary issues impact student learning individually and through interactions?*
Dissertation Organization

This dissertation consists of five chapters. Chapter 1 briefly outlines the main purpose of the dissertation and describes the dissertation's research questions and main arguments. Chapter 5 summarizes the major findings from the three studies, makes concluding remarks, offers advices for practitioners and educators, and discusses opportunities for further research. Chapters 2, 3, and 4 consist of the following three independent but related publishable articles with each article aiming to answer one research question:

1) *A Review of Research: Boundary Issues in Global Virtual Teams.* This article represents the literature review portion of a traditional dissertation. The author tries to answer the first research question in this article by reporting the extent of knowledge or conceptual understanding among researchers with regard to boundary issues in global virtual teams. As a result of surveying previous studies, this article concluded that boundary issues have an impact on team performance individually and through interaction (Jarvenpaa, et al., 1998; Espinosa & Carmel, 2003, 2004; Espinosa et al., 2003; Earley & Christopher, 1993; Hiltz et al., 2000; Jarvenpaa & Leidner, 1999). It recommends future research directions for researchers to consider. It also suggests pedagogical strategies for educators to take into consideration when utilizing global virtual teams in their classrooms.

2) *Global Virtual Teams: Cross-boundary Collaboration and Team Performance.* This article provides quantitative evidence to support the first article's argument that boundary issues have an impact on team performance individually and through interaction. In the context of engineering student global virtual teams, this article
addresses the second research question investigating the relationship between cross-boundary and team performance. The quantitative research design follows the team input-process-output research framework and performs multiple t-test and ANOVA analysis.

3) *A Multi-Perspective Analysis Case Study on Boundary Issues in Student Global Virtual Teams in Higher Education.* This article provides qualitative evidence to support the first article's argument that boundary issues have an impact on team collaboration individually and through interaction. This article addresses the third research question investigating the presence and the relationship among boundary issues by employing a case study design to perform multi-perspective analysis of the virtual teams’ practice in higher education in international engineering education at a U.S. University. The case study design includes multiple perspectives from the students, course instructor, and instructional designer. The qualitative data resources include student postings, focus group sessions, and individual interviews.

As can be seen by the brief synopses of the three articles, the primary focus of the dissertation is addressing the complexity of using global virtual teams, especially in higher education. Together, the three articles urge higher education community and the global workplace to reexamine its practice and recommend new pedagogical approaches for designing and employing global virtual teams.

**References**


CHAPTER 2. A REVIEW OF RESEARCH:
BOUNDARY ISSUES IN GLOBAL VIRTUAL TEAMS

A paper to be submitted to The American Journal of Distance Education

Wenxia Wu

Abstract

The increasing popularity of global virtual teams has inspired a parallel growth in research examining various aspects of this phenomenon. Up to the date, there has been no study to give a comprehensive picture on how global virtual teams have been carried out and researched. This review summarizes 66 previously published works in academic journals on the practice and research on global virtual teams over the past 13 years. It covers scholarly investigations on the phenomena that has took place in both academic and organizational settings. Starting with building a classification system to review research, it identifies several boundary issues. In-depth discussion is then carried out on six boundaries: technological, organizational, cultural, geographic, temporal, and functional. For each boundary, this review develops a definition, describes the way it has been studied, what the findings are, and the issues that have remained unsolved and/or recommendations for future research. Specific research topics from previous studies are also discussed concerning their relationships to different boundaries. This study provides a foundation for future research on various aspects of global virtual teams in both academic and workplace settings.
Introduction

Global virtual teams, almost unheard of two decades ago, serve today as a critical mechanism for integrating information, making decisions, and implementing actions around the world (Maznevski & Chudoba, 2000). The increasing popularity of global virtual teams is a result of several factors: (1) the globalization of the work place requires international collaborations within multi-national companies and between organizations across the world; (2) advances in collaborative technologies such as groupware make virtual teams increasingly effective for collaboration and decision making (Saunders, Van-Slyke & Vogel, 2004); (3) an organization’s goals often require expertise beyond the capacity of any single individual and/or beyond the capacity of one organization; (4) in education, there is a need to empower today’s students to be competitive and collaborative in the future global work environment (Wu, 2007). McDonough, Kahn, and Griffin (1999) used Ford’s car development team that developed their world car, the Mondeo, as an example to illustrate the advantages of global virtual teams. The Mondeo team was distributed across Europe and the United States, and their goal was to develop a global new car platform. By first developing a global product platform, Ford then needed only small modifications to the base design to meet the needs of customers in individual countries. Having a global team was important to enable the team to come to an understanding of and an agreement about which of the consumer needs were global in nature. Individuals on the team from each of the different countries were also crucial for providing an understanding of their country’s local needs and requirements.
Virtual teams are defined as geographically distributed groups in which team members communicate through communication technology to accomplish one or more goals (Powell, Piccoli & Ives, 2004; Blomquist, Hallgren & Nilsson, 2005). When the virtual team members are located in different places of the globe, however, geographical dispersion is not the only characteristic associated with the team. Global virtual teams are defined as “temporary, culturally diverse, geographically dispersed, electronically communicating work-group of members…who think and act in concert within the diversity of the global environment” (Jarvenpaa & Leidner, 1999; Harvey, Novicevic & Garrison, 2004).

Researchers have singled out three components associated with the concept of global virtual teams. First, they are “global” because team members work and live in different countries. Second, they are “virtual” because they use technology-supported communication substantially more than face-to-face communication. Third, they are “teams” because they are identified by their organization(s) and members as a team, and they are responsible for making and/or implementing decisions important to the organization’s global strategy. Global virtual teams play an increasingly important role in the industrial workplace, as well as in education, to reach beyond traditional boundaries. These boundaries include geography, time, organization, function (Espinosa, Cummings, Wilson & Pearce, 2003), culture (Pauleen & Yoong, 2001), and technology (Kock & Nosek, 2005). Boundaries pose unique challenges to collaborators; at the same time they offer extraordinary opportunities to expand collaborators’ perspectives, approaches, and ideas.

The increasing popularity of global virtual teams has inspired parallel growth in research to examine various aspects such as coordination across distance (Olson & Olson,
trust among team members from different cultures (Jarvenpaa, Knoll & Leidner, 1998), and communication efficiency (Mazevski & Chudoba, 2000). Despite the fact that many researchers have carried out empirical studies and theoretical discussions, there is no literature review up to date to capture the current trends of this new phenomenon.

Many researchers have acknowledged the importance of understanding trends and issues in the advancement of research on teamwork. Cohen and Bailey (1997) examined studies of co-located teams in organizational settings published from 1990 to 1996 and focused on the effectiveness of their outcomes. In addition, Powell et al. (2004) gave a comprehensive review of virtual teams to report on issues discussed and findings generated. When it comes to global virtual teams, however, there is a need for a systematical review to give a comprehensive description of how the field has been studied.

The present review identifies publications that have examined global virtual teams over the past 13 years. It aims at drawing a comprehensive picture of current global virtual teams’ practices and research patterns, focusing on boundary issues, by answering the following questions:

- What issues have been investigated in global virtual teams?
- How has each of the issues been investigated?
- What is known and what needs further investigation?

In order to answer these questions, this review first builds a classification system to categorize research articles. Procedures to enhance the reliability and precision of classification are then discussed. Third, research methods that have been applied to study
each issue of global virtual teams are described. Finally, findings are put into a broader context of conventional virtual teams since the 1980s to discuss the implications.

**Literature Review Methods**

Previous publications in 30 academic journals and three conference proceedings on the practice and research of virtual teams in international settings in the fields of educational technology, communicational technology, human-computer interaction, psychology, human resources management, and engineering are summarized. These journals were selected because of their recognition among researchers in the field and because they were used as data sources in previous studies on virtual teams. Although the focus of the review is on empirical studies, a few important conceptual and theoretical articles have also been included to help understand the theoretical inquiry route for studying this new phenomenon. The number of articles collected was 87, and the 21 of those articles that were editorials, commentaries, interviews, debates, and book reviews were disregarded. A total of 66 articles were reviewed.

The literature review process closely followed the guidelines provided by Galvan (2004) and the standards for reporting on empirical social science research published by the American Educational Research Association (AERA, 2006). Specifically, content analysis of the identified articles was carried out in the present review. Content analysis is defined as a research method that examines the content and themes of written and oral textual materials (Insch, Moore & Murphy, 1997), and data obtained through content analysis in the review is amenable to both qualitative and quantitative studies in the future. Although most journal examined here clearly stated the topic in their title, abstract, and key words, the author of the
present review, nonetheless, examined each article in detail to identify research topics, methods, and boundary issues by recoding the context according to the classification system provided by this review. Through content analysis, this study collected data from the articles that fell into the categories of boundary issues, research topics, and research methods.

To ensure the precision of classification, a triangulation method (Merriam, 2002) was adopted. At first, the author classified the data based on first impressions of the content analysis. Then the classified data was compared to issues, research topics, and research methods generated from literature reviews on conventional virtual teams (e.g., Powell et al., 2004; Hertel, Geister & Konradt, 2005; Olson & Olson, 2000). Based on previous research, the author developed the following system, which accounts for six global virtual team boundaries:

- geographic boundary
- temporal boundary
- cultural boundary
- functional boundary
- organizational boundary
- technological boundary

The system is described in details in the next section. Finally, using the new classification system, the author analyzed the collected articles to confirm and adjust the classification of data. An audit trail (a research journal in this case) was recorded to help the author define the
path of the literature review and to be consistent and reflective during the systematic review process.

**Boundaries in Global Virtual Teams**

“Boundary” is defined as “something that indicates or fixes a limit or extent” (Merriam-Webster’s Online Dictionary). Researchers (Watson-Manheim, Chudoba & Crowston, 2002; Chudoba, Wynn, Lu, & Watson-Manheim, 2005) have described the incoherence or a gap in aspects of the team’s work, such as the work setting, task, and the relationships with others. Espinosa and colleagues (2003) introduced the concept of “boundary” to refer to these incoherence or gap. In the present review, the use of the term “boundary” means an in-coherence, edge, or other dividing characteristic present in the work context of a virtual team.

Several researchers have attempted to identify boundaries in the field of virtual work and collaboration. Watson-Manheim et al. (2002) identified incoherence in the areas of physical location, temporal location, work group membership, organizational affiliation, relationship with an organization, and cultural identity. Building on their work, Espinosa et al. (2003) further developed the concept of “boundary,” and identifies the boundaries associated with virtual teams as geographical, functional, temporal, or organizational. Moreover, Pauleen and Yoong (2001) and Kock and Nosek (2005) expanded the scope of e-collaboration to include a technological boundary. During the first review of the identified articles, the review notes revealed that the most important theme that emerged in research on global virtual teams was the boundary issue. In fact, 73% of the articles deal with different boundary issues. As mentioned above, a system to define different boundary issues was
developed in this review to understand how each of the boundaries has been studied. The following system accounts for six global virtual team boundaries:

- **Geographic boundary**: team members are geographically dispersed. In global virtual team environments, team members are located in at least two countries.

- **Temporal boundary**: team members are separated by working hours, time zones, and/or working rhythms.

- **Cultural boundary**: team members are separated by national culture, socio-psychological culture (e.g. individualism vs. collectivism), and group identity.

- **Functional boundary**: team members possess different functional expertise, such as marketing, engineering, manufacturing, etc.

- **Organizational boundary**: members belong to more than one organization. There are different organizational structures and administrative structure among the organizations.

- **Technological boundary**: team members have different technology infrastructure and proficiency, different technology choice and usage, and different communication patterns associated with technology choice and usage.

The review of recent studies on global virtual teams indicates the need for researchers to identify and account for team boundaries. In the early stages of a study, it is not always clear which boundaries are present (Espinosa et al., 2003), thus making it difficult to define the research design and interpret the results correctly. This is especially true in a field study,
such as in global software development companies or global product development companies. This study finds that seven articles out of 66 (11%) ignored the boundary issues and six articles (9%) tried to deal with all boundary issues in global virtual teams simultaneously. Other than that, most researchers appeared to understand the importance of isolating and evaluating the boundary effect on team performance (80%). In addition, much of the existing empirical research on virtual teams has identified interactions among boundary variables (Espinosa et al., 2003). These research practices make a case for the present review, which aims to highlight the importance of accurate measurement of boundary issues and the importance of comprehensive consideration of boundary issues when conducting research on global virtual teams.

**Findings on Global Virtual Team Boundary Issues**

This study reviewed 66 publications on global virtual teams from the past 13 years. Forty-five articles were classified using the classification of boundary issues. Twenty-one articles that deal with issues such as trust, best practice, virtuality, etc. could not be categorized with any specific boundary issues (see Appendix A for studies reviewed and classified).

The analysis of boundary issues revealed that the majority of the articles focus on a technological boundary (21%), followed by cultural boundary (12%), organizational boundary (12%), and temporal boundary (10%). Only a small portion of the articles is concerned with geographical boundary (3%) and functional boundary (2%). In addition, 9% of the articles attempt to take all boundary issues into consideration at once. Fourteen articles out of 66 (21%) focus on topics that are either independent of boundary issues or associated
with several boundary issues. It is noteworthy that 11% of the articles ignored the boundary issues in studying global virtual teams. Figure 1 and Table 1 present the number and percentage of the articles that investigated boundary issues and other issues.

The analysis yielded results that are different from the findings of previous studies on boundary issues. Previous studies found that two of these boundaries—geographic and temporal—are considered most important when studying virtual teams mediated by communicational technology and are most frequently discussed in empirical studies, while other boundaries—organizational and functional—are neglected (Watson-Manheim et al., 2002; Espinosa et al., 2003). In contrast, the analysis carried out in this review indicates that four boundaries—technology, cultural, organizational, and temporal—are frequently studied in global virtual teams, while two other boundaries—geographic and functional—received little attention. The next section will discuss each of the six boundary issues using the following format:

1. Definition of each boundary

2. How each boundary has been studied

3. Unsolved issues and/or recommendations for future research

The analysis of specific research topics revealed that the majority of the articles focused on technology (15%), followed by best practice (8%), culture (8%), communication (6%), trust (6%), and time, coordination, and distance (6%, 6%, 5%, respectively). Only a small percentage of the articles focused on leadership and virtuality. Other topics discussed include: awareness of collaboration, conflict, team design, simulating games, group identity, instructional modules for team collaboration in school settings, instrument development for
measuring team effectiveness, power issues, research methodology to study virtual teams, and human resources management. Twelve percent of the articles are classified as “overall issues,” which are articles that attempted to understand how virtual teams work in international settings without identifying any specific research topics (see Appendix B for Figure 2 and Table 2 for the numbers and percentages of the articles investigated in each research topic). In the following section, discussions of the topics are carried out with their relationship to one or more boundary issues.

Figure 1. Percentage of articles investigating boundary issues and other issues
<table>
<thead>
<tr>
<th># of Articles</th>
<th>Geographic Boundary</th>
<th>Temporal Boundary</th>
<th>Cultural Boundary</th>
<th>Functional Boundary</th>
<th>Organizational Boundary</th>
<th>Technology Boundary</th>
<th>All Boundary Issue</th>
<th>Other Issues</th>
<th>Boundary Issues Ignored</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>3%</td>
<td>9%</td>
<td>12%</td>
<td>2%</td>
<td>12%</td>
<td>21%</td>
<td>9%</td>
<td>21%</td>
<td>11%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 1. Number and percentage of articles investigating boundary issues and other issues

**Technological Boundary**

Technological boundary is present when there are different technology proficiencies among team members (Kock & Nosek, 2005), different attitudes towards technology (Watson & Liu, 2000), and difference in technology choice and usage (Huysman et al., 2003). It is also present when there are different communication patterns associated with technology choice and use (Maznevski & Chudoba, 2000).

Several research methods were applied to study technological boundary in global virtual teams. Among them, the most frequently used ones were case studies followed by quantitative studies and theoretical inquires. Most studies associated with technology took place in organizational settings, and only a few studies were carried out in higher educational institutions.

Technological boundary has been explored in various aspects. Most publications on this topic have investigated factors that affect media choice and usage. These factors included technology inherent structural characteristics (Maznevski & Chudoba, 2000), team size (Bradner, Mark & Hertel, 2005), social presence in technology (Robert & Dennis, 2005; Walther, Slovacek & Tidwell, 2001); and cultural preference (Watson et al., 2000). Adaptive
Structuration Theory (AST) was adopted by some researchers (e.g. Maznevski & Chudoba, 2000) to describe how inherent structural characteristics of a technology shaped interaction patterns without determining the interaction in a definitive way, and how the way people chose to appropriate the technology helped shape their decision processes. The literature showed that in effective virtual teams, the higher the level of decision process and the more complex the message content, the richer medium is needed. If a rich medium is not required, the most accessible medium is used. Huysman et al. (2003) proposed the notion of “media stickiness,” a phenomenon the teams experience during the process of structuring media-use patterns. The evolution of media usage was found to be path dependent; that is to say, steps taken by a team in the early stages of its life cycle constrained later flexibility in terms of media usage.

Technology associated with social presence was found to be a double-edged sword. The social presence theory argues that media differ in the ability to convey the psychological perception that other people are physically present. Some media have greater social presence (e.g., videoconferencing) than other media (e.g., email). Researchers (Robert & Dennis, 2005) found that on the one hand, media high in social presence induced increased motivation but decreased the team’s ability to process information; on the other hand, lean media low in social presence induced decreased motivation but increased the ability to process information. Another study by Walther et al. (2001) examined a media that displayed team members’ photographs during synchronous virtual meetings, and the researchers concluded that in new, unacquainted teams, seeing one’s partner promoted affection and social attraction, but in long-term virtual teams, the same type of photograph dampened
affinity. The authors concluded that it might be due to the fact that long-term virtual teams had more time to develop inter-personal relationships.

Culture also plays a role in media choice and attitudes towards technology. Watson et al. (2000) found that individualist cultures would be more open to technology use than collectivist cultures. Though attitudes towards technology would likely differ because of the cultural preferences, those differences also depend more or less on the level of professionalism.

Unlike research on co-located teams, which paid much attention to the effect of team size on task process and team performance, only one study out of the 66 investigated the effect of team size in global virtual teams. Bradner et al. (2005) concluded that team size had an effect on technology choice in international collaborations: larger teams adopted technology to support the coordination of asynchronous work, while smaller teams were able to coordinate themselves more effectively without formal coordination mechanisms. Smaller teams adopted technology that primarily supported collaboration rather than coordination.

Besides studying factors that affected media choice and usage, researchers have also paid attention to the types of technology adopted to support virtual team collaboration. The technology for supporting teams and groups was referred to as “groupware” by Stough, Eom, and Buckenmyer (2000). Their study categorized groupware technology into three groups:

1. Groupware for facilitating communication, which includes email, computer-based conferencing systems, and collaborative writing/programming/drawing technology.
2. **Groupware for supporting information storage and retrieval**, which includes workgroup database management systems, workflow automation systems, workgroup scheduling systems (workgroup calendaring systems), workgroup shared text-base systems.

3. **Groupware for supporting decision making**, which includes group decision support systems, group support systems, and electronic meeting systems.

Despite the fact that global virtual teams relied on technology to communicate among members to accomplish one or more goals, most publications on global virtual teams did not specifically identify the technologies employed, how the technologies were used, or the technology infrastructure the team had. Only one study out of the 66 compared and contrasted different types of technologies to evaluate their possible effects on team performance (McDonough et al., 1999). The researchers found there was no correlation between technologies, such as teleconference, email, company databases, and fax, with team performance. Contrary to what might have been expected, video conferencing was found to be negatively related to performance.

Moreover, with an intention to understand the technology infrastructure of the global teams, a survey conducted at Intel Corporation in 2003 created an index of the technology used by employees. The index presented a picture of technology choice and usage in a highly virtualized international cooperation where global virtual collaborations happened often. Figure 3 presents indicators with significant per-employee trending in Intel Corporation from 2003-2004. The study concluded that there were both overlaps and gaps between daily needs for collaboration and the technology infrastructure at Intel Corporation. There were no other
research efforts on technology structure in higher education or other organizations presented in the 66 articles.

Many aspects associated with technological boundary remain unknown. A broader level of analysis is needed when considering factors affecting technology choice and usage. One recommendation was that the characteristics of team task might influence the media choice (Bradner, et al., 2005). Moreover, temporal communication rhythm patterns in global virtual teams might also play a role in technology choice and usage. There is a need for larger scale studies to investigate the relationships between project performance, the use of different communication mechanisms, and the different teams’ needs for speed, richness, and volume (McDonough et al., 1999). When it comes to cultural influence on technology attitudes and usage, further research is also needed to study when and what other members’ backgrounds and context dimensions besides cultural preference affect collaboration processes most. Future research can also explore the perspectives and relevant predictors within a collectivist culture and within an individualist culture. As to the social presence aspect of technology, researchers need to be aware that photograph displays might invoke stereotypical impressions. The physical presentation of partners might not have to be a static image, and the effect of images may be an important aspect of videoconferencing as well (Walther et al., 2001). More efforts are needed to investigate the technologies adopted by global virtual teams, the effects of different types of technology on team collaboration process, and the technology infrastructure in an organization or a team.
Cultural Boundary

Cultural boundary is present when members of a team are from different national cultures, ethnic cultures (Pauleen & Yoong, 2001), or socio-psychological cultures (e.g. individualism vs. collectivism) (Sosik & Jung, 2002). It is also present when group members are not defined by the same team identity because they work on multiple projects with multiple teams or because team members with broad backgrounds find it difficult to establish a common knowledge base (Shapiro, Furst, Spreitzer, & Von Glinow, 2002) and a shared awareness of collaboration (Leinonen, Jarvela & Hakkinen, 2005).

On the one hand, virtual collaboration helps break down traditional boundaries of cultures; on the other hand, “tensions [arise] within societies when new influences [run] tangent with age-long traditions” (Hung & Chen, 2003). Researchers believe the effects of
culture in virtual team settings can be profound (Pauleen & Yoong, 2001; Rutowski, Vogel, Genuchten, Bemelmans, & Favier, 2002) and can lead to different group performance, group potency, and functional heterogeneity (Sosik & Jung, 2002).

Cultural boundary has captured researchers’ attention and is thus ranked second after technological boundary in terms of the number of studies conducted on global virtual teams. Topics that have been discussed with regard to the culture boundary include: individualism versus collectivism, cultural impact on team communication, the in-group and out-group effect in cross-cultural teams, cultural impact on group performance, group identity, and awareness of collaboration among members. Among these topics, the interaction of culture and team communication characteristics seems to interest researchers most. Whereas the study carried out by Setlock, Fussell, and Newirth (2000) focused on the cultural impact of group communication characteristics, such as conversational efficiency, conversational content, interaction quality, persuasion, and performance, a study by Anawati & Craig (2006) analyzed the behavior change in writing and speaking communications among cross-cultural team members. Researchers have concluded that culture affects communication characteristics such as conversational grounding and persuasion, but does not affect task performance or usage of words indicating politeness (Setlock et al., 2000). Culture also has an impact on the communication behavior that team members can adapt in both spoken and written communication to allow for different cultural traditions and religious beliefs (Anawati & Craig, 2006).

When discussing national cultures, many research studies categorized cultures as individualistic and collectivistic cultures. Individualists highlight differences among group
members while collectivists emphasize shared values, similarities, and commonalities among
group members (Sosik & Jung, 2002). Consequently, individualists see diversity in group
members as a way of bringing unique qualities and multiple perspectives on problem solving
to the group, while collectivists may likely perceive diversity as a threat to the common
values. Overall, the identified empirical studies indicate that most virtual teams consist of
members from both individualistic and collectivistic cultures, especially from the United
States and China. Earley (1993) attempted to study an East-Mideast-West team to test the
cultural impact on individuals’ performance in group settings.

There can be tension among team members due to the fact that cultural groups
possess different views on competition. Sosik and Jung’s (2002) study pointed out that
competition within a team is an indicator of low team performance. One study conducted by
Wu (2006) found that 75% of Chinese students who participated in a virtual collaboration
project for undergraduate engineering students believe competition is necessary for success
in academic performance. However, previous research did not find similar results among
team members in an individualistic culture. Additionally, there can also be conflict among
team members due to cultural differences. In fact, researchers (Joshi, Labinaca & Galigiuri,
2002) found that the most critical conflict can happen not between headquarters and country
subsidiaries, but between two different country subsidiaries.

Issues related to cultural boundary arise when group members do not possess the
same team identity because they work on multiple projects with multiple teams or because
team members with broad backgrounds find it difficult to establish a common knowledge
base (Shapiro et al., 2002) and a shared awareness of collaboration (Leinonen et al., 2005).
Researchers have concluded that a lack of team identity and low awareness of collaboration results in group members making only minimal efforts on the group’s task (Shapiro et al., 2002; Leinonen et al., 2005).

Several research methods such as combined methods, theoretical inquiry, and case study have been applied to study cultural boundary with the quantitative method being predominant. Both the higher educational institution setting and organization setting have been equally studied. The most frequently adopted is an in-group and out-group teams design (e.g. Setlock et al., 2002; Wu, 2006; Earley, 1993; Sosik & Jung, 2002), where participants are grouped either into their same culture team (in-group) or into a team with members of other cultures (out-group). Many researchers have carried out a comparison of in-group and out-group teams using questionnaires and/or interviews to evaluate the differences. They found that individualists’ performance was lower in an in-group or an out-group context than when working alone, whereas collectivists’ performance was lower in an individual or out-group context than in an in-group context (Earley, 1993; Setlock et al., 2002).

Research recommendations have been made to improve the research practice: in most of the cultural studies based on the dimension of individualism-collectivism, no efforts have been made to single out a national culture effect (Earley, 1993). Other issues associated with cultural divide, such as language and religion, were also studied in the 66 articles. Evaluation is needed to ensure that the tasks of cross-culture teams are culturally appropriate (Sosik & Jung, 2002) to help ensure members’ motivation and participation. Furthermore, researchers have found that when designing the collaboration process, it is important to take into consideration the length of collaboration, so that one can observe the amelioration of social
loafing—even for the individualists in in-group conditions—and to detect how time might interact with the individualism-collectivism dichotomy to influence certain group characteristics (Earley, 1993; Sosik & Jung, 2002).

Despite the fact that cultural boundary poses challenges to global collaborations, when it comes to team design most studies purposely diversify the cultural identity of team members. In 48 empirical studies on global virtual teams, 35 countries are represented from both individualistic and collectivist cultures (see Appendix C for a summary of collaborating sites involved in global virtual collaborating by country presented in 48 empirical studies). Of these countries, the United States was most frequently presented in the 48 empirical studies on global virtual teams (24 studies), followed by the United Kingdom, Australia, China, India, and Ireland (6, 5, 5, 5, 5 studies, respectively). No research has tried to explain this phenomenon yet, but the author’s understanding is that most global product development companies are based in the United States, while most of their partners located in India, China, and the United Kingdom.

**Organizational Boundary**

Organizational boundary is present in a team when its members belong to more than one organization. It is present when there are differences in administrative structure and philosophy, in organizational affiliation (Espinosa et al., 2003), and in technology infrastructure.

The globalization of the workplace has brought about inter-organizational arrangements such as outsourcing, joint ventures, partnerships, and alliances. Those arrangements have led to an increase in teams that cross organizational boundaries. A quick
scan of the 66 articles on global virtual teams indicated that many global teams included members from different organizations. However, the organizational boundaries were often unspecified in the field research studies (Watson-Manheim et al., 2002; Espinosa et al., 2003), and were often ignored by researchers on virtual collaborations. Among the eight articles focusing on organizational boundary issues, researchers tried to approach the topic from different angles, yet there was no consensus reached on the specific variables to measure organizational boundary and its impact on virtual teams.

Some researchers (Chudoba et al., 2005; Lu, Watson-Manheim, Chudoba, & Wynn, 2006; Kirkman & Mathieu, 2004) stated that measuring an organization’s virtuality is important because it works as an index for an organization’s ability to work in a virtual global inter-organizational environment. Virtuality is characterized in the workplace by three factors:

- Team distribution
- Workplace mobility
- Variety of practices (Lu et al., 2006; Chudoba et al., 2005).

Three studies investigated the level of virtuality in Intel Corporation using virtuality indexes to assess virtual teaming within the organization, virtuality’s impact on performance, and the resultant implications for ICT platforms to support virtual team environments. As results, variety of practices (Lu et al., 2006; Chudoba et al., 2005) and workplace mobility (Chudoba et al., 2005) were found to be negatively associated with team performance, while team distribution had no impact on self-assessed team performance (Chudoba et al., 2005).
Not intending to identify organizational boundary variables, some researchers focused instead on successful collaboration practices that helped members cross the organizational boundary. Paasivaara and Lassenius (2003) conducted a multiple case study of eight successful inter-organizational projects in global software development, which were perceived as successful. Successful practices were found to be: synchronization of main milestones, frequent deliveries, establishment of peer-to-peer links, problem-solving practices, informing and monitoring practices, and relationship building practices.

Strong leadership has been considered an important factor that improves team performance in inter-organizational global teams (Keyworth & Leidner, 2002; Pauleen, 2003). Effective team leaders deal with paradox and contradictions by performing multiple leadership roles simultaneously. To be specific, effective team leaders act in a mentoring role and exhibit a high degree of understanding, and they have been found to be effective at providing regular, detailed, and prompt communication with their peers and in articulating role relationships. Moreover, effective leaders help with cross-cultural communication and problem team members.

These research efforts have revealed that leadership and virtuality play an important factor in inter-organization teams. Nevertheless, many questions associated with organizational boundary remain unanswered. Accordingly, Espinosa and colleagues (2003) have suggested that more research is needed to address measurement of organizational boundary: the similarity or dissimilarity of regulation, cognition, and norm among institutions of different countries. In addition, measurement of density and centrality may be important in representing patterns of organizational affiliation. Given that organizational
boundaries are often unspecified in the field research studies, it is important to acknowledge their potential direct effect on global virtual teams while also considering their interaction with other boundaries.

**Temporal Boundary**

Temporal boundary is present when the team members are separated by time due to differences in time zones. It is present because of non-overlapping weekend days, different work shifts, schedules, and working rhythms (Espinosa & Carmel, 2004) that reduce the time available for same-time interaction (Espinosa & Carmel, 2003). It also exists when team members hold a different perception of time or time vision (Saunders et al., 2004).

When studying a time-effect on team outcome, it is important to distinguish whether team members are separated by time or distance. For example, team members located in the United States and Mexico are not necessarily separated by time zones but by distance. However, when members reside in the United States and China, multiple boundaries are involved including culture, time, and geography. Therefore, strategic research design is essential here to make sure the temporal boundary is singled out, and if other boundaries are involved, their effects should be recognized and be taken into consideration as well.

Temporal boundary has been explored in the following three aspects: time separation and coordination, temporal coordination and communication patterns, and time vision. The majority of articles concerning temporal boundary have focused on time separation and coordination. It is noteworthy that Espinosa and colleagues were dominant in this area. The scope of their research covered the effect of time separation on coordination costs—communication, clarification, delay, and rework—and on coordination outcomes. Massey,

The interaction of time and other boundaries has also gained researchers’ attention. Researchers found that time vision is heavily influenced by cultural and religious beliefs. For instance, a study by Saunders et al. (2004) defined time vision as clock, event, timeless, and harmonic, and discussed how individuals’ time visions were shaped by their cultural and religious beliefs. Other researchers (Sarker & Sahay, 2004) advanced a qualitative ethnography inquiry based on this time vision theory.

Different research methods have been applied to study this phenomenon. Among them, theoretical inquiry is most common. Higher education institutions and organization settings have been studied equally.

The studies have found that time separation can have problematic effects on coordination because it increases the coordination cost such as communication, clarification, delay, and rework (Espinosa & Carmel, 2003). Temporal boundary was found to have an effect on coordination outcomes, processes, and mechanisms (Espinosa & Carmel, 2003; Massey et al., 2003). Among them, communication patterns, task interdependence, and communication media choice are often inherently linked to temporal boundary. Temporal boundary also has an effect on time vision (team member’s perception of time) in regards to national-cultural boundaries (Saunders et al., 2004).

Given that temporal boundary variables are hard to single out, recommendations from the afore-mentioned studies include studying teams with similar temporal boundaries and time zone differences; measuring and controlling temporal boundary on teams with similar
temporal boundaries; measuring other variables caused by temporal boundary; and doing qualitative analysis on the causes of group behavior due to temporal changes. One could consider measuring national and cultural affiliations as potential control variables and measure perceptions of work rhythms, the size of participating organizations, and preferential modes of communication as an alternative measurement of time vision.

**Geographic Boundary**

Geographic boundary is present in a team when some of its members are separated by distance. In global virtual teams, team members are separated by national borders.

Researchers have tried to define geographic dispersion in different ways. McDonough, Kahn, and Barczak (2001) conducted a study of three levels of geographically dispersed teams: co-located, within one country, and global. O’Leary and Cumming (2002) used clearer categories to describe geographic dispersion in a large sample of firms. Members were asked whether each of the others (1) “worked immediately next to you,” (2) “worked on the same floor as you,” (3) “worked in a different building than you in the same city,” (4) “worked in a different city,” or (5) “worked in a different state or country.”

In a frequently cited study, O’Leary and Cummings (2002) developed a robust view of varying degrees of geographic dispersion. They carried out a study through which a series of 11 archetypal work teams were constructed. Team A was a completely co-located team and functioned as a control group. At the other end of the continuum, Team H had one member in each of the ten globally-spanning cities. The remaining nine teams represented various configurations between the fully co-located and fully-dispersed extremes. Findings revealed that different measures of dispersions were associated with communication
frequency in different ways, the negative effects of dispersion on communication decreased over time, and the measures of dispersion warranted use in future studies.

Findings from other studies were not included in the present review because the author and other researchers found their methodology problematic. McDonough and colleagues’ (2001) three levels of virtual teams, for example, were questionable. On the one hand, their definitions conflated cultural diversity and location; on the other, it mixed teams that were dispersed across different floors of the same building with teams dispersed across different countries. Another study that investigated the relationship between delay in cross-site work, and the degree to which remote colleagues were perceived to help out was conducted by Herbsleb and colleagues (2002). However, delay was a temporal concept which was mainly associated with time separation, rather than geographic boundary. Therefore, their study did not map out an appropriate inquiry and their interpretation of the results was problematic. Latane, Liu, Nowak, Bonevento, and Zheng (1995) constructed a measurement by taking remembered interactions among team members (the social influence), dividing them by distance per mile, and then plotting them against distance. But, Knowles (1999) called this measurement of geographic distance on social influence into question by arguing that the fact that the inverse of distance plotted against distance had a slope of -1.00 when plotted in logarithms was tautological (measurement artifact), not a true indication of how social influence deceased as a function of distance. He urged for new and more precise measurements.

Although geographic boundary is considered as a classic divide by researchers studying global virtual teams (Espinosa & Carmel, 2004; Pauleen & Yoong, 2001), the
present review located only four out of 66 publications that focused on this phenomenon. This confirmed O’Leary and Cummings’ (2002) argument that tools and terms are needed to characterize teams’ geographic dispersion. The major reason for the lack of studies on geographic boundary might be due to the difficulty of isolating this factor in the face of other factors associated with distance collaboration (Espinosa et al., 2003), such as culture, time, and organization. This assumption has been supported by the discussion above.

Despite the fact that geographic boundary is less researched than other classic boundaries, global virtual teams researchers and designers strive to make sure their team members are globally located. As mentioned earlier in this study, sites from 35 countries were involved in the body of research on global teams. Region-wise, Europe, North America, and Asia were the most active. Table 3 presents the number of times a region was involved in global virtual collaboration from the reviewed 48 empirical studies.

How to measure geographic boundary has been the biggest concern among researchers, and there are a number of recommended possibilities. O’Leary and Cummings (2002) outlined several measures of geographic dispersion: 1) the number of sites represented within the team, 2) the degree of isolation (measured by dividing one by the average number of team members per site), 3) the separation of sites (the weighted average travel time between sites), 4) a role index that reflects the fact that distance for some members (particularly the leader or the headquarter) is relatively more important, and 5) an external index that reflects the fact that distance to some outside constituents (e.g., the customer) is relatively more important than to others.
### Table 3. Summary of collaborating sites involved in global virtual collaborating by region presented in 48 empirical studies

<table>
<thead>
<tr>
<th>Number of times involved</th>
<th>Europe</th>
<th>North America</th>
<th>Asia</th>
<th>Latina America</th>
<th>Mid-East</th>
<th>Australia</th>
<th>Africa</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>36%</td>
<td>23%</td>
<td>21%</td>
<td>6%</td>
<td>5%</td>
<td>8%</td>
<td>2%</td>
<td>100%</td>
</tr>
</tbody>
</table>

#### Functional Boundary

Functional boundary is present when more than one area of functional expertise is present in a team. Only one study out of the 66 publications investigated functional boundary (Grinter, Herbsleb, & Perry, 1999), and it found that benefits coming with multi-functional teams included a larger pool of experts, better work load balancing, and developed and enhanced expertise among the team members. Furthermore, it also found that problems stemmed from coordinating and managing projects that span sites.

It is commonly recognized by researchers that one prominent advantage of global virtual team lies in their ability to bring different expertise together. Among the six boundary issues, however, functional boundary is the least researched. The lack of research on functional boundary is likely due to the difficulty of separating the effect of function from other factors. When each function (expertise) is located in a separate site, function and other boundary measures can be confounded, thus making it difficult to assess whether particular work patterns are a result of differences in functions or in organization, culture, distance, etc. Researchers (Grinter et al., 1999; Espinosa et al., 2003) have recommended several research methods to make the study of functional boundary possible: study sample group with an even mix of functions across locations; measure perception of expectations, reputation, power, and authority of function; study sample teams with similar functions or similar distributions of
Boundary Issues Ignored

There were seven articles (11%) out of the 66 that did not deal with boundary issues. These articles were primarily published in journals of *Global Software Development* and *Software Process Improvement and Practice*. Written by practitioners from international companies or from global virtual teams in software development, the major goal of those articles was to present lessons from the best practices of global virtual teams. Through describing the project, process, and results, and through interviews, surveys, or case studies, they reported on specific practices that were found to be effective in global virtual teams. It was hard to tell whether the authors acknowledged the presence of boundaries because boundary issues were barely mentioned. Therefore, those articles were classified as the articles ignoring boundary issues. However, they were not excluded from the present review because they brought the practitioners’ point of view. Global software development could be the place where global virtual teams are most practiced because 50% (18 articles) of the articles that specified the research field were carried out in global software development.

Dealing with Several Boundary Issues

The six articles (9%) dealing with several boundary issues simultaneously tried to identify what boundaries a specific group of global virtual teams was facing. They developed different categories of boundaries due to the nature of the team concerned. When studying four types of international collaborating teams in banking, software development, product development and leadership, Espinosa et al. (2003) identified boundaries as identity-based,
geographic, functional, temporal, and organizational. Pauleen and Yoong (2001) categorized boundaries as organization, culture/language, time, and distance. Moreover, a study conducted by Wu (2007) on China-USA undergraduate engineering student teams identified boundaries as educational system, culture, language, and time. These studies served as a foundation for the present review to develop the index of six boundaries to study global virtual teams.

Wu (2007) took an interesting approach in treating all cross-boundary issues as one team input variable when comparing team performances of co-located virtual teams with those of global virtual teams. The findings indicated that cross-boundary teams outperformed co-located ones. The findings also indicated that cross-boundary issues interacted with time and the number of tasks on team performance.

**Other Issues**

There were issues that were either not associated with any specific boundary or were associated with several boundaries at the same time. Those issues were: trust, communications, staffing the global virtual teams, research methodology to investigate the phenomenon, behavior control, and questionnaire development.

Trust was considered by researchers as a factor independent of boundary issues that affect team performance. Trust was essential in global virtual teams because it “is the glue of the global workplace—and technology doesn’t do much to create relationships” (O’Hara-Devereaux & Johansen, 1994, cited by Jarvenpaa et al., 1998). Findings confirmed this belief that trust was found to positively influence the efficiency, effectiveness, and satisfaction level of team members (Edwards & Sridhar, 2005). Social physiologists made efforts to define
trust from various points of view; in summary, trust was based on the expectation that others would behave as expected. However, could trust exist in global virtual teams since such teams lack the shared social contexts? Research questions were raised about from where trust was imported to the global virtual teams and how trust was maintained via telecommunication.

With those research questions in mind, researchers have identified the process that provoked trust, antecedents of trust, different forms of trust, and in which ways trust affected virtual teams (Jarvenpaa et al., 1998; Javenpaa et al., 2004; Jarvenpaa & Shaw, 1998). Among different forms of trust, such as interpersonal trust, impersonal or institutional trust, and swift trust, much attention was paid to swift trust in temporary teams. Swift trust was formed around a common task with a finite life span. The tight deadlines for team tasks left little time for relationship building, and therefore, swift trust de-emphasized the interpersonal dimensions and was based initially on broad categorical social structures and later on action (Jarvenpaa et al., 1998). Findings indicated that team trust was predicted more strongly by some communication behaviors (Jarvenpaa & Leidner, 1999) and by perceptions of other members’ integrity, and least by the perceptions of their benevolence; the salience of other members’ perceived ability on trust deceased over time (Jarvenpaa et al., 1998). Findings also indicated that trust affected virtual teams differently in different situations and trust effects were not necessarily linear and direct. Early in a team’s existence, the members’ propensity to trust had a significant and unchanging effect on trust (Jarvenpaa, Shaw, & Staples, 2004; Jarvenpaa et al., 1998). Later on, a member’s trust in a team operated as a moderator, indirectly affecting the relationships between team communication and perceptual outcomes (Jarvenpaa, et al., 2004).
Findings and theory from these studies have several implications for future research. Future research should more rigorously assess swift trust and the means to maintain it. Further examinations are also needed to specificity the context within which the effect of trust might differ (Jarvenpaa et al., 2004; Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999).

Team communication is another stand-alone factor that catches researchers’ attention. Several boundary issues together with other team coordination mechanism are found to affect communication indirectly. McDonough and colleagues (1999) concluded that team communication is affected by six factors: 1) the approach used to solve problems, 2) the means used to communicate with leaders, 3) decision-making practices, 4) different languages, 5) the technological capability of the member’s country of origin, and 6) extreme geographical dispersion.

Despite the fact that researchers study various aspects of communication—such as factors that affect communication, communication and trust, communication patterns and characteristics in global virtual teams—yet there is no agreement on the role that communication plays to help the teams cross different boundaries. Nor is there an agreement on what communication characteristics or patterns exist in global virtual teams. Study of team communication is still a wide open field that needs further systematic examination.

**Summary**

Although there have been several literature reviews that studied conventional virtual teams from different aspects (e.g., Powell et al., 2004; Hertel et al., 2005; Olson & Olson, 2000), prior to this review there was no other review to date that investigated a phenomenon that has caught researchers’ attention in the new millennium: global virtual teams. This study
reviewed 66 publications investigating global virtual teams over the past 13 years. While this study examined journal articles in the field of educational, communication, and information technology published since 1980, it did not locate any publications prior to 1993 that focused on global virtual collaboration. The 1990s might have shown a reluctance to begin research on global virtual teams (5 publications, 7.5% of the total of 66), but the new millennium has witnessed blossoming research interest (61 publications, 92.5%). Global virtual teams in higher education and in organizational settings have been equally studied.

Based on previous research, this review built a classification of boundary issues to identify six boundaries: geographic, temporal, cultural, functional, organizational, and technological boundary. Using the classification system, the author systematically reviewed and categorized the 66 identified publications. The analysis of boundary issues revealed that the majority of articles investigated technological boundary, followed by organizational, cultural, and temporal boundaries, and only a small quantity of articles dealt with geographic and functional boundaries. A small number of articles dealt with multiple boundaries that faced a specific group of international teams simultaneously.

Boundary issues were not the concern of some researchers (20% of the 66 articles). Their studies focused on lessons learned and best practices and boundary issues were ignored. A substantial portion of the articles (14 articles, 14%) studied issues that are either independent of boundaries or interact with several boundaries simultaneously. Among them, trust and team communication catch researchers attention.

Despite the fact that many researchers have investigated global virtual teams, the phenomenon is still not well understood. One of the difficulties of studying team boundaries
in field studies is that numerous boundaries are often present in the team simultaneously. Consequently, it is impractical to address all boundary issues in a single study. Another difficulty lies in the ambiguity of measurable variables associated with each boundary. It is important to identify what a given boundary means in the specific research context and then select one or more measures that represent the most relevant aspects of those boundaries (Espinosa et al., 2003).

In summary, the present review contributes to the literature on global virtual teams in several ways. First, it builds a classification system of boundary issues based on previous researchers’ efforts (e.g., Espinosa et al., 2003; Pauleen & Yoong, 2001; Kock & Nosek, 2005) to categorize publications in this field. By building a classification system of boundary issues, the present review captures the essential characteristics that are likely to be present in most global virtual teams. Second, it identifies a wide range of publications over the past 13 years on global virtual teams in the fields of software development, product development, human resources management, higher education, government agencies, etc. Third, it is the first literature review on research of global virtual teams up to date. Finally, this study provides a foundation for future research on various aspects of global virtual teams in higher education and in organizational settings.

**Acknowledgements**

Special thanks are due to Dr. Niki Davis, my major professor, who has provided tremendous support, feedback, and guidance to me on the literature review process. Unbounded thanks also go to Ruslan Suvorov, graduate student in English at Iowa State University, who worked closely with me on the editing process.
References


on Global Software Development at the International Conference on Software Engineering Work, Portland, OR.


*Standards for Reporting on Empirical Social Science Research in AERA Publications.*


## APPENDIX A: STUDIES REVIEWED BY BOUNDARY ISSUES AND OTHER ISSUES

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Title</th>
<th>Boundary Issues &amp; Other Issues</th>
<th>Methodology</th>
<th># of Participants</th>
<th>Time Frame</th>
<th># of Countries</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edwards, H.K.</td>
<td>2005</td>
<td>Analysis of software requirements engineering exercises in global virtual team setup</td>
<td>All boundary issues and coping strategies</td>
<td>Quantitative. Survey to 24 teams collaborated on software engineering projects</td>
<td>201</td>
<td>5 weeks</td>
<td>2</td>
<td>global software development</td>
</tr>
<tr>
<td>Sarker, S. &amp; S. Sahay</td>
<td>2004</td>
<td>Implications of space and time for distributed work: an interpretive study of U.S.-Norwegian systems development teams</td>
<td>All boundary issues and coping strategies</td>
<td>Qualitative: ethnography. 8 virtual students teams of 8-10 members collaborated on information system design projects over 14 weeks. Analysis of message postings &amp; observations.</td>
<td>74</td>
<td>14 weeks</td>
<td>2</td>
<td>informational system development</td>
</tr>
<tr>
<td>Wu, W.</td>
<td>2007</td>
<td>Cross-boundary virtual team: effect of time and number of tasks on team performance</td>
<td>All boundary issues: boundary as one input variable</td>
<td>Quantitative. 10 co-located virtual teams vs. 7 global virtual teams.</td>
<td>68</td>
<td>12 weeks</td>
<td>2</td>
<td>Engineering</td>
</tr>
<tr>
<td>DeLone et al.</td>
<td>2005</td>
<td>Bridging global boundaries for IS project success</td>
<td>All boundary issues: factors for success</td>
<td>Qualitative. F-f or phone semi-structured interviews</td>
<td>9</td>
<td>N/A</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>Espinosa J.A. et al.</td>
<td>2003</td>
<td>Team boundary issues across multiple global firms</td>
<td>All boundary issues: theoretical discussions about boundary issues</td>
<td>Case study: cross case. Cross-case analysis. 4 cases. 1) 36 participants, semi-structured f-f interviews; 2) 20 interviews and documents; 3) 78 teams observations, surveys 6 times over 1 year; 4) 14 semi-structured interviews, documents</td>
<td>148</td>
<td>N/A</td>
<td>N/A</td>
<td>global software development</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Title</td>
<td>Boundary Issues &amp; Other Issues</td>
<td>Methodology</td>
<td># of Participants</td>
<td>Time Frame</td>
<td># of Countries</td>
<td>Fields</td>
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<tr>
<td>Pauleen D.J. &amp;</td>
<td>2001</td>
<td>Relationship building and the use of ICT in boundary-crossing virtual teams: a facilitator's perspective</td>
<td>All boundary issues: theoretical discussions about boundary issues</td>
<td>Qualitative. Action learning. Semi-structured interviews and discussions with participants. Analysis on researcher's journal, participants' notes, organizational documents and electronic conversations.</td>
<td>N/A</td>
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<td>Yoong, P.</td>
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<td>Leinonen</td>
<td>2005</td>
<td>Conceptualizing the awareness of collaboration: a qualitative study of a global virtual team</td>
<td>Culture: awareness of collaboration</td>
<td>Case study. One team (19). Pre- and post-questionnaires, log files, and company documents. 3 month.</td>
<td>19</td>
<td>N/A</td>
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<td>Anawati, D. &amp;</td>
<td>2006</td>
<td>Behavioral adaptation within cross-cultural virtual teams</td>
<td>Culture: behavior adoption</td>
<td>Case study. Interviews to 15 team members. Questionnaires to 122.</td>
<td>122</td>
<td>N/A</td>
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<td>Craig, A.</td>
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<td>Sosik J.J. &amp;</td>
<td>2002</td>
<td>Work-group characteristics and performance in collectivististic and individualistic cultures</td>
<td>Culture: collectivististic vs. individualistic</td>
<td>Quantitative. Students from two countries put into collaboration group to complete 2 decision-making tasks. Two questionnaires after a short term and a long task.</td>
<td>302</td>
<td>15 weeks</td>
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<td>Jung, D.I.</td>
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<tr>
<td>Setlock, L.D. et al.</td>
<td>2002</td>
<td>Taking it out of context: Collaborating within and across cultures in face-to-face settings and via instant messaging</td>
<td>Culture: communication</td>
<td>Combined. 48 students (24 American and 24 Chinese), 3 types of groups: AA,AC,CC. Quantitative: Complete 2 tasks and complete one questionnaire after each task. Qualitative: f-f meeting transcribed. IM message coded.</td>
<td>48</td>
<td>2 hours</td>
<td>2</td>
<td>survival</td>
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<td>Joshi, A. et al.</td>
<td></td>
<td></td>
<td>Culture: conflict</td>
<td>Survey. Questionnaire to one global team</td>
<td>30</td>
<td>N/A</td>
<td>6</td>
<td>management</td>
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<td>Earley, P.C.</td>
<td>1993</td>
<td>East meets west meets mid-west: further explorations of collectivistic and individualistic work groups</td>
<td>Individual vs. out-group vs. in-group</td>
<td>Quantitative. Survey. Participants work either individually, work out-group or in group.</td>
<td>165</td>
<td>N/A</td>
<td>3</td>
<td>management</td>
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<td>Gurung, A. &amp; E. Prater</td>
<td>2006</td>
<td>A research framework for the impact of cultural difference on IT outsourcing</td>
<td>IT outsourcing</td>
<td>Theoretical inquiry. Looking at the effect of cultural differences on IT outsourcing and virtual teams performance.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Shapiro, D.L. et al.</td>
<td>2002</td>
<td>Transnational teams in the electronic age: are team identity and high performance at risk?</td>
<td>Team identity</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Grinter, R.E. et al.</td>
<td>1999</td>
<td>The geography of coordination: Dealing with distance in R&amp;D work</td>
<td>Functional</td>
<td>Case study. 5-6 interviews to 6 product development organizations of one telecommunications systems company</td>
<td>27</td>
<td>N/A</td>
<td>3</td>
<td>global product development</td>
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<td>E.S. Knowles</td>
<td>1999</td>
<td>Distance matters more than you think! An artifact clouds interpretation of Latane, Liu, Nowak, Bomevento, and Zheng's Results</td>
<td>Geography</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>O'Leary, M.B. &amp; J.N. Cumming s</td>
<td>2002</td>
<td>The spatial, temporal, and configurationally characteristics of geographic dispersion in work teams</td>
<td>Geography</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Battin, R.D. et al.</td>
<td>2001</td>
<td>Leveraging resources in global software development</td>
<td>Ignored</td>
<td>Case study. Description of best practice</td>
<td>N/A</td>
<td>N/A</td>
<td>6</td>
<td>global software development</td>
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<td>Ebert, C. &amp; Neve, P.D.</td>
<td>2001</td>
<td>Surviving global software development</td>
<td>Ignored</td>
<td>Case study. Description of best practice</td>
<td>N/A</td>
<td>N/A</td>
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<td>Lurey, J. S.</td>
<td>2001</td>
<td>An empirical study of best practices in virtual teams</td>
<td>Ignored</td>
<td>Quantitative</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>McDonough, E.F. et al.</td>
<td>2001</td>
<td>An investigation of the use of global, virtual, and collocated new product development teams</td>
<td>Ignored</td>
<td>Combination. Qualitative: interviews based on grounded theory. Quantitative: questioners on relationship between communication and performance. 103 firms.</td>
<td>N/A</td>
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<td>Mockus, A. &amp; Weiss, D.M.</td>
<td>2001</td>
<td>Globalization by chunking: a quantitative approach</td>
<td>Ignored</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
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<td>global software development</td>
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<td>Prikladnicki, R. et al.</td>
<td>2003</td>
<td>Global software development in practice lessons learned</td>
<td>Ignored</td>
<td>Case study. Case study on 2 teams. 1 data sources: 11 individual interviews. 2nd data source: documents, etc.</td>
<td>22</td>
<td>2 years</td>
<td>N/A</td>
<td>global software development</td>
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<td>Repenning, A. et al.</td>
<td>2001</td>
<td>Using components for rapid distributed software development</td>
<td>Ignored</td>
<td>Case study. Description of best practice to evaluate an existing process</td>
<td>N/A</td>
<td>N/A</td>
<td>2</td>
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<td>German, D.M.</td>
<td>2003</td>
<td>The GNOME project: a case study of open source, global software development</td>
<td>Organization &amp; function</td>
<td>Case study. Analysis of the logs and the archives of 104 mailing lists.</td>
<td>185</td>
<td>6 years</td>
<td>5</td>
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<td>Kayworth T.H &amp; Dorothy E. Leidner</td>
<td>2002</td>
<td>Leadership effectiveness in global virtual teams</td>
<td>Organization: leadership</td>
<td>Combined. Quantitative: survey to team members, not to team leaders. Qualitative: open-ended questions to both team members and leaders.</td>
<td>13</td>
<td>N/A</td>
<td>3</td>
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<td>Hornett, A.</td>
<td>2001</td>
<td>Virtual executives: A paradox with implications for development</td>
<td>Organization: power &amp; conflict</td>
<td>Case study: Qualitative. A team of executives in a Fortune 50 company based in USA. 4 members. 3 interviews to each member 3 times over 9 month; recorded sessions.</td>
<td>4</td>
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<td>Paasivaara M &amp; Lassenius, C.</td>
<td>2003</td>
<td>Collaboration practices in global inter-organizational software development projects</td>
<td>Organization: success &amp; best practice</td>
<td>Case study. Interviews</td>
<td>34</td>
<td>N/A</td>
<td>N/A</td>
<td>global software development</td>
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<td>Chudoba, et al.</td>
<td>2005</td>
<td>How virtual are we? Measuring virtuality and understanding its impact in a global organization</td>
<td>Organization: virtuality</td>
<td>Quantitative. Survey to 2100 employees at Intel Cooperation</td>
<td>2100</td>
<td>N/A</td>
<td>N/A</td>
<td>global software development</td>
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<td>Kirkman, B.L. &amp; J. Mathiew</td>
<td>2004</td>
<td>The role of virtuality in work team effectiveness</td>
<td>Organization: virtuality</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
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<td>Lu. et al.</td>
<td>2006</td>
<td>Virtuality and team performance: Understanding the impact of variety of practice</td>
<td>Organization: virtuality</td>
<td>Combined</td>
<td>1269</td>
<td>N/A</td>
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<td>Pauleen D.J.</td>
<td>2003</td>
<td>Leadership in a global virtual team: an action learning approach</td>
<td>Organizational: leadership</td>
<td>Qualitative: action research: action learning</td>
<td>N/A</td>
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<td>Piccoli, G. et al.</td>
<td>2004</td>
<td>Virtual teams: Team control structure, work processes, and team</td>
<td>Other issues: behavior control</td>
<td>Quantitative</td>
<td>201</td>
<td>5 weeks</td>
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<td>Tavcar, J. et al.</td>
<td>2005</td>
<td>Skills for effective communication and work in global product</td>
<td>Other issues: communication - skills for effective communication</td>
<td>Quantitative</td>
<td>68</td>
<td>N/A</td>
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<td>Suchan, J. &amp; Greghayzak</td>
<td>2000</td>
<td>The communication characteristics of virtual teams: A case study</td>
<td>Other issues: communication characteristics</td>
<td>Case study</td>
<td>28</td>
<td>N/A</td>
<td>N/A</td>
<td>customer support</td>
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<td>McDonough, E.F. et al.</td>
<td>1999</td>
<td>Managing communication in global product development teams</td>
<td>Other issues: communication - factors affected communication</td>
<td>Combined. Qualitative: telephone interviews to 15 and f-to-f interviews to 19. Quantitative: questionnaires on 22.</td>
<td>22</td>
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<td>Panteli, N. &amp; R.M.</td>
<td>2004</td>
<td>The role of subgroups in the communication patterns of global virtual</td>
<td>Other issues: Communication-subgroups</td>
<td>Qualitative. Content analysis on communication exchange, discussions forums, files exchange, online chats.</td>
<td>7</td>
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<td>Bing, J.W.</td>
<td>2001</td>
<td>Developing a consulting tool to measure process change on global</td>
<td>Other issues: question are development</td>
<td>Quantitative. Questionnaire to 2 global teams: 12 members of each</td>
<td>24</td>
<td>N/A</td>
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<td>Gallivan, M.J &amp; Benbunan</td>
<td>2005</td>
<td>A framework for analyzing levels of analysis issues in Studies of</td>
<td>Other issues: research methodology</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
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<td>Harvey, M at al.</td>
<td>2004</td>
<td>Challenges to staffing global virtual teams</td>
<td>Other Issues: staffing</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
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<td>Prasad</td>
<td>2002</td>
<td>Global virtual teams: What impacts their design and performance</td>
<td>Other issues: team design</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
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<td>Alexandre</td>
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<td>Other issues: trust</td>
<td>Qualitative: action research. Qualitative: content analysis on emails, interpretive. Quantitative: questioners</td>
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<td>Jarvenpaa S. &amp; T. R. Shaw</td>
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<td>Global virtual teams: Integrating models of trust</td>
<td>Other issues: trust</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
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<td>Jarvenpaa S. et al</td>
<td>2004</td>
<td>Towards contextualized theories of trust: The role of trust in global virtual teams</td>
<td>Other issues: trust</td>
<td>Quantitative. Study 1 vs. Study 2. Pre &amp; post surveys. Study 1: 16 teams, 94 students from 11 universities and 8 countries. Study 2: 26 teams, 150 students from 13 counties. One team with 6 students from 6 countries</td>
<td>244</td>
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<td>Jarvenpaa S. et al</td>
<td>2000</td>
<td>Communication and trust in global virtual teams</td>
<td>Other issues: Trust</td>
<td>Case study. Email message archives, responses to demographic questions, two questionnaires.</td>
<td>350</td>
<td>6 weeks</td>
<td>25</td>
<td>business</td>
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<tr>
<td>MacEachren, A.M.</td>
<td>2001</td>
<td>Cartography and GIS: extending collaborative tools to support virtual teams</td>
<td>Technology: GIS</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
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<td>Solem, M.N. et al.</td>
<td>2003</td>
<td>Using the internet to support international collaborations for global geography education</td>
<td>Technology: instructional module</td>
<td>Quantitative. Surveys. Students from 3 countries of 2 groups: USA-Canada, USA-Australia. 6-8 students per team.</td>
<td>312</td>
<td>1 semester</td>
<td>3</td>
<td>geography education</td>
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<td>Maznevski</td>
<td>2000</td>
<td>Bridging space over time: Global virtual team dynamics and effectiveness</td>
<td>Technology: media choice</td>
<td>Case study. Qualitative Case study: 3 teams over 21month. Multiple data collection methods: semi-structured interview, unstructured interview; observation f-f; observation of conference call, documents, and questionnaires.</td>
<td>23</td>
<td>21 months</td>
<td>7</td>
<td>manufacturing technology</td>
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<td>Robert, L.P &amp; Dennis, A.R.</td>
<td>2005</td>
<td>Paradox of richness: A cognitive model of media choice</td>
<td>Technology: media choice</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
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<td>Huysman, M. et al.</td>
<td>2003</td>
<td>Virtual teams and the appropriation of communication technology: Exploring the concept of media stickiness</td>
<td>Technology: media stickiness</td>
<td>Combined. Qualitative Interpretive &amp; inductive methodology. Qualitative data gathered through observation, videotaping, audio recording of the meetings, interview members. Quantitative: questionnaires to reduced researchers' subjectivities.</td>
<td>6</td>
<td>N/A</td>
<td>2</td>
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<td>Watson, M. R. et al.</td>
<td>2000</td>
<td>Openness to technology in virtual teams: Implications for international human resource development</td>
<td>Technology: openness to technology, culture</td>
<td>Quantitative. Pre-post surveys to 520 students on a 7-week collaboration project.</td>
<td>520</td>
<td>N/A</td>
<td>6</td>
<td>N/A</td>
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<tr>
<td>Doyle, D. &amp; Brown, F.W.</td>
<td>2000</td>
<td>Using a business simulation to teach applied skills - the benefits and the challenges of using student teams from multiple counties</td>
<td>Technology: stimulation games</td>
<td>Qualitative. Semi-structured interviews to 30 team members of 5 teams from 3 countries.</td>
<td>30</td>
<td>12 weeks</td>
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<td>Favela, J. &amp; Pena-Mora, F</td>
<td>2001</td>
<td>An experience in collaborative software engineering education</td>
<td>Technology: tool use</td>
<td>Case study. Students from 2 countries collaborated on 3 software development projects. Questionnaires, asynchronous email frequencies, control group vs. experimental group</td>
<td>N/A</td>
<td>32 weeks</td>
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<td>Lanubile, R. et al.</td>
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<td>Tool support for geographically dispersed inspection teams</td>
<td>Technology: tool use</td>
<td>Case study. Questionnaires, asynchronous email frequencies, control group vs. experimental group</td>
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<td>Stough, S. et al.</td>
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<td>Virtual teaming: A strategy for moving your organization into the new millennium</td>
<td>Technology: types of technology</td>
<td>Theoretical inquiry</td>
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<td>N/A</td>
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<td>Walther, J. et al.</td>
<td>2001</td>
<td>Is a picture worth a thousand words</td>
<td>Technology: visual presence</td>
<td>Quantitative. 2 (long-term/short-term) * 2 (photograph/no photograph) design. Questionnaire at the end of the projects.</td>
<td>24</td>
<td>12 weeks</td>
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</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Title</td>
<td>Boundary Issues &amp; Other Issues</td>
<td>Methodology</td>
<td># of Participants</td>
<td>Time Frame</td>
<td># of Countries</td>
<td>Fields</td>
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<td>-------------------------</td>
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<td>Munkvold</td>
<td>2005</td>
<td>Experiences from global E-collaboration: Contextual influences on technology adoption and use</td>
<td>Technology; infrastructure</td>
<td>Case study. A comparative two-case study design. Criteria based &amp; maximum variation. Individual interviews, longitudinal interviews over 6 years.</td>
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<td>Pickering, C. &amp; Wynn, E.</td>
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<td>An architecture business process framework for global team collaboration</td>
<td>Technology; infrastructure</td>
<td>Theoretical inquiry</td>
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<td>Bradner, E. et al.</td>
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<td>Team size and technology fit: Participation, awareness, and rapport in distributed teams</td>
<td>Technology; team size</td>
<td>Quantitative. Survey to 204 members of 18 teams. Team size of 4-18 members</td>
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<td>Herbsleb, J.D. et al.</td>
<td>2003</td>
<td>Distance, dependencies, and delay in a global collaboration</td>
<td>Time: dependencies and delay</td>
<td>Qualitative. Survey.</td>
<td>194</td>
<td>N/A</td>
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<td>global software development</td>
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<td>Massey, A.P. et al.</td>
<td>2003</td>
<td>Because time matters: Temporal coordinating in global virtual project teams</td>
<td>Time: temporal Coordination</td>
<td>Combined. 35 teams. Qualitative: content analysis on discussions. Quantitative: cluster analysis on interaction patterns</td>
<td>175</td>
<td>N/A</td>
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<tr>
<td>Espinosa J.A. &amp; E. Carmel</td>
<td>2003</td>
<td>The impact of time separation on coordination in global software teams: A conceptual foundation</td>
<td>Time: time separation and coordination</td>
<td>Theoretical inquiry</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Espinosa J.A. &amp; E. Carmel</td>
<td>2003</td>
<td>Modeling coordination costs due to time separation in global software teams</td>
<td>Time: time separation and coordination cost</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>global software teams</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Title</td>
<td>Boundary Issues &amp; Other Issues</td>
<td>Methodology</td>
<td># of Participants</td>
<td>Time Frame</td>
<td># of Countries</td>
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<td>Espinosa J.A. &amp; C. Pickering</td>
<td>2006</td>
<td>The effect of time separation on coordination processes and outcomes: A case study</td>
<td>Time: time separation and coordination,</td>
<td>Case study. Semi-structured interviews to 23 team members</td>
<td>23</td>
<td>N/A</td>
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<tr>
<td>Saunders &amp; Vogel</td>
<td>2004</td>
<td>My time or yours? Managing time visions in global virtual teams</td>
<td>Time: time vision &amp; culture</td>
<td>Theoretical inquiry</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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APPENDIX B: PERCENTAGE AND NUMBER OF ARTICLES BY SPECIFIC RESEARCH TOPICS

Figure 2. Percentage of articles by specific research topics
Table 2. Number and percentage of articles by specific research topics

<table>
<thead>
<tr>
<th>Research Topic</th>
<th>Article</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>10</td>
<td>15%</td>
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<tr>
<td>Overall Issues</td>
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<td>12%</td>
</tr>
<tr>
<td>Best Practice</td>
<td>6</td>
<td>9%</td>
</tr>
<tr>
<td>Culture</td>
<td>6</td>
<td>9%</td>
</tr>
<tr>
<td>Communication</td>
<td>5</td>
<td>8%</td>
</tr>
<tr>
<td>Trust</td>
<td>5</td>
<td>8%</td>
</tr>
<tr>
<td>Time</td>
<td>4</td>
<td>6%</td>
</tr>
<tr>
<td>Coordination</td>
<td>4</td>
<td>6%</td>
</tr>
<tr>
<td>Distance</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>Leadership</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Virtuality</td>
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<td>3%</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>100%</td>
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<tr>
<td>Region</td>
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<tr>
<td>North America</td>
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<td>USA</td>
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<td>Ireland</td>
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<td>Norway</td>
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<td>Europe</td>
<td>France</td>
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<td>Netherlands</td>
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<tr>
<td>Latin America</td>
<td>Brazil</td>
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<td>Mid-East</td>
<td>Israel</td>
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<td>Mid-East</td>
<td>Turkey</td>
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<td>Africa</td>
<td>South Africa</td>
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CHAPTER 3. GLOBAL VIRTUAL TEAMS: CROSS-BOUNDARY COLLABORATION AND TEAM PERFORMANCE

Submitted to *Journal of Research on Technology in Education*

Wenxia Wu\(^1\) and Jennifer R. Seymour\(^2\)

**Abstract**

This study seeks better understanding of how global, or “cross-boundary,” virtual teams work. It identified challenges that virtual teams face when crossing traditional boundaries of culture, educational system, language, and time. The authors conducted a study on 17 American virtual teams that collaborated on undergraduate civil engineering student projects over a 12-week period. Among them, seven teams were put into a cross-boundary setting to collaborate with engineering students in China (cross-boundary teams) while 10 teams collaborated only with American students (within-boundary teams). Quantitative analyses were conducted on the effect of international collaboration on team performance, the effect of international collaboration, time, and the number of tasks on team performance separately and through interaction. The results indicate that time and the number of tasks had an effect on the performance of both types of teams, which confirms the results from previous studies. The results indicate that cross-boundary teams outperformed within-boundary teams on overall performance, over time, and with the increase of

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\(^2\) Graduate student and Assistant Professor, respectively, College of Human Science, Iowa State University.
number of tasks to some degree. The results also indicate that the performance of both types of teams decreased over time and with an increasing number of tasks. The latter two findings contradict with what had been predicted. Implications of the findings and limitations of this study are discussed.

INTRODUCTION

The increasing popularity of virtual teams has inspired the parallel growth of researchers examining various qualities of virtual team collaboration. Virtual teams are defined as geographically distributed groups in which the team members are brought together through communication technology to accomplish one or more goals (Blomquist, Hällgren & Nilsson, 2006; Powell, Piccoli & Ives, 2004). Geographical dispersion has many implications when the virtual team members are located in different places on a global scale. Global virtual teams cross traditional boundaries such as nation, culture, organizational system, time, language, and distance. Because cross-boundary virtual teams differ in structure from those virtual teams whose members are located within one country (Espinosa, Cummings, Wilson, & Pearce, 2003), additional research is needed to understand cross-boundary virtual team (a) characteristics, (b) collaboration process, and (c) overall team performance.

These three aspects of global virtual teams are quantitatively investigated in this study of 17 virtual teams that collaborated on an undergraduate engineering student project over a 12-week period in spring 2006. This study compares the performance of seven teams that volunteered to engage in a cross-boundary virtual team to collaborate with engineering students who were located in China (cross-boundary teams), to the performance of the
remaining ten strictly-American virtual teams (within-boundary teams). The performance of the two types of teams and the characteristics that influence their performance were both of equal interest. These characteristics include two process dependent variables: student online-participation and the number of tasks completed as a team. The performance dependent variable, other than overall performance, is fluctuation in scores across the 12-week project-based learning task period.

**CONTEXT OF THIS GLOBAL VIRTUAL TEAM**

Cross-boundary virtual teams are deployed widely as a key strategy for improving practicing engineers’ abilities to be competitive and collaborative globally. International engineering education plays an important role, familiarizing and empowering engineering faculty and engineering students to succeed in the globalized engineering working place. A public university in the Midwest United States is conducting a five-year multi-faceted joint-education program with a public university in northwest China in engineering education to engage students and faculty from both universities. One key element of this program is to create opportunities for students to work in real and virtual global engineering settings.

To create these opportunities, the Virtual Engineering Team (VET) project was developed. The design and practice principles of this project were to: 1) increase engineering students’ ability to work in multi-national teams; 2) increase engineering students’ understanding of the global diversity in engineering codes and practices, and the emergence of international codes and practices; and 3) increase engineering faculty members’ involvement in working and collaborating in international education settings. The VET project was integrated into existing civil engineering courses of both universities. Students in
China joined teams of American undergraduates enrolled in the same civil engineering synthesis course. For 12 weeks, teams collaborated on civil engineering tasks to analyze economic costs of a civil engineering project from an international perspective. A project-based, technology-enhanced collaboration environment was designed in a course management system to support and scaffold teamwork in the students’ cross-boundary virtual collaboration for the VET project.

It is important to note that the first author collaborated with the course instructor, a senior lecturer in construction, civil, and environmental engineering, to design the research and design the virtual instruction with several goals in mind: ensuring that the projects were culturally relevant, that the subtasks were inter-dependent, and that the virtual space in the WebCT course management system was designed to maximize productive collaboration. The first author is from China, is an instructional designer in curriculum and instructional technology, and specializes in distance education. She is not educated in engineering concepts and processes. Thus, the course instructor monitored and evaluated performance, and the first author oversaw the technology and data collection.

THEORETICAL FRAMEWORK, LITERATURE REVIEW, AND HYPOTHESIS

The theoretical framework, which includes input, process, and output variables, is described next, with in-depth definitions of input and output variables. The remaining sections intersperse the literature review throughout the definitions of variables and the generation of the six hypotheses. There are three sets of two hypotheses each, for a total of
six. They include the effects (a) of input on output, (b) of process variable 1 and input on output, and (c) of process variable 2 and input on output.

**Theoretical Framework**

This study was framed in the classic team input-process-output system theoretical perspective of team research (e.g., Powell et al., 2004; Sosik & Jung, 2002). Team inputs represent composition characteristics of the virtual teams and the endowment of resources, skills, and abilities with which the team begins its work. Inputs that have been investigated by previous research are identified by Powell et al. (2004) as team design, culture, technical experiences, and training. In this study, the input variable is isolated to international collaboration, which includes characteristics of the team in terms of their boundary-crossing and online participation.

Team process is categorized as a socio-emotional process (relationship building, cohesion, and trust) and task process by Powell et al. (2004). The task process is what occurs as team members work together to accomplish a task or a goal. Previous studies have identified communication, coordination over time and distance, and task-technology-structure-fit as important elements of the task process. The task process is the main concern in this study, which focused only on time and the number of tasks as the two team-process variables.

Current virtual-team research on team output, or outcomes, has focused on team performance. Some studies have examined specific aspects of team performance, such as decision quality and the length of time to reach a decision (e.g., Sosik & June, 2002), quality of the team products, creativity (numbers of idea generated) (e.g., Ocker, 2005), and team
members’ satisfaction with the experience (Piccoli, Powell & Ives, 2004). The present study focused on the quality of team products as measured by the course instructor within a given time limit as a team performance variable.

In summary, the study identified team input variables as international collaboration, team process variables as time and the number of tasks, and team outcome variables as team performance. The input-process-output framework proposes that team input variables together with team process variables affect team performance separately or through interaction. The following section discusses these variables separately and the relationships among them to propose six hypotheses.

**Definitions of the Input Variable: International Collaboration**

This study did not separate the effects of each different boundary crossed by the VET global virtual teams but instead treated them as one team input variable—international collaboration. The authors intended to investigate their cumulative effect on team performance and its interaction with other team process variables (time and number of tasks). The authors also intended compare the effect and the interaction of international collaboration teams to those of collocated teams. Powell, Piccoli and Ives (2004) in their literature review of forty-three publications investigation virtual teams argued for the importance of such an approach to evaluate the intervention at the team input stage and to evaluate its impact on the team outputs. Their review concluded that the majority of previous studies on virtual teams identified one important team input variable as virtual collaboration, and conducted investigation of its cumulative effect on team output comparing them to collocated teams.
It is also important to contextualize these quantitative results with a full definition of the input variable: international collaboration. The VET project offered students the opportunity to reach beyond the boundaries included in the frequently-cited framework provided by Espinosa et al. (2003) that identified these boundaries as geographic boundary, functional boundary, temporal boundary, identity boundary, and organizational boundary. More recently, Kock and Nosek (2005) identified boundaries of technology, culture, space, and time. In the following sub-sections, specific aspects of the boundaries that pose challenges specifically to VET collaboration are reviewed based on a previous study (Wu, 2005). They include the boundaries of culture, education system, time, and language. Thus, the definition of international collaboration, the input variable, includes the cumulative effects of the boundaries that were crossed by the VET global virtual teams, which are each described in the following subsections.

**Cultural boundary.** On one hand, virtual collaboration helps break down traditional national boundaries; on the other hand, the effects of different cultures in virtual teams can be profound (Rutowski, Vogel, Genuchten, Bemelmans, & Favier, 2002; Pauleen & Yoong, 2001) and can affect group performance, group potency, and functional heterogeneity (Sosik & Jung, 2002). As a result, conflicts among the team members might occur because the eastern and the western cultures view team diversity differently. Social psychologists often describe Chinese culture as “collectivistic” and U.S. culture as “individualistic.” Collectivists emphasize shared values, similarities, and commonness among group members, while individualists highlight differences among group members. Consequently, collectivists may see diversity as a threat to the commonality valued in eastern cultures, whereas individualists
perceive such diversity as bringing unique qualities and multiple perspectives on problem solving to the group (Sosik & Jung, 2002).

There also might be tension among team members related to team members’ notions about competition within a team. Sosik and Jung’s (2002) study pointed out that competition within a team is an indicator of low team performance. A survey conducted with the VET Chinese students revealed that 75% of them believed competition was necessary for academic success (Wu, 2005). This belief about competition might be a factor that leads to low team performance.

**Educational system boundary.** The VET project students crossed the boundary of educational systems. The processes of teaching and learning at a university are influenced by the educational beliefs of teachers and students, and those educational beliefs differ among ethnic groups. Research has indicated that the primary contrast between educational systems is student degree of freedom. The U.S. democratic educational system, which encourages individual student autonomy, differs fundamentally from the Chinese centralized education system, which focuses on the teacher’s role as an authority. Wu (2005) indicated that there is a tendency among VET Chinese students to agree with teacher-centered education. Although, Huang and Chen (2003) recognized that “in essence” the “globalization of learning would aid in bringing convergence to various cultures, both western and eastern” (p.7), they also noticed a widening divide between newer approaches (e.g., constructivism and active learning) and traditional ones (e.g., didactic lectures) because of distinctive learning epistemologies. Therefore, it is important for course instructors to acknowledge these differences and have a plan to help VET students be aware of and navigate crossing the educational system boundary.
**Time boundary.** The 14-hour time difference between the American and the Chinese universities made synchronous communication in the VET project difficult. The time separation also increased coordination costs due to communication delays, task reworking (Espinosa & Carmel, 2003), and different perceptions of timing (Saunder, Van-Slyke & Vogel, 2004). Research has also indicated that low team response rates in asynchronous communication can be an acute problem that hinders virtual collaboration.

**Language boundary.** Researchers have found that effective communication is the key for virtual team success, but challenges can rise from differences in saliencies and interpretations of written texts. When cross-boundary virtual teams bring people with different native languages to work together, language is considered by some researchers as the number one barrier for team members to communicate (Abel, 2002; Mulligan & Krikpatrick, 2000). In the VET project, English was the official working language, which posed challenges to the Chinese students whose native language is Mandarin.

**Definitions of Output Variable: Team Performance Indicated by Grades and Online Participation**

In the past 10 years, many researchers have investigated factors that impact virtual team performance or team effectiveness, this field has not yet identified unified moderators of effectiveness (Karayaz & Keating, 2005) nor has there been an agreement on the definition of team performance/effectiveness. This study adopted the concept of team performance developed by Piccoli et al. (2004) that defines team performance in terms of group-produced outputs and the consequences a team has for its members. Effective teams should be able to produce high-quality output (Jarvenpaa & Ives, 1994). In higher education
settings, the quality of output is often reflected by the scores given by the instructor to the team products. Accordingly, in the VET project, the team performance was reflected by the scores given by the instructor.

Another important indicator of team performance is communication effectiveness. Communication is at the core of any virtual team, and numerous researchers have discussed the importance of communication by focusing on the need to create a team of excellent communicators, the selection of the right technology for most effective communication, and the communication difficulties engendered by the virtual environment (Powell et al., 2004). Successful co-located teams are found to be able to communicate effectively and share information crucial to project completion in a timely manner. For virtual teams, considerable challenges to effective communication arise including technology divides among team members (Kock, & Nosek, 2005), time delays in communications (Herbsleb, Mockus, Finholt, & Grinter, 2000), lack of a common agreement on a teamwork structure because of cultural difference (Leinonen, Jarvela & Hakkinen, 2005), and different native languages. Although some researchers have conducted content analysis on virtual teams’ discussion postings and virtual meeting records to identify different types of communication, such as task-related, social-connection related, and awareness of collaboration-related communication, it is unclear which types of communication are effective and which are not. Therefore, the amount of online participation was used as a second indicator of team performance in the present study.

Effective teams are able to deliver a timely, high-quality product, and effective teams communicate using the technology available for the completion of team tasks. The quality of
product indicated by grades and the amount of online participation are both used as indicators of the output variable team performance.

**Hypotheses**

*Effect of input variable international collaboration on output variable team performance.* A literature review of 10 years of publications on virtual teams by Powell et al. (2004) found that virtual teams are generally found to be outperformed by their co-located counterparts with respect to the ability to exchange information orderly and efficiently and to engage in effective planning. Because the cross-boundary teams face more challenges than the within-boundary teams, this study predicted that within-boundary teams would outperform cross-boundary teams on team project performance. While cross-boundary virtual teams may offer a wide range of potential benefits, implementation is at risk if teams fail to adequately address the challenges in the virtual context. Previous research has highlighted the significant difficulties that cross-boundary virtual teams face as they attempt to coordinate across traditional boundaries.

Efficient communication has been identified as the most important vehicle for virtual teams to achieve their objectives and successfully complete their project (Powell et al., 2004). The fact that cross-boundary virtual team members are separated by boundaries indicates that discussion and team interaction can be lengthy and confusing, leading to poorer comprehension and understanding. Researchers have also observed that virtual teams communicate more often than co-located teams. Taking into consideration these challenges of cross-boundary teams, this study predicted that cross-boundary teams would outperform within-boundary teams in terms of amount of online participation.
This study compared two types of virtual teams: cross-boundary virtual teams versus within-boundary co-located virtual teams. Taking into consideration the challenges VET cross-boundary teams faced when Chinese and American students work together virtually, the first set of hypotheses that were tested is as follows:

*Hypothesis 1:* Within-boundary teams outperform cross-boundary virtual teams in team project scores.

*Hypothesis 2:* Cross-boundary virtual teams outperform within-boundary teams in online participation.

**Effect of process variable number of tasks and input variable international collaboration on output variable team performance.** Many researchers have emphasized the team project/task design for virtual teams (Hertel, Geister & Konradt, 2005; Karayaz & Keating, 2005). The popular term used by these researchers is “team task design.” However, in this study the team project was divided into five interdependent tasks; therefore, the term of “team project design” is used instead. The team project involved students in the identification of a project and the generation of activities and products designed to meet the project goal (Dede, 1998). Projects that require a lower degree of team members’ physical work and a higher degree of information-based work are better suited for virtual teams.

When it comes to cross-boundary virtual teams, culture issues should also be taken into consideration because a project that is culturally irrelevant to some team members may lead to their low participation and poor performance (e.g. Sosik & Jung, 2002).

The interdependence of team project subtasks also has an effect on team performance. Task interdependence describes the degree or requirement of task-driven interaction among group members (Hertel et al., 2005). Potential positive effects of high task interdependence
include increased team cohesion, trust, and sense of indispensability of personal contributions to the team (Hertel et al., 2005; Karayaz & Keating, 2005). Therefore, the VET student team project, described later, was designed to be culturally relevant to students from both Chinese and American culture and the subtasks were designed to be highly inter-dependent.

These hypotheses focused on the relationship between the number of tasks and team performance. The sequence of project tasks was designed to help students go through the four phases of Tuckman’s cycle of team development: forming, storming, norming, and performing (1965, 1977). Researchers have found that teams that do more than one task may go through the cycle more than once. In such cases, cohesion, trust, and skills of communicating develop positively over time and by the number of tasks (Blomquist et al., 2006). Therefore, the second set of hypotheses to be tested was as follows:

Hypothesis 3: Performance of virtual teams improves with the number of tasks for both cross-boundary and within-boundary virtual teams.

Hypothesis 4: Within-boundary virtual teams outperform cross-boundary virtual teams in the number of tasks.

Effect of process variable time and input variable international collaboration on output variable team performance. Virtual teams develop over time. Dividing the time frame into five parts, Gersick (1988) found that the critical time is the midpoint when the teams defined their goals and strategies. If the team gets through this punctuated equilibrium, it performs similar to Tuckman’s performing phase. Blomquist et al (2005), who carried out a study on virtual teams in a project management online course in Sweden, confirmed that virtual team efficiency develops positively over time. We wondered if this would be true for
within- and cross-boundary virtual teams in an engineering undergraduate class, especially considering the challenges cross-boundary teams often face. The third set of hypotheses to be tested was as follows:

*Hypothesis 5*: Performance of virtual teams improves over time for both cross-boundary virtual teams and within-boundary virtual teams.

*Hypothesis 6*: Within-boundary virtual teams outperform cross-boundary virtual teams over time.

**METHOD**

**Research Design**

The input-process-output framework proposes that team input variables (within or cross-boundary team) together with team process variables (student online participation and number of tasks) affect team performance (individual and team performance scores) separately or through interaction. The primary analysis used multiple \( t \)-test procedures, and the two remaining analyses used two-way analysis of variance procedures (ANOVA). These are described in detail within the analyses and results section. In the method section, we provide details regarding the design, participants, and data collection, including how we defined each variable.

The primary analysis in this experimental design compared the performance of the treatment group (cross-boundary teams) to the control group (within-boundary teams). Per the aforementioned hypotheses, quantitative analysis also explored the effects on team performance over time and over the number of tasks.
A secondary analysis compared team performance of cross-boundary teams and within-boundary teams on each task. It focused on the potential relationship between the number of team project tasks and the team performance and it examined if the two types of virtual teams differed by task. The analysis also examined whether the sequence of tasks has an impact on both types of virtual teams. The secondary analysis compared the two phases of the virtual teams. The Chinese students did not participate until the second phase because their spring semester started six weeks later than the spring semester at the American university. This secondary analysis specifically compared team performance during the first phase without Chinese students’ participation (17 within-boundary teams), to the team performance during the second phase with Chinese students’ participation (Seven cross-boundary teams and 10 within-boundary teams).

**Participants**

American participants included 68 undergraduate students enrolled in a civil engineering synthesis class. The students were primarily sophomores in a college of engineering, and all Americans were native English speakers. Chinese participants included 12 undergraduate students enrolled in a similar civil engineering synthesis course at a Chinese university. Those students were sophomore engineering students, and their native language was Chinese-Mandarin, while English was their second language.

**Procedures**

**Team construction.** The 68 American students were required to sign up on a first-come-first-serve basis to 17, four-person virtual engineering teams organized according to
their interest in one of the specific topics listed by the instructor. Among the 17 teams, in phase two, seven of the teams collaborated with one or two Chinese students (cross-boundary teams). The Chinese students were offered their choice of teams based on their interest in one of the specific topics listed by the instructor. Each formed team finalized their project topic and gave the team a name. Figure 1 illustrates threaded discussion topics and number of postings of the VET 17 virtual teams in the project-base collaboration environment. Note that all teams had access to all other teams’ online collaboration postings.

Figure 1. Team projects with topic names and number of postings

**Student collaboration project design and performance evaluation.** All virtual teams collaborated for 12 weeks to complete the team project, which was to analyze the economics
of a civil engineering project from an international perspective. The student team project was divided into two phases: Phase I (the first six weeks) and Phase II (the last six weeks). Phase I consisted of Task 1 and Task 2, while Phase II consisted of Task 3, 4, and 5, as illustrated in Table 1. The tasks included the following:

- **Task 1**: The team provided a rationale for their chosen topic.
- **Task 2**: The team provided a research outline which identified specifically what they would research in that general topic.
- **Task 3**: The team provided a draft report on their research.
- **Task 4**: The team provided a PowerPoint presentation and made an oral presentation to the class at the American university campus. Although the Chinese students were not present, they were required to help American teammates prepare their slides.
- **Task 5**: The team provided a final written report.

Successful completion of the VET project was worth 100 points. Each task was assigned a different portion of the 100 points according to the complexity of the task in Table 1, and each of the team members were graded individually after the completion of each task based on the quality of the team products and on the individual’s contribution.

### Table 1. The design of virtual engineering student team project

<table>
<thead>
<tr>
<th></th>
<th>Virtual Engineering Teams: Analysis of an International Civil Engineering Project</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I</strong></td>
<td><strong>Phase II</strong></td>
</tr>
<tr>
<td>First 6 Weeks</td>
<td>Last 6 Weeks</td>
</tr>
<tr>
<td>Task 1: (25 points)</td>
<td>Task 2: (20 points)</td>
</tr>
<tr>
<td>Report on Selected</td>
<td>Task 3: (20 points)</td>
</tr>
<tr>
<td>Topic</td>
<td>Project Report Draft</td>
</tr>
<tr>
<td>Task 4: (20 points)</td>
<td>Task 4: (20 points)</td>
</tr>
<tr>
<td>Oral Presentation</td>
<td>Task 5: (45 points)</td>
</tr>
<tr>
<td>Final Report</td>
<td></td>
</tr>
</tbody>
</table>
As an example, among the 17 teams, one of the cross-boundary virtual teams named themselves as “The Best Dam Group” and consisted of four American students and two Chinese students. Their team did an economical analysis on the biggest dam of the world—the Three Gorges Dam on Yangtze River located in southern China. To complete the team project, they developed a research outline, wrote a preliminary report, made an oral presentation, and developed a final report through online collaboration using WebCT tools. The team members communicated through their 111 online threaded discussion posts over the 12 weeks.

Data Collection

The authors collected data through records of WebCT functions. The independent variable was what type of team students belong, whether cross- or within-boundary groups. The dependent variables included performance, online participation data, number of tasks completed, and midpoint group process evaluation.

Performance of cross-boundary and within-boundary teams. Recall that students were given two scores for each task: a group product score and an individual performance score on the task. Only individual performance scores were collected by individuals, and scores were averaged across all completed tasks. Individual performance averages were then contrasted by the type of team to which individuals belonged.

Student online participation data. Online-participation scores were collected by individuals and included participation in all of the three virtual communication areas: (a) team communication space for threaded discussion, (b) team presentation space where teams uploaded their task products, and (c) team feedback space where team members gave other
team task products formative evaluations. Scores were collected per individual as a sum of the number of times each member (a) logged into WebCT (WebCTHit), (b) the number of posts and articles each member read (WebCTRead), and (c) the number of posts each member posted (WebCTPost).

**Number of tasks completed.** This independent variable was defined using the information in Table 1. American students each completed five tasks, and Chinese students completed only three of the five tasks due to their semester starting six weeks later than the American semester. All students who began the course finished the assigned tasks.

**Time.** This independent variable was the first six-weeks (Phase I) contrasted with the last six-weeks (Phase II). The 17 teams all included Americans for the entire 12 weeks; thus, we wanted to compare performance during the first half of the course with performance during the latter half of the course. Research has indicated that activity in virtual teams after the midpoint is often significantly different than during the first half of collaboration. In this research, because of the constraints of the university schedules, the midpoint did overlap with the entrance of the Chinese students. Nonetheless, these students were added to teams that had already existed for six weeks. Thus, time was defined as a comparison between Phase I of the project and Phase II.

**Team subtask score average.** This dependent variable was defined as the average of the subtask team scores the instructor assigned. To be clear, this did not include the scores assigned to individual students on the subtask, but rather the score assigned to the team product for the subtask.
ANALYSIS AND RESULTS

Effect of International Collaboration on Team Performance

Before testing the effect of international collaboration on team performance, it was necessary to know first if students from the two types of teams were different in academic performance in general. If they were not, then it was safe to further analyze the effect of international collaboration on team performance. If academic performances were different, then the differences needed to be taken into consideration together with the international collaboration treatment. A *t*-test was conducted on course grades between students from cross-boundary teams (*n* = 28) and within-boundary teams (*n* = 40). The results indicated that the mean difference was not statistically significant at a .05 level (*t* = -.867, *p* = .389 two-tailed, which exceeds the preset α = .05.see Table 2 for the results summary). That is to say students from both types of teams were not different from each other in academic success. Therefore, it was safe to go further to test the effect of international collaboration on team performance.

Team project scores and team online participation were used as variables. Team online participation was reflected by the number of WebCT logins (WebCTHit), the number of readings in WebCT (WebCTRead), and the number of posts in WebCT (WebCTPost). Figure 2 presents raw data about team project scores, course grades, and participation in WebCT. It indicates that there were performance differences between the two virtual teams. To find if these observed differences were statistically significant, multiple *t*-tests were conducted comparing means for the two groups.
Multiple *t*-tests were conducted on the team project scores and online participation (see Table 2 for the *t*-test results summary). The results indicate that a statistically significant difference at the .05 level existed between cross-boundary teams (*n* = 28) and within-boundary teams (*n* = 40).
boundary teams \((n = 40)\) in team project scores \((t = 2.940, p = .005\) two-tailed). \(T\)-test results also showed that there were statistically significant differences in online participation in WebCTHit, WebCTRRead, and WebCTPost at the .05 level \((t = 2.184, 2.268, 4.950, p = .032, .027\) and \(<.001\), respectively.) The observation and test results indicated that cross-boundary teams outperformed within-boundary teams in team project scores and that cross-boundary teams also outperformed the within-boundary teams in online participation.

**Hypothesis 1:** Within-boundary teams outperform cross-boundary virtual teams in team project scores.

**Results for Hypothesis 1:** Hypothesis 1 was not supported. The results indicated the opposite direction: cross-boundary teams outperformed within-boundary virtual teams in team project scores.

**Hypothesis 2:** Cross-boundary virtual teams outperform within-boundary teams in online participation.

**Results for Hypothesis 2:** Hypothesis 2 was supported. Cross-boundary virtual teams outperformed within-boundary teams in online participation.

In conclusion, when it comes to the effect of international collaboration on team performance, cross-boundary virtual teams outperformed within-boundary teams in both team project performance and in online participation.

**Effect of Number of Tasks and International Collaboration on Team Performance**

To test the effect of the number of tasks and international collaboration on team performance, a team was treated as a unit; therefore, for cross-boundary virtual teams \(n = 7\)
(seven teams), and for within-boundary teams $n = 10$ (10 teams). The team average task scores were used as indicators of team performance. Figure 3 presents raw data concerning team average scores for each task for each team between the two types of teams. It illustrates visually that within-boundary teams showed a linear tendency between the team task scores while cross-boundary teams did not show a linear tendency.

When group task average scores were used for analysis and two groups were put together for comparison purposes, cross-boundary teams outperformed within-boundary teams (see Figure 4). The team performance also decreased over the number of tasks in both groups. However, as these differences are statistical significant, a two-way ANOVA was conducted to answer the question.

Figure 3: Team average task scores by task and by team
There were two independent variables (international collaboration and the number of tasks) and one dependent variable (team task scores) in this set of hypotheses. Because the team performance, not the individual performance, was our interest, each team was treated as one unit. Accordingly, team average task scores were used instead of individual scores. As mentioned above, the time-wise midpoint for the team project was after the team finished Task 2. Therefore, we divided the project into Phase I (first six weeks) and Phase II (last six weeks). Phase I consisted of Task 1 and Task 2, while Phase II consisted of Task 3, 4, and 5. Accordingly, during the 12-week collaboration, cross-boundary teams did not collaborate with their international peers until the beginning of Task 3. At that point, a new indicator, IntCollaborate, referring to international collaboration, was introduced. For IntCollaborate, a 1 indicated that there were international collaboration efforts, and 0 indicated a lack of collaboration efforts, as illustrated in Table 3.

Figure 4: Group average task scores by task
Table 3. The occurrence of international collaboration with phase and type of team

<table>
<thead>
<tr>
<th></th>
<th>Number of Teams</th>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Task1</td>
<td>Task2</td>
</tr>
<tr>
<td>Cross-boundary teams</td>
<td>7</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Within-boundary teams</td>
<td>10</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

To test the effect of international collaboration and the number of tasks on team performance, a linear model for two-way ANOVA was estimated. A linear model for two-way ANOVA is the expression that represents an individual score as additive components that are associated with the main effects, the interaction effect, and random error (Hinkle, Wiersma & Jurs, 1998). This linear model for two-way ANOVA presented individual team task scores in the VET project as additive components. The components were associated with three parts: the main effects (µ as grand mean of the population, Taski as the effect of being in a particular task, and IntCollaborationj as the effect of having international collaboration elements); the interaction effect (presented as Taski * IntCollaborationj, the interaction in a particular task and with/without international collaboration); and the random error (presented as eijk, the random error associated with this score belongs to kth team). Therefore, an average team task score for a team on a task in this study was expressed through the following model:

\[ X_{ijk} = \mu + \text{Task}_i + \text{IntCollaboration}_j + \text{Task}_i \times \text{IntCollaboration}_j + e_{ijk} \]

where:

- \( X_{ijk} \) = score of the kth team in the ith task and with jth international collaboration effect.
• \( \mu \) = grand mean of the population.
• Task\(_i\) = the effect of being in a particular task.
• IntCollaboration\(_j\) = the effect of having international collaboration elements.
  
  \((j=1 \text{ if it does; } j=0 \text{ if it does not.})\)
• Task\(_i\) * IntCollaboration\(_j\) = interaction of being in a particular task and with/without international collaboration.
• \( e_{ijk} \) = random error associated with this score belonging to the kth team.

The statistical software SPSS was used to perform the two-way ANOVA. The results are shown in Table 4. Where \( n = 7 \) cross-boundary teams and \( n = 10 \) within-boundary teams, the \( F \)-ratio for task effect = 12.450, and \( p = < .001 \) (two-tailed), the results indicated that the number of tasks had a statistically significant effect on team performance. With \( F \)-ratio for IntCollaborate effect = 3.010 and \( p = .088 \) (one-tail, which does not exceed the preset one-tail \( p \) value of .10, but it was close), it can be concluded that international collaboration has a marginal statistically significant effect on team performance.

**Table 4. Two-way ANOVA results on number of tasks and international collaboration**

<table>
<thead>
<tr>
<th>Source</th>
<th>Numerator d1</th>
<th>Denominator df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>20.504</td>
<td>8242.364</td>
<td>.000</td>
</tr>
<tr>
<td>Task</td>
<td>4</td>
<td>66.564</td>
<td>12.458</td>
<td>.000</td>
</tr>
<tr>
<td>IndCollaborate</td>
<td>1</td>
<td>62.921</td>
<td>3.010</td>
<td>.088</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Score.
Hypothesis 3: Performance of virtual teams improves with the number of tasks for both cross-boundary and within-boundary virtual teams.

Results for Hypothesis 3: Hypothesis 3 was not supported. The results indicated the opposite: performance of virtual teams decreased with the number of tasks for both cross-boundary and within-boundary virtual teams.

Hypothesis 4: Within-boundary virtual teams outperform cross-boundary virtual teams in number of tasks.

Results for Hypothesis 4: We should be cautious in concluding that Hypothesis 4 was not supported. The analysis indicated a marginally statistically significant tendency for cross-boundary virtual teams to outperform within-boundary teams with the number of tasks.

From the above two-way ANOVA tests, it can be concluded that the number of tasks had a statistically significant effect on team performance, and that there is limited evident that international collaboration had an effect on team performance.

Effect of Time and International Collaboration on Team Performance

To test the effect of time and international collaboration on team performance, a team again was treated as one unit (n = 7 for cross-boundary teams, n = 10 for within-boundary teams). The teams’ average task scores were used as the dependent variables. Figure 5 shows that both types of team performance decreased from Phase I to Phase II. It also shows that there were team performance differences between the two types of virtual teams during the two phases. However, as these differences were statistically significant, a two-way ANOVA was conducted.
An average team score for a team for a phase can be expressed through the following model:

\[ X_{ijk} = \mu + \text{Phase}_i + \text{IntCollaboration}_j + \text{Phase}_i \times \text{IntCollaboration}_j + e_{ijk} \]

where:

- \( X_{ijk} \) = score of the kth team in the ith phase and with jth international collaboration effect.

**Figure 5:** Cross-boundary and within-boundary teams team performance for phase I and phase II
• $\mu$ = grand mean of the population.

• Phase$_i$ = the effect of being in a particular phase. In this study, it refers to Phase I or Phase II.

• IntCollaboration$_j$ = the effect of having international Collaboration elements. $j=1$ if it does; $j=0$ if it does not.

• Phase$_i$ * IntCollaboration$_j$ = interaction of being in a particular phase and with/without international collaboration.

• $e_{ijk}$ = random error associated with this score belong to kth team.

The software SPSS was used to perform the two-way ANOVA for Hypothesis 5 and Hypothesis 6, and the results of the analysis are shown in Table 5. At the .05 level, with $F$-ratio for Phase (time) effect = 53.312, $p = <.001$, the results indicated that time had a statistically significant effect on team performance. With $F$-ratio for IntCollaborate effect = 2.725, $p = .112$ (which exceeds the preset $\alpha = .05$), it can be concluded that international collaboration did not have a statistically significant effect on team performance over time.

<table>
<thead>
<tr>
<th>Source</th>
<th>Numerator df</th>
<th>Denominator df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>24.942</td>
<td>3097.148</td>
<td>.000</td>
</tr>
<tr>
<td>Phase</td>
<td>4</td>
<td>17.830</td>
<td>53.312</td>
<td>.000</td>
</tr>
<tr>
<td>IndCollaborate</td>
<td>1</td>
<td>23.675</td>
<td>2.725</td>
<td>.112</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Score.

*Hypothesis 5*: Performance of virtual teams improves over time for both cross-boundary virtual teams and within-boundary virtual teams.
Results for Hypothesis 5: Hypothesis 5 was not supported. The analysis results indicate the opposite: performance of virtual teams decreased over time for both cross-boundary virtual teams and within-boundary virtual teams.

Hypothesis 6: Within-boundary virtual teams outperform cross-boundary virtual teams over time.

Results for Hypothesis 6: Hypothesis 6 was not supported. The analysis indicated that within-boundary virtual teams did not outperform cross-boundary virtual teams over time.

Conclusions about effect of time and international collaboration on team performance can be drawn: time had a statistically significant effect on team performance, while international collaboration had a limited effect on team performance.

DISCUSSION

This study tested six hypotheses grouped into three main ideas through a field experiment employing a two-group design with 17 virtual teams. In summary, the main findings indicate a) that international collaboration had a marginal statistically significant positive effect on virtual team performance and b) that time and the number of tasks had a statistically significant negative effect on virtual team performance. Surprisingly, in terms of the first two findings, the third finding is that c) the cross-boundary virtual teams still statistically significantly outperformed within-boundary virtual teams in overall team performance even after taking into account the overall negative impact of time and the number of tasks completed on overall team performance. In other words, while all team performance unexpectedly decreased over time and number of tasks, it was also a surprise
that the cross-boundary teams consistently outperformed the within-boundary teams. Both of these findings are counter to previous reported research and indicate compelling evidence that cross-boundary global virtual teams can enhance team performance.

One possible explanation of this result is that the diversity of a cross-boundary virtual group supported effective team performance. Therefore, future research should explore what features of cross-boundary teams enable successful online collaboration. For example, one finding consistent with the literature was that cross-boundary teams outperformed within-boundary teams in online participation. However, this conclusion has to be taken with caution. Cross-boundary virtual teams must depend on WebCT online participation and presentation tools to perform. In contrast, within-boundary virtual teams can use other tools such as a telephone or even face-to-face meetings (though this was strongly discouraged by the instructor) for communication purposes. The difference in communication tools available to within- and cross- boundary teams may have skewed the results, and analyses of future semesters of the VET project are needed.

While analysis of future semesters of the featured engineering course, and indeed other online courses, are necessary to explicate which features of cross-boundary global virtual teams are productive for group team performance, we are currently conducting a follow-up qualitative examination of this study’s semester of VET teams’ online participation. We can share two preliminary findings. First, cross-boundary teams appeared to collaborate more on content related issues than within-boundary teams. For example, cross-boundary groups spent significant amounts of online space discussing the engineering content of the course, including attachments with diagrams of their understanding of engineering concepts, and asynchronous online discussions took place about how these
different ideas impacted their task products. Second, cross-boundary teams appeared to negotiate interpersonal differences more than within-boundary teams. For example, when two female Chinese students worked online with four American men in a virtual team, they addressed cross-boundary issues. The following online posting is an example of their efforts to cross the culture and language boundary in their collaboration:

American Man: “Tell me about yourself, man. How old are you, what kinds of things do you like to do, etc.?”
Chinese Woman: “I am a girl. I like drawing, so I chose Civil Engineering. Am I like a boy? Hah~”
American Man: “dui bu qi (Sorry in Chinese). I kind of used the word “man” without even thinking about it…I don’t think you are boyish.”

Most of the Chinese Students came to America after the project was over and spent a considerable amount of time socializing with their team members, including the student who said “Tell me about yourself, man.”

The quantitative and qualitative findings reported here are influencing the redesign of the VET project course for Spring 2007 semester. For example, even though this study is organized into a task, how the members collaborated is not a focus of this study. A more organized collaborative group structure for virtual collaboration mandated by the course instructor could enable systematic study of the collaborative roles across the two types of teams. In addition, pedagogically each of the groups would likely benefit from these defined roles, as has been found in prior research. Thus, the outcome measures would be more reflective of both the teams’ capability and their virtual group collaboration process.

Another finding that also requires consideration in qualitative study is that time and the number of tasks had a significant effect on all of the virtual teams’ performance. Previous studies (e.g. Blomquist et al., 2005; Gersick, 1998) concluded that team performance
improves over time and with an increase in the number of tasks. Upon closer follow-up examination of the previous studies’ task descriptions and requirements, the first author found that the complexity of tasks increased with the number of tasks. This finding might put the hypotheses tests on time verses team performance and number of tasks verses team performance into question. However, it is common with a student project that the task complexity increases over the number of tasks. Thus, in future research, one might take task complexity into consideration when examining team performance.

Indeed, one can derive several suggestions for future research from the limitations of the present study. Some researchers (e.g. Piccoli et al., 2004) have argued that the realism and generalizability of an experiment using students is constrained. One of the criticisms of using students as a means to examine teams over time is the predominant reliance on zero-history teams as well as the limited duration of the experiences. Not having enough time for virtual teams to develop team cohesion, trust, and team coordination mechanism is one shortcoming of short-lived virtual teams that researchers have observed. If allowed, more time for the virtual teams to collaborate might reveal more significant differences where time effect on team performance is concerned.

Another limitation of this study is the number of participants. Although there were 80 participants, in the analysis of effect of time and number of tasks on team performance, a team was treated as one unit. Therefore, the subject number was reduced to 17 (17 teams), which made it difficult to find differences to be statistically significant between the two types of teams. A subject size of 30 is normally expected in a quantitative study. This is a common problem when studying global virtual teams. In 2007, the author conducted a study reviewing 13 years of publications on global virtual teams, and she found that among the 20 empirical
studies, the majority (65%) work with 30 teams or under. This might be partially due to the difficulty in coordinating large-scale research projects in global virtual settings.

In conclusion, this study contributed to the literature on virtual teams in several ways. First, it extended research on virtual team collaboration across nations and identified the concept of boundaries as a means for advancing theoretical perspectives on virtual teams. Second, it was one of the first studies in the literature to compare and contrast virtual teams in two different settings: cross-boundary versus within-boundary. Finally, this study provided a foundation for future research of the elements that affect virtual team performance in a global education environment.

Acknowledgements

Special thanks to Dr. Niki Davis and Dr. Mack Shelly from the Iowa State University College of Human Sciences, and to Kun Liang, doctoral student from Iowa State University statistics department for their tremendous support and great patience. Professor Davis continued her support after relocating to the University of Canterbury in New Zealand in April 2008. Thanks to the civil engineering class instructor, Marlee Walton, and the VET project participants from China and from America. Last but not the least, thanks to students and faculty from Lanzhou Jiaotong University, Lanzhou, China for their enthusiastic participating and support. This study was financially supported by Iowa State University Department of Curriculum & Instruction tuition scholarship and a graduate assistantship from Iowa State University Extension.
References


CHAPTER 4. A MULTI-PERSPECTIVE ANALYSIS CASE STUDY ON BOUNDARY ISSUES IN STUDENT GLOBAL VIRTUAL TEAMS IN HIGHER EDUCATION

A paper to be submitted to *Educational Technology Research and Development*

Wenxia Wu

**Abstract**

Thoughtful pedagogical uses of global virtual teams in higher education require good understanding of this complex and situated form of collaborative learning. In this study, the author proposes the adoption of the conceptual framework of “boundary” to capture the essential characteristics of global virtual teams in higher education and to evaluate its impact on student collaborative learning. In this study, the author attempts to develop better understanding of what boundary issues are present and what their impact is on teamwork in the context of international engineering education. In order to do so, the author employed a case study design to perform multi-perspective analysis on a group of student global virtual teams that collaborated through distance over five engineering tasks. The multiple perspectives include that of individual students, student virtual teams, and the course instructor and instructional designer. As a result, the current study identifies boundary issues that have been found present among student virtual teams and factors that had attributed to the existence of each boundary. The findings indicate that boundary issues not only were
present individually and concurrently, but also interacted among one another to impact team collaborative learning. The findings suggest future research directions to investigate factors that bridge the boundaries to maximize the benefits of global virtual teams. This paper also offers recommendations on team set up and team project design for practitioners to enhance collaborative learning practice in higher education.

Introduction

When Watson-Manheim, Chudoba, and Crowston carried out a literature review on virtual work in 2002, the number of research articles retrieved from ABI Inform database using the search term of "global team" was zero. In the year 2009, global virtual teams have grown to become a vital mechanism for decision making, product development, and strategic management in the workplace. A quick search using the same term of "global team" in early 2009 in the Business Source Elite database yielded 49 research articles. The popularity of global virtual teams in industry, especially in software engineering and in products development, may have inspired more researchers to study this phenomenon.

Previous research on traditional teams laid a foundation and provided a starting point for studying global virtual teams. For the past few decades, researchers have highlighted the

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importance of collaboration/cooperation in collocated teams and have examined this collaboration from various aspects. After a review of previous studies, Gersick (1988) concluded that there have been two main trends of research and theory about teamwork. The first trend deals with team dynamics during different team development stages with a focus on the psychosocial and emotional aspects of team life. For instance, Tuckman (1965, 1977) synthesized this literature in a sequential model of team development that is frequently cited today. The second trend is about the team decision making process or problem solving process with a focus on the sequences of activities through which teams reach decisions. A frequently quoted study in this tradition is Bales and Strodtbeck’s (1951) three-step model of team’s movement toward decisions: orientation, evaluation and control.

When it comes to virtual teams with members located within one country, the life circle of a virtual team might differ from that of collocated teams due to the fact that geographically dispersed teams mainly rely on technology to communicate among team members. Powell, Piccoli, and Ives (2004) reviewed 43 research articles on virtual teams and described the life circle of a virtual team as having four general categories: inputs, socio-emotional processes, task processes, and output. Team inputs represent the design and composition characteristics of the virtual teams, while research on team outputs focuses on the team performance or effectiveness. Research on the team socio-emotional process is concerned with relationship building, specifically on team cohesion and trust. Team task processes represent the processes that occur as team member work together to accomplish a task or goal.

Using teamwork has been a long tradition in education, and research has shown that collaborative learning helps students attain higher levels of cognitive thinking, motivation,
and interest than they attain by learning in more individual settings (Johnson, Johnson & Smith, 1998; Solem et al., 2003). In his book of *Cooperative Learning: Integrating Theory and Practice*, Gilies (2007) discussed various aspects of using teamwork to enhance learning. He concluded that students benefit academically and socially from cooperative learning associated with teamwork. Academic benefits include higher attainments in reading comprehension, enhanced conceptual understanding, and increased achievement in science. Social benefits include more on-task behaviors, higher self-esteem, and improved attitudes towards learning.

Teamwork activities in education often involve project-based learning. Project-based learning involves students in the identifications of a project and the generation of activities and products designed to meet the project goal (Blumenfeld et al., 1991). Accordingly, the center of a project-based learning environment is the project or problem that learners attempt to accomplish or solve (Jonassen, 2000; Dabbagh, Jonassen, Yueh, & Samouilova, 2000; Savery & Duffy, 1995). In geographically dispersed virtual teams, distributed project-based learning is emerging as an interactive online learning method. Scripture (2008) made ten recommendations for designing distributed project-based learning activities. In addition, Rooij and Williams (2009) suggested processes and procedures based on best practice from the angle of project management to scaffold such a learning experience.

While previous researches on collocated and virtual teams provide valuable contributions to the understanding of teamwork, the unique characteristics of global virtual teams require additional and specialized research. Global virtual teams are defined as “temporary, culturally diverse, geographically dispersed, electronically communicating work-group of members…who think and act in concert within the diversity of the global
environment” (Jarvenpaa, Knoll, & Leidner, 1999). There are three essential characteristics associated with global virtual teams. First, the teams are “global” because their members are located in different parts of the world. Second, the teams are “virtual” because team members use technology-supported communication substantially more than face-to-face communication. Third, the teams are “teams” because they are identified by their organization(s) and members as a work group who is responsible for making and/or implementing decisions.

In education, there is an increasing need for higher education to take advantage of the virtual form of global collaboration to prepare students for the future global workplace. A second goal of using student global virtual teams is the acquisition of intercultural competence, which is the capacity to change one's knowledge, attitudes, and behaviors so as to be open and flexible to other cultures (Davis & Cho, 2005). The advancement of instruction and communication technology in higher education has paved the way for global collaboration practices. Since student global virtual teams offer the aforementioned benefits, educators started to implement such teams in higher education classrooms. For example, a group of geography educators (Solem et al., 2003) formed 166 global virtual teams among four institutions in the United States, Canada, and Australia in their undergraduate geography education class. The student participants did not find that language and culture hindered their teamwork, but instead listed time differences and scheduling difficulty as the major problems. Another group of researchers (Jarvenpaa, Shaw, & Staples, 2004) carried out two studies on student global virtual teams. The first study consisted of 94 students from 11 universities in eight countries who worked in 16 teams, and the second study consisted of 150 students from 13 counties who collaborated in 26 teams. The studies examined the
emergence of an individual’s trust and the consequences of trust among multination virtual team members and concluded that trust affected virtual teams at different stages of team development. Researchers have also made recommendations on strategies to build and support student team collaboration in the virtual classroom (i.e., Hasler-Waters & Wallace, 2002). In the field of engineering education, international engineering education is considered a key to empowering engineers and engineering graduates to be competitive and collaborative in a global work environment.

Despite the fact that global virtual teams are frequently employed in industry and are also growing in use in classrooms to enhance teaching and learning, the current literature has not yet identified the special characteristics associated with the context of higher education. More studies are needed to systematically examine the complex pedagogical issues of computer-supported collaborative learning, particularly in the context of cross-cultural education at the global level (Solem et al., 2003). In-depth knowledge of the characteristics and impacts of such teams needs to precede meaningful improvements of educational strategies.

In order to do so, the author proposes adopting the concept of “boundary” (Espinosa, Cummings, Wilson, & Pearce, 2003) to define and evaluate the IT-enhanced international collaboration context in which global virtual teams have taken place. Previous studies have identified six boundaries in the work context of global virtual teams: organizational, temporal, technological, cultural, functional, and geographic boundaries. Researchers have made efforts to identify factors that had contributed to the existence of each boundary, pointed out variables to measure each boundary, and discussed the potential or observed impact each boundary has had on team collaboration.
On one hand, boundaries in global virtual teams introduce discontinuity in the workflow of the team; on the other hand, some factors or strategies leading to continuities simultaneously emerge addressing these discontinuities. Discontinuity can be described as a gap, incoherence, edge, or other dividing characteristic present in the work setting of a virtual team (Espinosa, et al., 2003) and relationship with team members (Watson-Manheim et al., 2002). Discontinuity is introduced to the work context of global virtual teams by different boundary issues. Organizational boundary is characterized by discontinuity in the organizational structure, administrative philosophy, and organizational affiliation among team members. Temporal boundary is characterized by discontinuity in time zones, work shifts, schedules, working rhythms, and time vision (i.e., team member’s perception of time). Technological boundary is characterized by discontinuity in technology infrastructure, technology usage and choice, attitudes towards technology, and technology proficiency. Cultural boundary is characterized by discontinuity in national and ethical cultural backgrounds, and socio-psychological cultures among member members. Functional boundary is characterized by discontinuity in expertise and functionality. Geographic boundary is characterized by discontinuity in physical locations of team members. The discontinuity aspect of boundaries creates divisions in the coherence of a work environment of a virtual team; as a consequence, challenges arise in which team members must collaborate over these divides. For example, since discontinuity in time reduces the possibility for virtual members to use synchronous communication, some researchers consider discontinuity in time as the primary challenge to team collaborations. Indeed, in one study 265 student participants in global virtual teamwork reported that scheduling difficulty was their number one concern (Solem, et al., 2003). Other researchers have also found that
time discontinuity could be problematic because it could cause delays, duplication of work, and confusion in communication (Espinosa & Carmel, 2003).

In higher education, this author predicts that the existence of boundary issues creates discontinuity in student global virtual teams. Researchers have noticed an epistemological learning divide between students from the Eastern higher institutions and from those in the West (e.g., Hung & Chen, 2003). They noticed a widening divide between newer approaches (e.g., active learning) and traditional ones (e.g., didactic lectures) because of the distinctive learning epistemologies that exist in different educational systems. For example, survey data on a group of Chinese college students revealed that 94% of them agreed with the statement that “you rely on teachers to tell you what is important for you to learn” (Wu, 2005).

While close to half of the available 49 empirical studies on teamwork used college students as participants, no research has specifically investigated technological discontinuity in higher education. The author predicted that technological incoherence in higher education likely would come from different accesses to technology among students. For example, the students in the United States might have more access to computers and the Internet than students in inland cities of China. A study that surveyed a group of Chinese students who signed up to participate in an American online learning class found that 40% of Chinese students did not have a computer at home or in their dorm (Wu, 2005). Hung and Chen (2003) used the term “digital divide” among learners to describe differing access to technology, and their concern was that those with access to technology might have more advantages than those who don’t.

This author predicted that another factor that contributes to the discontinuity in technology might be different media choices in higher education institutions. On one hand,
new developments in various learning management systems (LMS), such as Moodle, Blackboard, and Design2Learn, provide choices for higher education institutions to suit their needs; on the other hand, the variety of practice might create a boundary among team members whose universities adopted different LMS.

When it comes to culture, the author predicted discontinuity in culture in student global virtual teams. With participants from the United States and China, the current study focuses on the individualism-collectivism dimension because it has been used previously to compare cultures from the two countries (e.g., Earley, 1993; Hung & Chen, 2003). More details about participants in this study will be provided in the Methodology section. Collectivists emphasize shared values, similarities, and commonalities among team members while individualists pay attention to differences among team members (Sosik & Jung, 2002). As individualists values personal goals, initiatives, autonomy, and privacy (Sosik & Jung, 2002), they have been found to be less cooperative than collectivists in group settings (Chen, Chen & Meindl, 1998; Hardin, Fuller, & Davison, 2007); at the same time, individualists tend to encourage and value different perspectives and expertise that team members bring to the group (Sosik & Jung, 2002). In contrast, collectivist societies emphasize the importance of group goals and objectives over individual preferences, and, therefore, they have been found to be more cooperative in a team. However, at the same time, collectivist societies also try to forge a consensus by covering up differences (Hardin et al., 2007). Consequently, the author predicted the student team members in the current study would demonstrate different teamwork skills because of their cultural backgrounds.
Economides (2008) addressed the importance of setting up a collaborative learning environment to suit learners’ different cultural profiles. These learners’ profiles may more or less fit into the cultural dimensions; however, a learner may not belong strictly to one extreme of a cultural dimension (e.g., individualism-collectivism dimension). Instead, he/she may have characteristics from both cultural extremes of each dimension. Therefore, in the current study, the author predicted that with the trends of globalization and with the new cultural characters emerging with the younger generations, student team members might not strictly belong to either a individualistic group or collectivistic group; rather, they might demonstrate characters from both cultural extremes of the dimension.

In addition, besides different cultural backgrounds that students bring to the classroom, there emerges a new generation and its culture needs to be further explored: the digital natives and their culture. Digital natives are young people who grew up with technology such as computers, the Internet, and multi-media (Prensky, 2001; Bennett, Maton, & Kervin, 2008). Prensky reported that new media and technology has intrinsically changed the way how digital natives think, learn, and react. The challenges facing educators is to identify teaching strategies appropriate for digital natives, recognize their differences in processing information, and develop tools to maximize the potential of their unique cognitive style.

When analyzing the discontinuity side of boundary, it became apparent that many previous studies investigating global virtual teams were simultaneously addressing existing or emerging continuities. Continuity is described as “factors or strategies for bridging the discontinuities” (Watson-Manheim et al., 2002). Previous researchers have made recommendations about strategies to address discontinuity associated with one or more
boundary. For example, Espinosa and Pickering (2006) recommended coordination processes and mechanisms to cope with time separation, and Pauleen and Yoong (2001) recommended steps to facilitate the awareness and adjustment in relationship-building among team members.

In addition, after reviewing 66 articles on global virtual teams published over the past 13 years, the author concluded that continuity is also part of the nature of some boundaries as is discontinuity. For example, on one hand, technological boundary creates discontinuity in technology usage and choice, and in technology proficiency; on the other hand, asynchronous technology (e.g., online bulletin board, emails) helps to bridge the discontinuity in time zones. Technology high in social presence was also found to help in bridging geographic discontinuity (Robert & Dennis, 2005; Walther, Slovacek, & Tidwell, 2001). The social presence theory argues that media differ in the ability to convey the psychological perception that other people are physically present. Some media have greater social presence (e.g., videoconferencing) than other media (e.g., email). Therefore, the social presence of virtual team members who used richer media might be higher than that of members who used lean media. Consequently, technology high in social presence helps the virtual team members to develop a sense of being physically together over distance.

Surfacing the continuity side of boundary issues helps practitioners identify factors and strategies that help teams coordinate in a virtual environment that spans several boundaries. Surfacing the continuity side of boundary issues also helps researchers grasp the nature of boundary issues and measure the impact of both continuity and discontinuity on team collaboration.
This author seeks better understanding of global virtual teams, especially when they are adopted in higher education to prepare students for the global workplace. The study investigates the working context of such teams in higher education – the technology-supported, project-based, collaborative learning environment at the global level. To be specific, the author aims to illustrate layers of boundary issues present in student global virtual teams and to illustrate how these issues impact student collaborative learning in a team setting individually and through interaction with one another. In order to do so, a case study design is used to perform a multi-perspective analysis of the boundary issues in global virtual teams in higher education. Engineering students in the United States and students in China were put in a project-based, technology-enhanced global learning environment. Over five weeks, students worked in teams to collaborate on five engineering tasks, which led to the completion of their team project. Data were collected through 845 student online posts during the collaboration phrase and through focus group interviews. Interviews were also carried out with the course instructor and the course instructional designer to include additional perspectives. This article first maps out the research method that was used to perform a multiple perspective case study. It then reports on findings of the presence of boundary issues and their impact on student collaborative learning. Last it discusses the implementations and makes recommendations for future research.

**Methodology**

**Research Questions and Design**

The general research question in the current study is how the global virtual team experience impacts student collaborative learning in a project-based, technology-supported,
international teamwork environment. It investigates the components of the international collaboration context of global virtual teams in higher education, and it adopts the concept of “boundary” to identify these components and to evaluate their impact on team learning. This study investigates layers of boundary issues present in student global virtual teams and the impact of these issues on student collaborative learning. To be specific, the research aims to answer the following questions:

- What boundaries are present in student global virtual teams?
- How do boundaries impact student collaborative learning in a team and individually?
- How do boundaries impact student collaborative learning in a team through interaction?

It is the author’s hope that by answering these questions, a better understanding will be developed about student teamwork in a collaborative global e-learning environment. Therefore, the current study will join the efforts to usher in a new wave of possibilities in educational advancement with the pavement of recent advances in e-learning technology, coupled with the growth of distance education.

This study employed a case study design to perform multi-perspective analysis (Tellis, 1997) of the boundary issues in global virtual teams in higher education. Engineering students were provided with project-based learning activities through which they collaborated with their international counterparts as teams at a distance. Case study is appropriate for this study because the context of the study and the phenomenon under study were intricately woven together and also because multiple personnel played different roles in
the context. Those perspectives from the personnel involved provide different angles to help understand the research questions.

**Study context**

Globalization of the workplace makes international education important to empower college graduates to be competitive and collaborative. A mid-west public university in the United States is conducting a five-year multi-faceted dual degree program in engineering collaborating with a public university located in northwestern China. One key element of this program is to create opportunities for students to work in real and virtual global engineering settings. The Virtual Engineering Teams (VET) project was designed to fulfill this goal.

Using the VET project to study global virtual teams is both representative and purposeful. The VET project was set in a global cross-boundary virtual environment in the sense that it utilized e-learning technology to bring together engineering students from the East and the West over distance to work as a team on student engineering projects. The VET project offered students opportunity to reach beyond traditional boundaries. A frequently quoted framework provided by Espinosa and colleagues (2003) identified these boundaries as a geographic boundary, a functional boundary, a temporal boundary, an identity boundary, an identity boundary,

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and an organizational boundary. Kock and Nosek (2005) identified the boundaries as technology, culture, space, and time.

Similar to global virtual teams in international companies, which are composed of team members in different countries, student team members in the VET project were located in the Eastern and Western hemispheres. Accordingly, the author anticipated that the VET project virtual teams would also encounter multiple boundaries, such as geographic, temporal, cultural, and language, as identified by researchers in global virtual teams in industry. Since student team members were from different ideology systems, the author also anticipated that the VET project virtual teams would encounter organizational boundary as well. These factors, therefore, makes the VET project a representative and rich case for studying boundary issues in student global virtual teams.

**Participants**

Forty-four students in a civil engineering class offered in spring of 2007 who completed the VET project were participants in the current study. Among them, 28 were U.S. students and 16 were Chinese students at the Chinese university. The majority were sophomore students with a declared major of civil engineering. The participants also included the course instructor and the author as the course instructional designer. The course instructor is a professor in environmental engineering who was raised and educated in the United States with extensive professional experiences in Europe, the Middle East, and China. The instructional designer is Chinese, who was raised in China and educated in both China and the United States. Her professional experiences include international academic program coordination with a focus on distance education, and she is also the researcher and author of
this paper. These participants provided multiple perspectives for the case study from the views of students, the course instructor, and the course instructional designer.

**Procedures**

The Civil Engineering Synthesis course required students to synthesize different aspects of civil engineering-associated knowledge, such as construction, geotechnical, and structure, to work on comprehensive civil engineering projects. Another goal of the course was to bring an international touch to the class, which previously focused only on Midwest U.S. civil engineering projects. In order to achieve these goals, the instructor and the instructional designer initiated the VET project to have students work in teams to complete one project: a critique of an existing civil engineering structure from economic and environment engineering points of view.

For five weeks during the spring of 2007, students worked in nine virtual teams. Each team had four to six members, with three students in the United States and one or two students in China. The nine teams collaborated over a distance on five tasks that were required to complete the team project:

- *Task 1*: The team chose a specific civil engineering topic from a list provided by the instructor, named their team according to the topic they chose, and provided a rationale for the chosen topic.
- *Task 2*: The team provided a team project outline for the chosen topic, which identified specifically what they would research within that general topic.
- *Task 3*: The team provided PowerPoint slides summarizing their research.
- **Task 4**: The team presented its project to the whole class through an interactive video-audio system.

- **Task 5**: The team submitted a final written report.

An online collaboration space was set up to facilitate the global virtual team collaboration using the course management system WebCT. Student teams were instructed to use this online space for communication and for sharing sub-reports and sub-products among team members.

The course instructor and the course instructional designer co-designed the course and the team project. A team building section was carried out to introduce students to virtual teamwork and to the WebCT tools. The instructor and the instructional designer facilitated the team collaboration process in complementary ways: the instructor monitored the discussion content and ensured the quality of the team task products, while the instructional designer facilitated the technology use of the virtual space as well as the team collaboration process.

**Instruments**

A distinctive characteristic of the current case study is that the primary instrument for data collection and for data analysis was the researcher herself. It is, therefore, of paramount importance to articulate the researcher’s role in the context of the study and the data collection process. It is also important to make explicit the researcher’s background and assumptions that she brought to the project (Esterberg, 2002).

The author had multiple roles to play in the current study: course instructional designer, cultural ambassador, and participatory researcher. Working as the instructional
designer for the VET project, the author collaborated with the course instructor to build a space for student teams to work within. Employing WebCT course management software, the VET project space was designed to be a project-based, technology-enhanced virtual learning environment. Both the author and the course instructor hoped that through the process of design, implementation, and reflection in the VET project, the VET teaching team would develop better understanding of global virtual collaboration environment.

As the author was raised and educated in China and later pursued her advanced degree in the United States, her personal experiences in both cultures and educational systems made her a cultural ambassador for the VET project. Bringing with her an intercultural perspective on education, the author helped students from both countries to raise their awareness and understanding of the variety and relevance of both cultures, which is a key component of students’ intercultural competence (Davis & Cho, 2005). This perspective also helped the author to be able to interpret boundary issues from an international point of view when analyzing and writing the present study.

As a participatory researcher, the author did not isolate herself from the participants as a neutral, disinterested observer; instead, she was the primary instrument for data collection and data analysis. Since developing better understanding of the impact of boundary issues on student collaborative learning is the focus of the current study, the human instrument, which is able to be immediately responsive and adaptive, would seem to be a reasonable means of collection and analyzing data (Merriam, 2002). Other advantages of being a participant researcher included working closely with participants during the entire process. The author was able to expand her understanding through verbal as well as nonverbal communications, process data immediately, clarify and summarize material, check
with participants for accuracy of interpretation, and explore unusual or unanticipated responses during the data collection process.

Nevertheless, the author is also aware that a researcher serving as the primary instrument for data collection and for data analysis has limitations. As a participatory researcher as well as the course instructional designer, the author was part of the study and part of the student virtual team collaboration process. Therefore, there is a possibility that participant bias might occur. The strategies that the author adapted to address the possible participant bias included taking the insider-outsider position, which will be discussed in more details in a later part of the section.

**Data collection and analysis**

In order to embrace a multi-perspective analysis in the current study, the sequence of data collection events included a variety of sources: 1) student team online threaded discussion posts, 2) a student focus group discussion, 3) individual interview with the course instructor, 4) individual interview with the course instructional designer, and 5) archived reflection journals of the researcher. The first four sets of data served as the primary resources and the reflection journals were used to verify ancillary events relating to the course design and research process.

The data collection process and data analysis process were not two separate procedures; instead, the two processes informed each other to help shape the next steps in the research. The sequenced data collection and data analysis procedure is illustrated in Figure 1.
Figure 1. Time frame of student global virtual teams project tasks, data collection, and data analysis

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<td>Interview to Course Instructor</td>
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**Step 0: Preparation**

Students signed up for nine virtual teams and chose their team project topic. The author set up the course WebCT space for students to collaboration within. She also set up the threaded bulletin board in WebCT to record team posts to gather data.

**Step 1: Data collection -- student global virtual teams’ online threaded discussion posts**

Each student virtual team had their own threaded discussion space within WebCT, and student teams mainly relied on it for communication purpose. A total of 845 posts in March and April of 2007 during the virtual team collaboration were documented. Some teams used chat rooms outside of WebCT for communication and in most cases minutes from the chats were posted in the WebCT team discussion space.

**Step 2: Data analysis**
At the end of the eighth week when students had completed their team projects, the data gathered through teams’ online threaded discussion posts was analyzed for two purposes: 1) to identify if boundary issues were present as were reflected in the team posts, and if there were, then 2) to identify what boundary issues were present in teams. The data analysis procedures at this point followed the planned sequence of elicitation, reduction, selection, coding, clustering, and visualization, as proposed by Roano, Donovan, Chen and Nunamaker (2003) for analyzing Web-based qualitative data.

As a result of preliminary data analysis at this stage, boundary issues and associated sub-categories were identified for further discussions, and two virtual teams were identified for further investigation for focus group sessions. This round of data analysis also helped the author to construct questions for the focus group sessions and for the individual interviews with the course instructor and with the instructional designer. The selection of the two teams for the focus group discussions was purposive and theoretical (Miles & Huberman, 1994) in the sense that in qualitative research, “choices of informants, episodes, and interactions [were] driven by a conceptual question, not by a concern for ‘representativeness’ (p. 53)”.

The two teams were chosen because the majority of the themes identified were present in the two team posts and because there was evidence in their team posts that multiple boundary issues interacted among one another in the two teams. In addition, these two teams were chosen because they distinguished themselves from rest of the teams by having different solutions from other teams when they encountered interactions among boundary issues. Therefore, the author anticipated that their focus group discussions would be more likely to contribute to the second research question of “how boundaries impact student collaborative
learning in a team individually” and answer the third research question of “how boundaries impact student collaborative learning in a team through interaction.”

**Step 3: Data Collection -- semi-structured student face-to-face focus group discussions**

Semi-structured student focus group discussions were carried out in the twelfth and thirteenth week with each of the two student teams identified. The primary goal of the focused group sessions was more in-depth understanding of student learning experiences that occur as virtual teams cross boundaries during the collaboration process. To be specific, the focus group discussions aimed at serving multiple purposes: 1) to understand from the team’s point of view how the presence of boundary issues affected collaborative learning; 2) to understand from the team’s point of view how boundary issues interacted among one another to impact on student learning; 3) to gather recommendations for future design and set up of such teams for higher education from the students’ perspective; and 4) to determine if global virtual team experiences enhanced student learning in general and, if yes, in which ways.

A characteristic of a focus group that distinguishes it from other methods of research survey and individual interviews is that data collection occurs in, and is facilitated by, a group setting (Stewart & Shamdasani, 2006). A noteworthy fact of the current study is that though the team members collaborated through distance virtually, the focus group sessions were face-to-face. The Chinese students had come to study at the U.S. campus after they completed the VET project; therefore, the researcher had the opportunity to bring the virtual teams together in a real-time, face-to-face discussion.
The steps of setting up the focus group sessions were carefully planned, following the procedure proposed by Krueger and Casey (2000) to ensure the validity of the data collected from focus groups. The author prepared for the focus group sessions by identifying the major objectives of the meeting as mentioned above, carefully developing semi-structured questions (see Appendix A), contacting the selected teams to invite them to the meeting, making plans to record the session with both audio and audio-video recorders, and deciding on the agenda. During the focus group sessions, the author facilitated the process by following the procedures below:

- Introduced the author as the facilitator and as the researcher.
- Introduced the purpose of the focus group sessions.
- Introduced the agenda of the focus group sessions.
- Explained the means to record the sessions.
- Carefully worded each question and facilitated discussion around the answers to each question.
- After each question was answered, checked with the group about a summary of what was said.
- Ensured participation from all participants.

**Step 4: Data Collection -- semi-structured interview with the course instructor**

A semi-structured interview was carried out with the course instructor in the fourteenth week of the project. The purpose of the interview was to gain the instructor’s perspective on boundary issues associated with employing student global virtual teams in higher education (see interview questions to the course instructor in Appendix B). The semi-structured character of individual interviews was used to help make the conversation flexible.
but focused. The researcher facilitated the flow of the conversation in a way that was not controlling but permitted important and pertinent topics to arise, and also allowed the course instructor to raise concerns and or/questions.

Step 5: Data Collection – semi-structured interview with the course instructional designer

Chiseri-Strater and Sunstein (1997) recommended the technique of “stepping out” in qualitative research as a way of getting out of the context to help in “making familiar things strange.” This technique was employed in the current study through a semi-structured interview with the author herself. In this way, the role of course instructional designer was isolated from other roles the author played in the current research as cultural ambassador and as participatory researcher. By “stepping out” of multiple roles, the author was able to answer the semi-structured questions to review in-depth insights from the course instructional designer’s perspective when the boundary issues in global virtual teams were concerned. The questions were almost identical to the questions posed to the course instructor for the purpose of internal validity for later data analysis and comparison.

It is useful to clarify that the semi-structured individual interview with the author as course instructional designer differs from the researcher’s reflection in several ways. First, a researcher’s reflection is a critical self-reflection to identify the researcher’s “assumptions, worldview, biases, theoretical orientation, and relationship to the study” (Merriam, 2002), while the interview is a way for the author to “step out” of the role of researcher and to focus on the perspective of course instructional designer. Second, the primary goal of a researcher’s reflection is to make explicit in what ways the researcher’s position may affect
the investigation, while the purpose of the interview is to gather data from the course instructional designer’s perspective on boundary issues in student virtual teams.

**Step 6: Comprehensive data analysis**

When all data collection procedures were completed, analysis procedures were carried out following the planned sequence proposed by Romano and colleagues (2003) for analyzing qualitative data. As a critical step in data analysis, the author selected, focused, simplified, abstracted, and transformed raw data and recorded it in a spreadsheet file. In this way, the author reduced the volume of data to make it manageable and to help her to focus on the research questions. Each step of the data analysis process is itemized and explained in the following:

**Selecting.** During the selecting stage, the author decided on initial categories of boundary issues and sub-boundary issues, and developed category schemes. Initial categories were informed by the literature review. However, the author made sure that the selection process remained open to derive new meanings and new categories from the data.

**Coding.** During the coding stage, the author grouped the data into classes to establish specific sets of codes for the categories as developed in the selection stage, derived from theories, or based on the word frequencies. To avoid the researcher’s bias during this stage, peer review techniques were adapted to bring in an experienced outside reviewer to check the coding system. The result of coding was an unbiased coding scheme.

**Clustering.** During the clustering stage, the author first applied the coding scheme to the data that had been classed during the selection section, then grouped the coded data into category to develop themes that were grounded in theories and supported in data. The author
did not use an outside coder to help the process. She spent adequate time during the data analysis process to saturate the data, which helps assure the research’s internal validity.

**Ensuring the “Quality” Of the Study**

Steps were taken to ensure the validation and reliability of the qualitative case study research design. In an effort of addressing the quality issue of both quantitative and qualitative research, a set of nine legitimation types was proposed for a mixed-research design by other researchers (Onwuegbuzie & Johnson, 2006; Onwuegbuzie & Daniel, 2003) as illustrated in Appendix C. The current study classifies itself as qualitative research, yet finds it beneficial to apply four types from the set of typology of legitimating types to promote validity and reliability for qualitative research. The rest of the legitimating types are more suitable for mixed-methods research and therefore do not apply to the current study. Procedures were taken to address the following four issues of legitimation:

**Sample integration legitimation.** As mentioned above, the current study carried out a multi-perspective analysis. The choice of participants representing the different perspectives of students, the course instructor, and the course instructional designer was both purposeful and representative. The sample choice and integration embraced the multiple perspective analysis case study design.

**Insider-outsider legitimation.** Onwuegbuzie and Johnston (2006) referred to the insider-outsider legitimation as “the extent to which the researcher accurately presents and appropriately utilized the insider's view and the observer's views for purposes such as description and explanation.” In the current study, the author, as a participatory researcher, accurately captured and utilized the insider’s view by articulating the researcher’s position.
The author also captured the observer’s views by adapting the technique of “stepping out” in the format of conducting a semi-structured interview with herself as course instructional designer to isolate her role as course designer from other roles as cultural ambassador and participatory researcher. In addition, this insider-outsider strategy helped the author to be aware of the possibility of participant bias and act against it. In summary, the insider’s position helped the author to interpret behavior in a culturally appropriate way, while the outsider’s position helped the author to remain neutral during the focus group sections and during the interviews.

**Commensurability legitimation.** Since the current study is participatory research, the author was deeply engaged as an instructional designer during the process of course design, team project design and implementation, and course evaluation. The author was also deeply engaged as the primary instrument for data collection and analysis. She worked closely with participants during the entire process in such a way that she communicated with participants through nonverbal as well as verbal communication, processed data immediately, checked with participants for accuracy of interpretation, and explored unusual or unanticipated responses during the data collection process. These procedures ensured that the data became saturated to meet the commensurability legitimation.

**Multiple validities legitimation.** Several techniques were mapped to ensure triangulation in the current study. The author utilized multiple sources of data from online threaded discussion posts, focus group discussions, and individual interviews. Member checks were employed by taking data and tentative interpretations back to the interviewees. The author also kept an audit trail by keeping a research log on the process and on decision making points.
Findings

The focus of the current study is to develop better understanding of the context of the global virtual collaborative environment where student teamwork took place, the factors that contributed to the context, the process that students went through dealing with different boundaries, and strategies they came up with and the impact of such a process on their learning.

With these goals in mind, the author conducted a case study that investigated boundary issues in virtual student teams from multiple perspectives. This section maps out findings concerning these issues from three perspectives: individual students, student focus groups, and the course instructional team. The content analysis on 845 individual student online posts identified boundary issues that were present across several student teams. It also revealed the factors that attributed to the existence of each boundary issue and discussed the impact that each boundary had on student collaborative learning. The focus group discussion nested multiple boundary issues in a team setting, and the discussions illustrated the interaction among these issues as well as the possible effect that the interaction might cast on student learning in a distributed collaborative environment. In addition, individual interviews were conducted with the course instructional team—the course instructor and the instructional designer—to gain their perspective on boundary issues in student global virtual teams. The interviews revealed the boundary issues they had predicted to be present and the issues they actually observed among student virtual teams. The interviews with the course instructor and instructional designer shed light on the presence of boundary issues from a different angle.
Individual Boundaries across Student Virtual Teams

Data gathered from student online posts, focus group discussions, course instructor and instructional designer interviews indicated that there were several boundary issues present in student global virtual teams. They were cultural, organizational, functional, language, technological, and temporal boundaries. Among them, the organizational boundary was present most frequently among student team members, followed by the temporal boundary, cultural boundary, technological boundary, and functional boundary, and the language boundary was present least frequently. Table 1 describes boundary and sub-boundary issues present in student global virtual teams and teams where a boundary issue was encountered. The rest of the section elaborates on what boundary issues were present across student global virtual teams, factors that contributed to the existence of each boundary, and the impact of individual boundary on student collaborative learning.
Table 1. Boundary issues and teams where a boundary issue was encountered

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Sub-boundary</th>
<th>Teams where boundary issue was encountered</th>
<th>Number of Teams where boundary issue was encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational boundary</td>
<td>Leadership</td>
<td>1,2,3,5,7,8,9</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Fellowship</td>
<td>4,6,5,2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Research experience</td>
<td>2,7,8,9</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Teamwork experience</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Temporal boundary</td>
<td>Awareness of time difference</td>
<td>2,4,6,7,8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Synchronous f2f meetings</td>
<td>1,2,3,4,5,8,9</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Synchronous virtual meetings</td>
<td>2, 3, 4, 6, 7, 8, 9</td>
<td>7</td>
</tr>
<tr>
<td>Technological boundary</td>
<td>Technology choice</td>
<td>6,8,9</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Technology difficulty</td>
<td>1,3,6,8,9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Access to technology</td>
<td>1,7,8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Technology efficiency</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Cultural boundary</td>
<td>Socio-psychological culture</td>
<td>1,2,3,5,8</td>
<td>5</td>
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<tr>
<td></td>
<td>National culture</td>
<td>1,8</td>
<td>2</td>
</tr>
<tr>
<td>Functional boundary</td>
<td>Access to expert</td>
<td>1,2,6,7,9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Access to information</td>
<td>1,8</td>
<td>2</td>
</tr>
<tr>
<td>Language boundary</td>
<td>Access to information</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Language efficiency</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

**Organizational boundary**

Reviewing existing literature indicated that an organizational boundary is likely to be present in a team when its members belong to more than one organization. In the current study, the author identified the existence of an organizational boundary since student team members were from two different organizational systems: the Chinese and the U.S. higher education systems. The two systems prepare students differently for group work and being a leader, and, as a result, students demonstrated differences in their leadership traits and teamwork skills.
Research has found that successful leaders of virtual teams (Kayworth & Leidner, 2002) are effective in communicating with their peers and effective in articulating roles and responsibilities. In the current study, students from the United States, in general, demonstrated stronger leadership characteristics than their Chinese peers when coordinating teamwork. Virtual Team Two was made up of three U.S. students and two Chinese and they analyzed the Three Georges Dam in Southern China. Ross, a U.S. student, initiated the teamwork process by asking the team to decide on the split of work tasks. Later, another U.S. student, Alex, assumed the team leader role by articulating responsibilities of team members on the final report: “…you guys could start on the first five items in the outline details. We will then take the final eight things on the list. Once you have the assignment or part of the assignment done, please post it so we can review everything before submitting a final copy.”

On the other hand, students from China were looking for leadership so that their team’s tasks could be completed. Chinese student Seng from Team One, who was analyzing the Arizona Football Stadium, asked for directions about the split of the workload: “If you decided, please tell me quickly…Please tell us what jobs we should do.” Xang from Team Two raised similar question seeking leadership: “Our group leader, what we can do for you next”?

Another factor that attributed to the presence of an organizational boundary was that there might be different practices between the two higher education systems in preparing students for teamwork. The course instructor foresaw the presence of the organizational boundary. Since the course instructor had taught in China several times, he understood that there are differences in educational practices in student teamwork between the two countries. The instructor’s experience was that the U.S. education systems “tend to focus a lot more on
teamwork, team assignment, and group interaction,” while his observation of Chinese educational practice was that “there are more individual assignment, individual projects, and individual presentations.” Similarly, a Chinese student expressed in online posts his inexperience with teamwork: “this is my first time to do teamwork.” The instructional designer also predicted the existence of an organizational boundary. As she grew up in China and was educated in both the U.S. and Chinese higher educational systems, she personally experienced the different classroom practices between the two systems. Therefore, she believed that organizational boundary would arise from these different classroom practices between the two systems.

**Temporal boundary**

A temporal boundary was found to exist in the current study because student team members were separated by time zone. Temporal boundary was also found to exist because student team members held different perceptions of time. The American and Chinese team members were separated by a 14-hour time difference, and the time separation reduced the time available for same-time interaction. The only possible time that students might have to meet online for synchronous communication was either early morning in the United States, which was late evening in China, or the other way around. Coping with the time separation, students used several different strategies to coordinate across the temporal boundary. The majority of student teams depended on asynchronous communication to work with their international counterparts across the Pacific Ocean. Only one out of the nine student teams utilized a synchronous communication tool to bring most team members together seven times for same-time interaction over their eight weeks of collaboration.
In the current study a temporal boundary was found to exist because student team members had different awareness of the time separation. The majority of student team members was aware of the 14-hour time difference and frequently reminded their team about it. For example, when calling for an instant chat, Lindsey—from the team that was analyzing the South Valley Development in Egypt—reminded her teammates of the time separation: “Maybe everyone is free 8 am Tuesday (tomorrow) here in Iowa which would be 9 pm in China.” When some team members were not aware of the temporal boundary, it could be problematic. Because of the lack of awareness, some team members missed their online meeting because they confused time in China and time in the United States. Also because of the lack of awareness, some team members failed to receive the team’s decision in time for collaboration. Seng, from the Arizona Football Stadium team, felt he did not perform at the level he wanted during the team presentation because the team leader was not aware of the time difference and did not post the presentation process in time. Seng expressed his frustration in the online bulletin board after the presentation: “I get your message just now. I think we have time difference, so I hope you can think of it next time.”

Both the course instructor and instructional designer predicted the presence of a temporal boundary in student teams. The instructor and instructional designer were aware that time separation existed not only because of the 14-hour time-zone difference, but also because of the non-overlapping weekends and holidays. In addition, there was one and half months difference in semester starting dates between the two educational systems. The spring semester started in early March in China, while it started in the second week of January for the U.S. students. This 40-day time difference between semesters required flexibility in course design to suit both systems’ schedules.
**Cultural boundary**

A cultural boundary was found to exist in the current study because team members were from different national cultures and the national cultures had an impact on team members’ behavior. A cultural boundary was also found to exist because some team projects were culturally laden in a sense that in order to articulate the project premises and interpret the impact of the project, an understanding of the local context, situation, and/or culture where the civil engineering project was located was necessary.

The cultural difference between the United States and China are described by researchers as an individualistic culture versus a collectivist culture (Sosik & Jung, 2002; Early, 1993). In the current study, students from the collectivist culture (China) demonstrated stronger evidence of seeking consensuses among their team members. For example, after suggesting a plan to his team, Seng from the Arizona Football Stadium team asked for assurance by saying, “I don't know if you agree this plan. If you have more thorough plans, please tell us.” Similarly, Hana and Sang, from the team analyzing the Three Gorges Dam in China, asked for their teammates’ feedback: “Xang and I discussed last night and chosen task No. 1,2,3,4,5. What do you think? We expect your advices about our suggestions.” Students from individualist cultures (such as the United States) raised similar questions to their team members, but the occurrence was only half as frequent as their Chinese counterparts.

A cultural boundary was also found to exist because some of the team projects were culturally laden. For example, one team project was to analyze the Arizona Football Stadium and another project was to study the China River Diversion. As the United States is one of the few countries in the world to play football and the sport is foreign to Chinese culture, Chinese students realized the existence of this boundary and reacted accordingly: “We don't
know about U.S. football stadium, so we choose the task of ...” Their U.S. counterpart Tim recognized it as well and responded with “I might have a little more knowledge of the stadium and might be able to handle the more complex details.” Similarly, the team studying the China River Diversion looked to their Chinese team members to provide more detailed project information.

Both the course instructor and the instructional designer were aware of the possibility of the existence of a cultural boundary. When choosing team project topics for students to work on, the course instructor and the instructional designer purposely included some civic engineering projects in China, in the United States, and in other countries to provide opportunities to raise students’ awareness of cultural diversity in the field of engineering.

**Technological boundary**

A technological boundary was found present among student teams when there were differences in technology choice and usage among team members. The majority of the nine student teams depended on asynchronous technology, namely a threaded discussion board provided by the course learning management system. Some teams also utilized email as a supplementary tool to support their asynchronous communication. Two teams occasionally used a chat-room for decision-making, but only one team decided to utilize synchronous technology (a MSN chat room) as their main communication vehicle.

Researchers have made efforts to investigate factors that affected media choice and usage in virtual teams. Huysman et al. (2003) proposed the notion of “media stickiness,” a phenomenon the teams experience during the process of structuring media-use patterns. By analyzing the media choice and usage of the nine student virtual teams, the evolution of
usage in the current study was found to be media sticky, that is to say, path dependent. To be specific, student virtual teams stayed with the technology choice the team made in the early stage of its existence throughout the collaboration process.

The process of choosing technology was found to be short and decisions were made quickly among student team members. The typical process tended to be that one or two team members proposed several technologies in the early stages of collaboration, and then their teammates then responded with tools that were available to them and their preferences. Team members also took into consideration the temporal boundary issue and the course requirements when making a decision. See the following posts in WebCT threaded discussion board among members of the Venice Tide Barrie team as an example:

Bu: If you guys don’t mind, I think we can get contact with MSN. What do you think?
Dale: I don’t mind MSN, but we were required to write 3 messages through this website (Threaded Discussion Board in course WebCT) to receive a grade. Also, I am not sure that when you guys will be online. At my time, 9-11 am (your evenings) is not the best time for me.

This team dropped the idea of using MSN for synchronous conversation; instead they relied on the asynchronous WebCT threaded discussion board as their primary communication tool, with email as a secondary method, for exchanging idea and sub-reports.

When it comes to the technological boundary, while students tended to focus on the choice of technology to meet their team project’s needs, the course instructor and instructional designer paid more attention to technology arrangements to cope with the temporal boundary. The instructional designer reported in the interview that “I found it difficult to arrange equipment for students’ same-time online oral presentation.” She
struggled to negotiate with technology staff members for the two presentation sections to be held after hours to accommodate the 14-hour time difference.

**Functional boundary**

The review of the existing literature revealed that functional boundary existed in a team when more than one area of functional expertise is present in a team. In the current study, neither the course instructor nor the instructional designer predicted the presence of a functional boundary. Their rationale was that as the majority of students were sophomores in civil engineering, so they had not yet been able to develop functional expertise. However, the author observed the existence of a functional boundary among student virtual teams because there were differences in access to team project information and in access to content experts.

First of all, as it was been discussed in the section on the cultural boundary, since some teams’ projects were culturally laden, students had different access to the project information depending on who they were and where they were located. When working on the China River Diversion project, Tang took advantage of his access to the project information: “I got plenty useful information and resources in Chinese. I will rewrite them in my own word in English.” Teng also had first-hand information about the China River Diversion because he had visited one of the construction sites in person. Similarly, Kyle, from the team analyzing the Denver Lightweight Railway, informed his teammates that he had a cousin who lived in the Denver area. He planned to benefit from his access to project information: “I have put a word into my cousin who lives in Littleton to see if she can provide any additional information.”
Second, students had different access to content experts depending on where they were located. The U.S. students had more access to the course instructor for questions and clarification, so that they had an advantage in developing a better understanding of the team project. Tim, from the Arizona Football Stadium team, used his access to the instructor to help his team for clarification: “Here is what instructor said about what we need to do for the final report…”

Third, it was interesting to observe that students were aware of the difference in access to project information and that they managed to take advantage of it. Tang asked for his U.S. teammates’ help: “I wonder could you find the article of A Feasibility Study of the Yangtze River diversion project in China written by BERKOFF Jeremy. I have the Chinese version, but can't find the English Edition of this article.” Similarly, Sarah, from the same team, asked for help from her Chinese counterparts: “What we need the most help from you is to help us understand what other options there were to prevent flooding in the south and/or supply more water to the north.”

**Language boundary**

A language boundary was found present in the current study because U.S. and Chinese students spoke different native languages. When English was chosen as the working language, a language boundary was also present because of the difference in English proficiency among team members. In addition, when there were different social norms and social assumptions associated with the language usage, a language boundary was found present as well.
A language boundary was present in the current study when there were differences in English proficiency and it was found that problems arose in communication and task completion. For example, Hana, from the team studying the Three George Dam in China, expressed her concern in a post: “I am concerning the plagiarism. I think is hard for me to use my own words and prepare the summary or description.” Her U.S. teammate Areon agreed with Hana on this point: “It will be much easier for me to put into my own words than for you.”

A language boundary was also observed to be problematic when social norms and social assumptions were involved. One female Chinese student was upset when her U.S. team member referred to her in a post as “Hey man, …” and she protested: “I am a girl. Am I boyish? Uh…” In another team, Hai meant to show his sympathy towards his U.S. teammate, but instead he caused misunderstanding with his post saying, “I am sorry to hear that your grandfather was ill. It does not matter. Our project is not so important.”

The Interaction of Multiple Boundaries in a Team Setting

Examining individual boundaries across student virtual teams shed light on what boundary issues were present and factors that contributed to the existence of each boundary. However, there was only minimal evidence found related to the interaction among boundaries through the content analysis on student posts. In order to develop better understanding of how boundaries coexist and interact with one another to impact student teamwork and how teams evolved to cope with multiple boundary issues, two teams were chosen for a focus group discussion to further investigate multiple boundary issues.
Team Six, the team studying the South Valley Development in Egypt, and Team Eight, who examined the China River Diversion, were chosen to participate in the focus groups. These two teams were chosen for both purposive and theoretical reasons. Specifically, the two teams were chosen for further investigation because of their representativeness: the majority of the boundaries identified across student virtual teams were present in Team Six and Team Eight. In addition, these two teams were chosen because of their uniqueness. They had worked out different strategies from other teams when coping with similar boundary issues. More importantly, a content analysis on the two teams’ posts illustrated the existence of interactions among boundaries in the two teams. Therefore, the author estimated that their focus group discussions would help answer the third research question concerning the interactions among boundary issues and its impact on collaborative learning in a team. For this purpose, these two teams will be discussed in detail in the following section.

**The boundaries experienced by Team Six – South Valley Development in Egypt**

Team Six, made up of three U.S. students and two Chinese students, analyzed the South Valley Development in Egypt project. Their focus group discussions illustrated that this team experienced most of the boundaries discussed in the previous section and that they also experienced concurrency and interactions among these boundaries. Facing these challenges, this team coped with two unique strategies: by making different technology choices from the other teams and by having one person serve as the middle person between U.S. and Chinese team members.
Temporal and technological boundaries

Facing a 14-hour time separation and facing various technology choices, such as Bulletin Board, MSN, and QQ, Team Six decided to use synchronous technology for same-time interaction, while other teams relied on asynchronous technology for communication. The team managed to meet in a MSN chat-room seven times during their five-week collaboration. They provided a rationale behind their technology choice during the focus group discussions that even though “busy schedules and time constraints were the biggest challenges” to their team, they figured out that evening in China, which was early morning in the United States, worked best for them for a real-time virtual meeting. Another reason they preferred a chat room over the WebCT discussion board was that because with asynchronous technology “you have to wait for the person to reply and takes a long time get contact with each other.” One member concluded at the end of the project that a chat room “seems to be the easiest form of communication for our group.” Since the team mainly relied on a MSN chat room for content discussions and decision making, it was not surprising that the number of their WebCT discussion board posts was the least and the shortest among the nine student virtual teams.

Team Six was found to have strong cohesiveness among team members and this might due to the fact that this team utilized real-time interaction technology. Through the synchronous chat room, and sometimes through voice chat, Team Six members built a social network among team members, which, in turn, made team coordination smoother. For example, the team gave one team member support when her grandfather was in critical condition in a hospital. That team member returned the favor by working hard on the team project from the hospital while keeping her grandfather company. As a result, she “definitely
felt close to the students from China and was sad to see the project end.” This kind of team cohesiveness was not observed as obviously as in other teams.

**Technological and cultural boundaries**

Utilizing synchronous technology also helped Team Six members cope with cultural boundary. Being able to have real-time interaction helped team members to know more about each other’s cultures and about the angle from which other team members approached their team project. One U.S. member of Team Six “was excited to chat with a few of the students from China and discovered things about their culture. I also answered several questions they had about the U.S.” Team Six found members from the other culture were more “similar than you normally think.”

**Technological and language boundaries**

The language boundary made a stronger presence in Team Six than in other teams as this team communicated in same-time discussions. Asynchronous communication gave non-native English speakers time to work on their language for reading and postings, while the real-time communicate called for immediate response, which required good English efficiency. In addition, this team had not only communicated through written English but also through voice chat. Chinese students found voice chat most challenging, especially with listening comprehension and with English pronunciation. U.S students found that there were a few times they “had to explain further,” but for the most part, U.S. students were able to “realize what they (Chinese team members) were trying to say.”

**The middle person and boundary issues**

One member on the U.S. site worked as the “middle person” between the U.S. and Chinese team members. The middle person, a third-generation Chinese, grew up in Malaysia,
went to a Chinese/English school there, and has been studying in the United States since his freshman year of college. Since he was well equipped with the English and Chinese languages and was experienced with both education systems, he helped his U.S. and Chinese teammates to cross cultural, organizational, and language boundaries. He explained to both sides the difference classroom practices in the United States and in China, he pointed out differences in cultural norms and social assumptions, and he also helped translate conversations during the chat sessions.

**The boundaries experienced by Team Eight – China River Diversion**

Team Eight, made of three U. S. students and one Chinese student, analyzed the China River Diversion project in central China. Their focus group discussions illustrated that this team experienced most of boundaries identified above and also experienced interactions among these boundaries. Facing these challenges, this team coped using two unique strategies: by having a Chinese student serve as team leader, while other teams were led by U.S. students, and by making boundary issues work to their advantage.

**Organizational, cultural, and functional boundaries**

As discussed in the previous section, the author and other researchers predicted that Chinese students were less prepared in terms of leadership; however, the focus group discussions among Team Eight members told different story. Members of Team Eight noticed Tang, an average Chinese sophomore student, demonstrated strong leadership skills and they recognized Tang as their team leader. For instance, a U.S teammate commented on Tang’s leadership: “[Tang] started asking questions, started thinking of ideas, and threw them out there. That helps a lot.” The leadership role that the Chinese student took probably can be
attributed to the fact that their team project is culturally laden, which put him in an expert position. As this team worked on the China River Diversion project, Tang had the advantage in access to project information. First of all, his language skill in Chinese granted him to more access to project information in that language. Second, his father, who was an engineer at a hydrology power station, became one of his resources. Third, he gathered first-hand information on the project since he had visited one of the China River Diversion project sites.

It is interesting to note that later into the project after the information collecting phase was done, a U.S. student assumed the team leadership role. That may be due to her expertise in organizing team presentations and working on the final report, which were suited to the team’s needs in the later phase of the project.

**Temporal and technological boundaries**

Together with other student virtual teams, Team Eight also found the 14-hours time difference to be problematic. Peter from Team Eight concluded that “it is hard to try to find a time to meet. It would be night time there, morning here. We had to either meeting really early or really late. It made it difficult and complicated.” Accordingly, Team Eight decided to communicate asynchronously.

Similar to other teams, this team also demonstrated “media stickiness” in that the team stayed with their early choice of technology throughout the team collaboration. Team Eight communicated asynchronously through the WebCT discussion board technology with only one chat session using synchronous technology (a MSN chat-room) to prepare for the team presentation. When prompted to reflect on temporal and technological boundaries, Team Eight provided a rationale about their choice of technology to cross temporal boundary during the focus group discussions: “We didn’t choose email because email wasn’t that
quick. Webcam, we just didn’t have webcam. If we had a webcam, we would use it for sure. The resources are WebCT and MSN,” and also that “WebCT can recall everything. Once you got lost in the communication, you can go back to find the information there.”

Many researchers (Espinosa & Carmel, 2003, 2004; Espinosa & Pickering, 2006) consider the time separation as a difficulty for team coordination, yet members of Team Eight hold a different point of view. To Team Eight, time difference worked for them as an advantage in a sense that “because of the time difference, here (U.S.) is night when China is morning. We can work in the daytime. When I was sleeping, I just sent what I got to them. It is their daytime. It is, like, to make the whole project to run 24 hours,” In this way, Team Eight took advantage of the 14-hour time difference to make their team project run 24 hours a day.

Language boundary

Team Eight also took advantage of Chinese team member’s different language skills. During the focus group discussions, Team Eight described how they used the linguistic diversity among their team members. Tang collected project information in Chinese for the team and translated the information into English. His team members then continued to process the information and reorganize it for project reports. At some points in translation, Tang felt that he “cannot use the accurate vocabulary, but it did work.”

Discussion and Conclusions

The focus of the current study is to develop better understanding of how global virtual teams affect student team collaborative learning in a project-based, technology-enhanced virtual global learning environment. It approaches student global virtual teams from the angle
of boundary to identify and measure the international context in which team collaborations took place. The research provides evidence from a multi-perspective analytical case study of boundary issues in global virtual teams in higher education. Data collected from students, the focus group, the course instructor, and instructional designer indicates that several boundary issues were present in student global virtual teams. Analysis also indicates that the factors that attributed to the presence of boundary issues in student teams were different from those identified by the existing literature. The current study also provides evidence that boundary issues interact with one another in student global virtual teams to have an impact on student learning.

Organizational boundary was found to exist in the current study but not because of the differences in administrative structure, organizational affiliation, and technology infrastructure as other researchers pointed out (Espinosa et al., 2003); instead, the boundary was related to the differences in educational practices between the two organizations: the U.S. higher educational system and the Chinese higher educational system. The final report on the commission on the future of higher education produced by the United States Department of Education, titled *A Test of Leadership: Charting the Future of Higher Education* (2006), addresses the importance of nurturing leadership in college students because “for the country as a whole, future economic growth will depend on our ability to sustain excellence, innovation, and leadership in higher education” (p. 1). By contrast, in the mission statement of 2008 issued by the Ministry of Education of the People’s Republic of China, leadership is not listed as one of the important traits to encourage in students (The Ministry of Education of the People’s Republic of China, 2007). Accordingly, the two systems likely have different practices when it comes to student leadership. Indeed, findings
in this study indicate that student participants demonstrated differences in leadership skills and differences in relation to teamwork. The students, course instructor, and the instructional designer’s experiences revealed that in the current study students from the United States were more prepared in teamwork and possessed more leadership skills than their Chinese teammates.

Researchers have also noticed that a learning epistemological divide exists in the United States and China educational systems (Hung & Chen, 2003). However, there is no obvious evidence from the current study to indicate the presence of the learning epistemological divide. However, this does not necessarily mean that the field should discard this factor in future research design. Rather, educators need to keep this divide in mind when designing global virtual teams learning experiences for their students to address both newer and traditional approaches. For example, in Taiwan, there arose a call for a localized approach which would integrate the traditional conception of education. This call was based on an argument supporting the traditional underpinnings of Eastern culture and how it impacts online learning for Chinese students.

Previous research found that temporal boundary exists in a team because of the time separation among team members, non-overlapping week days, and different work schedules (Espinosa, et al., 2003; Espinosa & Carmel, 2004). Similarly, temporal boundary was found in the current study because of time separation among team members: there was a 14-hour time difference between the United States and China. Coping with the time separation, student teams mainly relied on asynchronous technologies, such as bulletin board posts and emails, to communicate. Different awareness of the existing temporal boundary also had an impact on student team members’ performance. Students who were not aware of the time
separation failed to make their team’s virtual meetings or failed to send information in time to their counterparts. Realizing the differing temporal awareness among team members, students often reminded their teammates about the time difference when coordinating virtual meetings. An additional temporal boundary issue was addressed by the course instructor and instructional designer to overcome the 40-day difference between the semesters of the two educational systems.

When studying temporal boundary in global virtual teams, it is important to distinguish whether team members are separated by time or distance. For example, team members located in the United States and Mexico are not necessarily separated by time zones but by distance. However, when members reside in the United States and China, multiple boundaries are involved including culture, time, and geography. Therefore, sound research design is essential to make sure temporal boundary is singled out. If other boundaries are involved, their effects should be recognized and be taken into consideration as well.

In addition, researchers have stated that the technological boundary is present in virtual teams when there are different accesses to technology (Wu, 2005), different technology proficiencies (Kock & Nosek, 2005), or different attitudes towards technology (Watson & Liu, 2000). This author also predicted that technological boundary might exist in higher education because of different LMS choices. However, the current study did not observe these phenomena among student virtual teams. This might be due to the fact that the young generations in the United States and in China were born in a digital age. These “digital natives” have convenient access to technology and they are proficient with frequently used communication technology.
Another type of technological boundary was found to exist in student global virtual teams because of differences in technology choice and usage among student teams. The notion of “media stickiness,” as proposed by Huysman and his colleagues (2003), was found in the current study. That is, student teams stayed with their early choice of technology throughout their team collaboration. Researchers (Watson & Liu, 2000) have reported that culture also plays a role in media choice and attitudes towards technology; however, the author did not find evidence to support this claim. Instead, the current findings indicate that technology high in social presence, such as chat rooms, raised students’ awareness of the cultural boundary and increased students’ motivation and involvement in their teamwork. This finding goes along with other researchers’ claims that social presence was stronger among team members who utilized the same-time interaction technology than might otherwise have been (Robert & Dennis, 2003; Walther et al., 2001).

The cultural boundary was found to exist because team members were from different national culture backgrounds. In the current study, there was an individualistic culture (United States) and a collectivist culture (Chinese). Collectivists emphasize shared values, similarities, and commonalities among team members, while individualists pay more attention to differences among team members (Sosik & Jung, 2002). Evidence indicated that in the current study the two cultures had an impact on team members’ behavior when it came to coordination and collaboration. Student team members from China focused more on finding commonalities and consensus from their teammates, while students from the United States paid more attention to identifying differences in experiences, skills, and abilities among group members. This finding concurred with existing studies (e.g., Sosik & Jung, 2002; Hardin et al., 2007).
The cultural boundary was also found to exist among student team members because some team projects were culturally laden. The contexts, situations, or communications associated with certain civil engineering projects carried meanings that were specific to a culture but often beyond the awareness of a general group. These culturally-laden projects granted some student team members more access to project information than others. This finding also went along with other researchers’ conclusion (McLeod, Lobel, & Cox, 1996; Sosik & Jung, 2002) that the cultural relevance of the team project could have an impact on team members’ performance. In addition, the culture of “digital natives” was found to exist in the current study to some extent. Students from the United States and China demonstrated technology proficiency and had easy access to technology.

Benefits from multi-functional teams, as identified by previous studies, include a larger pool of experts, better workload balancing, and enhanced expertise among the team members (Grinter, Herbsleb & Perry, 1999). At the same time, it has been found that a problem could come from coordinating and managing projects. In the current study, however, as students were traditional sophomores in civil engineering, the author did not expect different expertise among student team members. Indeed, the functional boundary was not found present in the current study because of different expertise. Instead it was found present because of different access to project information and to project experts and because of different language skills, which granted some members increased access to project information. In addition, as mentioned above, since some projects were culturally laden, some team members became the experts on the project because they were more familiar with that culture and were fluent in that language.
Although it is commonly acknowledged that the language boundary is probably present in global virtual teams due to the fact that team members speak more than one first language, the literature review the author conducted revealed that the language boundary has not been investigated systematically by researchers. The language boundary was found to exist in the current study because team members spoke different first languages: English and Mandarin Chinese. When English was agreed to as the communication vehicle, the language boundary was also found present because of different English proficiencies among team members. Some studies (Mulligan & Krikpatrick, 2000) considered language efficiency the number one barrier for non-native speaker learners when they participate in English-based activities.

It is interesting for the author to observe that despite these factors that lead to language boundary issues, the language boundary was not problematic. Even though some Chinese students expressed their efforts with both written and spoken English, all nine teams seemed to be able to carry out communication, and most teams said about their Chinese teammates that “their English was very impressive!” Therefore, it is not too surprising that the number of occurrence of language boundary issues was found the least in the current study. However, this does not necessarily mean that English proficiency would not pose difficulty in other student global virtual teams. The dominance of English on the Web and in the global workplace has created a divide between those who master the language and those who do not. On one hand, English provides a standardized platform for communication. On the other hand, it denies the needs of communication in other languages. As a result, it disfavors these groups to whom English is not their mother tongue. Previous research (Mulligan & Krikpatrick, 2000) estimated that language has been the number one barrier to
non-native speaker learners to participate in learning activities to such a degree that fewer than one in ten ESL (English as Second Language) students was able to understand the content and intent of their lectures very well. Therefore, it is essential to address learners’ language backgrounds to provide support for communication in English and to provide opportunities to maximize the potential of different language skills among team members to create a democratic, distributed, and collaborative learning environment.

Researchers have stated that the geographic boundary exists when team members are separated by distance; in global virtual teams, this distance spans national borders in most cases. Separation by distance also introduced differences in local/national economics and hydrological and meteorological characteristics associated with location. The author did not find evidence directly related to the existence of the geographic boundary even though team members were located in opposite hemispheres. It might be due to the fact that evidence referring to geographic boundary is often mingled with other boundary issues’ measurements, and, therefore, it may be difficult to single out. Espinosa and his colleagues (2003) concluded in their study to measure boundary variables that much empirical work often collapses in measuring distance with other boundaries, such as culture and functions.

**Interactions among Boundaries**

Other researchers (e.g., Espinosa, et al., 2003; Pauleen & Yoong, 2001) have noticed the interactions among boundaries; however, few efforts have been dedicated to identifying the interaction among boundaries and to articulate their impact on team collaboration. The current study identified a range of evidence to illustrate that boundaries were present concurrently and that they also interacted with one another among student team members.
When taking multiple boundary issues into consideration in a team setting, the author noticed that the temporal boundary and the technological boundary came together. The analysis of student online posts and of focus group discussions indicate that the nature of the temporal boundary determined the teams’ communication methods (e.g., synchronous vs. asynchronous communication), and the communication methods in turn dictated the communication technology (synchronous vs. asynchronous technology). In the current study, the 14-hour time separation reduced the chance for same-time communication among team members. Accordingly, an asynchronous tool, in this case the WebCT threaded discussion board, was the choice of most student virtual teams as their communication vehicle. Student teams also employed synchronous technology such as MSN chat rooms occasionally for decision making.

The technological boundary was also found to interact with the cultural boundary. Researchers have found that in high-context cultures, messages have little meaning without an understanding of the surrounding context, which may include the backgrounds of team members (Robert & Dennis, 2005). Therefore, technology high in social presence may help provide multiple channels to communicate non-speaking messages to help raise team members’ awareness of their teammates’ different cultural backgrounds. The current study found that the student teams who utilized a rich technology, such as voice chat-rooms, as their major communication tool demonstrated better understanding of the team diversity than other teams who relied on technology low in social presence, such as a discussion board. In addition, a virtual team facilitator is recommended by previous research (Pauleen & Yoong, 2001) as a strategy to help with communication and relationship building. Similarly, the
current study found that using a middle person who understands the cultural diversity among team members is beneficial.

Researchers found that cultural boundary, in turn, had impact on technology boundary in a sense that team members from individualistic cultures are more flexible in adopting new technology than those from collectivist cultures (Sosik & Jung, 2002). The author did not observe such a phenomenon in the current study; however, her observation was that students from both cultures were proficient with the technology to their choice. This might due to the fact that there is not much difference in attitudes towards technology in the young generation who grew up in the digital age.

In addition, there was clear evidence that the functional boundary mingled with language, cultural, and geographic boundaries to change the team dynamics. When a project is culturally laden, some team members had a better chance to become the project expert when they had more access to project information because of their language skills, because of where they were located, or because of the culture they came from. One obvious example could be that the Chinese student in the team examining the China River Diversion was regarded as the project expert by his team members. Another example could be that it was natural for the two U.S. students to bring in more information on the project analyzing the Arizona Football Stadium than their Chinese counterparts. Accordingly, other researchers also found that culturally laden team projects had impact on team performance and on the team development process (Sosik & Jung, 2002).

As has been discussed earlier, organizational boundary was present in the current study because the U.S. and the Chinese higher education systems prepare students differently for leadership. However, a noteworthy phenomenon was that the project expert also tended to
lead the team as well. Therefore, it is possible that the organizational boundary interacted with the functional boundary. The temporal boundary and the organizational boundary were not independent, individual boundaries in some cases. The 40-day difference of semester starting dates between the U.S. and Chinese higher education institutions required coordination between the two systems.

The findings of the current study also suggest that some boundaries, such as the geographic boundary, might be better discussed within the context of interactions among multiple boundaries. On one hand, researchers have found it difficult to separate the geographic boundary from other boundary issues and to measure it (McDonough et al., 2001; O’Leary & Cummings, 2002). On the other hand, the author and other researchers have found some research methodologies problematic when measuring the geographic boundary. McDonough and colleagues’ (2001) three levels of virtual teams, for example, appear questionable. Their definitions conflated cultural diversity (cultural boundary) and location (geographic boundary) in a sense that it mixed teams that were dispersed across different floors of the same building with teams dispersed across different countries. Another study that investigated the relationship between delay in cross-site work, and the degree to which remote colleagues were perceived to help out was conducted (e.g., Herbsleb, Mockus, Finholt, & Grinter, 2002). However, in the study delay was a temporal concept that was mainly associated with time separation, rather than a geographic boundary. As a result, their study did not map out an appropriate inquiry, and their interpretation of the results was problematic. Therefore, when examining the geographic boundary and its impact on teamwork, it might be wise to put it into the context of its interactions with other boundary issues. In fact, some researchers found that cultural boundary interferes with temporal
Boundary (Saunders, Van-Slyke & Vogel, 2004). Culture and religious beliefs were found to have an impact on virtual team members’ time vision and, therefore, lead to different team performance. The Author Did Not Observe Such A Phenomenon In The Current Study.

**Boundary or Bridge?**

The existing literature on global virtual teams that addresses the presence of boundaries sometimes has described boundaries in terms of “discontinuity” (Watson-Manheim et al., 2002; Chudoba et al., 2002). That term emphasizes the incoherence or a gap in aspects of a team’s work in the areas of physical location, temporal location, work-group membership, or other boundary. The findings of the current study suggest the need to be equally aware of factors that are in place or emerge to bridge the discontinuity–continuity. In other words, although boundaries lead to the discontinuity in a team’s work flow and thus raise the difficulty to coordinate teamwork, boundaries can also work as a bridge to bring unique qualities and multiple perspectives on problem solving to the group.

While the instructional team predicted the presence of several boundaries, they also believed that these differences among team members could work as bridges. When implementing student global virtual teams in the civil engineering program, they wanted to provide the opportunity for students to work in a multi-cultural team and to have an international focus in the current civil engineering program to develop a world-class engineering education. They planned to help students understand the benefits of having diversity in global teams and, therefore, be better prepared for the future global workplace. Accordingly, when designing the team project they made sure there were international civil
engineering projects to encourage students to take advantage of the language and cultural diversity among team members.

Although boundaries posed challenges for team collaboration, students found that the cross-boundary collaboration experiences “enhanced learning.” First of all, the cross-boundary collaboration experience was said to be “fun.” Some team members described the experience as “different” and “exciting,” which worked as motivation for participation. Second, students found this cross-boundary virtual teamwork experience “necessary.” They realized that with the trends of globalization there were certain things they could not accomplish without their international teammates so that “you have to work together to get things done, get done well.” Consequently, this experience helped students be better prepared for the future global workplace. Third, students learned to make boundaries work to their advantage. For example, they utilized teammates’ foreign language skills for information collection. Students also took advantage of the time difference to make the project run 24 hours a day. This confirmed researchers’ previous findings that global virtual teams can leverage time to their advantage (Saunders at al., 2004). Performing work asynchronously helped teams bridge different time zones so that the teams are productive over more than one work period.

Limitations and Implications

In common with all case studies, the findings of this case can only be generalized with careful consideration. It is up to the readers to recognize aspects that are useful to their contexts. In addition, the data and data analysis methods were primarily qualitative. Additional quantitative data on the effects and interactions of different boundary issues could
be illuminating in a future study. In addition, caution in interpretation of the findings is warranted because they might be influenced by the participatory researcher and the settings of the current study; that is to say the nature and characteristics of civil engineering, and the fact that participants were located in China and in the United States might have impacted the findings of the current study. Further studies involving different research sites are necessary to corroborate and extend the findings.

Despite these limitations, this study has important implications for research on global virtual teams in higher education and in commercial settings. Most obviously, it provides a set of solidly grounded findings on the presence of different boundary issues in student global virtual teams. Moreover, it identifies factors that contributed to the presence of each boundary in student teams, and it discusses how each boundary impacted student team learning. It also clearly demonstrates the interaction among boundary issues in a global virtual setting and offers insights about how the interactions influence team collaboration. As a result, this study fills a gap in the previous literature: student global virtual teams have not been adequately investigated by researchers, perhaps due to the fact that in the field study of global collaboration it is not always clear which boundary issues are present and interaction of boundary issues are difficult to separate from other factors (Espinosa et al., 2003).

In addition, this study suggests some future directions for global virtual team research. For instance, the continuity aspect of boundaries can be further explored, researched, and discussed. Future research could also investigate factors that could not only minimize the cost of boundary issues but also maximize the benefits. Another direction might be that, with the trends of globalization in the workplace, it is common to have team members with international experiences serve as the “middle person” in a global virtual team
to bridge boundary issues. Future research could investigate the roles the middle person can play and the impact on global virtual team dynamics. Furthermore, the current study identified several interactions among boundary issues, further research is needed to precisely describe and measure possible interactions observed in other global virtual team set-ups.

This study also makes important contributions to team learning in higher education in a virtual global collaborative environment. Though the existence of multiple boundary issues increases the challenges of team coordination, global virtual teams are already widely adopted in the workplace for their advantage in bringing different expertise together. In higher education, it is beneficial to utilize student global virtual teams to enhance students’ educational experiences and to prepare them for the future global workplace. The current study contributes to a better understanding of the components of an external collaborative context in which student teamwork took place and to a better understanding of how these components impact student learning individually and through interaction. Therefore, the study joins the efforts for educational advancement in teamwork in a global educational environment enhanced by current e-learning technology and the growth of distance education.

There are several practical recommendations the current study can make for the setup and use global virtual teams learning activities for students. Using such a strategy empowers students in terms of intercultural and team work competence; using such a strategy prepares students better for the future global workplace. Although more evidence is needed, it seems that it is beneficial to adapt technology high in social presence such as chat rooms to support same-time interactions. There is a common recommendation in the practitioner-oriented literature that a team face-to-face virtual meeting early in its existence would also be
beneficial (Maznevski & Chudoba, 2000). Similarly, when commenting on future set up of the student global virtual teams during the focus group sessions, students asked for an opportunity to “meet” their teammates at the beginning of the group project. Additionally, the current study provides clear evidence that it is important to choose projects carefully for teams to collaborate on. Projects that are culturally relevant, geographically appropriate, and linguistically beneficial could increase the chances for team members to take advantage of their diversity; therefore, those projects may raise team members’ awareness of the value of global virtual teams in higher education and in the future global workplace.

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**References**


APPENDIX A: FOCUS GROUP DISCUSSION QUESTIONS

Your group will carry out a focus group discussion about your group’s collaboration process. You may skip any question that you do not wish to discuss.

1. Please comment on the following description of your team’s collaboration work.

(Students will be presented with one of the following descriptions of their team’s collaboration work by the principal investigator.)

Team A

- Overall great collaboration in this team. Work split nicely, and team members exchanged ideas and commented on sub-reports efficiently.

- Time boundary. Your team met on MSN for synchronous discussions 6 times. They were aware of the time difference and were efficient to arrange online meetings. U.S. students met face-to-face twice during the project.

- Technology boundary. The team chose MSN as the most frequent technology for online chat over QQ. When using MSN, the team had difficulty when transferring reports. The team also experienced difficulty with WebCT—the format of their report got messed up when some team members tried to share the report with the whole group in Discussions. The team was also aware of which choice of technology was the most efficient the communication format.

- Culture/Leadership boundary. The team leader was an U.S. female.

- Language boundary. The team communicated with efficiency. One funny mis-communication: “I am sorry to hear that your grandfather was ill. It does not
Out project is not so important. Just go ahead to take care of your grandfather. ”—Chinese male.

- Social issues. Supported one another when one team member has an ill family member. They are sad when the teamwork was done.

Team B

- Overall: This team has 4 members—3 U.S. students and one Chinese. Collaboration went well. They discussed the projects, exchanged ideas, split the task, and completed sub-reports.

- Culture/Leadership boundary: The Chinese member was a driven leader from the very beginning and an U.S. student took the role of leadership later. There was no conflict.

- Language and Expertise boundary: The team recognized and took the advantage of the Chinese member’s access and understanding of project information in Chinese. Plagiarism was their concern.

- Time boundary: They mainly relied on the WebCT Discussion function for asynchronous communication. They tried to arrange online instant meeting three times but only did it only once with only two members showing up. The U.S. members relied on face-to-face meetings; they got the Chinese member up-to-date progress by posting team meeting minutes in WebCT Discussions area.

- Technology boundary: This team was debating about technology choice for their communication. They proposed a variety of technology for communication and teamwork including the following: MSN, WebCT Chartroom, Gmail, Skype,
webcam, email, and phone. They mainly relied on asynchronous technology, including WebCT discussion and email, for communication.

2. How would you describe your team’s collaboration work?

3. What were your teamwork experiences before you participated in the virtual student collaboration project in Civil Engineering Synthesis?

4. What were the challenges you anticipated for the U.S./China student team collaboration project?

5. What were the challenges you experienced during the U.S./China student team collaboration project?

6. How has this experience enhanced or not enhanced your learning, and how?

7. Please make suggestions to improve the virtual student collaboration experience.
APPENDIX B: SEMI-STRUCTURED INTERVIEW QUESTIONS TO THE COURSE INSTRUCTOR AND TO THE INSTRUCTIONAL DESIGNER

You will have an interview about your observations, your thoughts, and your reflections on student teams’ collaboration process. You may skip any question that you do not wish to discuss.

1. How would you describe student teams’ collaboration work?

2. What are learning objectives you have in mind for these student teams to accomplish?

3. From your observation of your students, do you think these visual collaboration teams enhance students learning or not and in which ways?

4. Would you describe your prior experience of directing students’ teamwork before this international collaboration course?

5. What are the challenges you anticipated for the students?

6. What was the challenge you observed from the student group collaboration?

7. If you are going to use similar student global virtual teams set up in your course in the future? What kind of change you are going to make?
### APPENDIX C: TYPOLOGY OF MIXED-METHODS LEGITIMATION TYPES

Table 2. Typology of Mixed-Methods Legitimation Types (Onwuegbuzie & Johnson, 2006)

<table>
<thead>
<tr>
<th>Legitimation Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample integration</td>
<td>The extent to which the relationship between the quantitative and qualitative sampling designs yields quality meta-inferences.</td>
</tr>
<tr>
<td>Inside-outside</td>
<td>The extent to which the researcher accurately presents and appropriately utilized the insider's view and the observer's views for purposes such as description and explanation.</td>
</tr>
<tr>
<td>Weakness minimization</td>
<td>The extent to which the weakness from one approach is compensated by the strengths from the other approach.</td>
</tr>
<tr>
<td>Sequential</td>
<td>The extent to which one has minimized the potential problem where in the meta-inferences could be affected by reversing the sequence of the quantitative and qualitative phases.</td>
</tr>
<tr>
<td>Paradigmatic mixing</td>
<td>The extent to which the researcher's epistemological, ontological, axiological, methodological, and rhetorical beliefs that underlie the quantitative and qualitative approaches are successfully (a) combined of (b) blended into a usable package.</td>
</tr>
<tr>
<td>Commensurability</td>
<td>The extent to which the meta-inferences made reflect a mixed worldview based on the cognitive process of Gestalt switching and integration.</td>
</tr>
<tr>
<td>Multiple validities</td>
<td>The extent to which addressing legitimating of the quantitative and qualitative components of the study result from the use of quantitative, qualitative and mixed validity types, yielding high quality meta-inferences.</td>
</tr>
<tr>
<td>Political</td>
<td>The extent to which the consumers of mixed-methods research value the meta-inferences stemming from both the qualitative and qualitative components of a study.</td>
</tr>
</tbody>
</table>
CHAPTER 5. GENERAL CONCLUSIONS

Introduction

While global virtual teams offer a wide range of potential advantages to organizations, implementation might be at risk if the many challenges present in the international virtual context are not addressed adequately. Previous research on the team dynamics and team development process of traditional collocated teams paved the way to investigate teams working at multination level; however, the special characteristics of global virtual teams require special attention from researchers.

The notion of “boundary” (Espinosa, Cummings, Wilson, & Pearce, 2003) is deployed in the current dissertation to define the challenges and opportunities that most global virtual teams encounter. It presents an investigation of boundary issues as a new multidimensional perspective on global virtual teams. The investigation was in three parts: a literature review followed by investigations of two phases of the use of global virtual teams in an engineering course at a Midwestern university. In the course, international undergraduate engineering student teams made up of U.S. and Chinese students collaborated over distance to complete projects. The first investigation found significantly differences in team performance when comparing global teams to teams made up of only U.S. students. The second investigation, which took place a year later, provided a rich case study description of boundary issues present in the virtual global teams.

The first article reviewed the literature on global virtual teams in industry, commerce, and higher education. Content analysis was adopted to systematically select and categorize 66 publications. The analysis mapped out six boundary issues that appeared most frequently
in global virtual teams. The majority of previous articles had investigated technological boundary, followed by organizational, cultural, and temporal boundaries, but only a few of the selected articles explored geographic and functional boundaries. Each boundary was found to have a profound impact on team performance and/or on team collaboration process (Espinosa & Carmel, 2003, 2004; Earley, 1993; Hiltz, Coppola, & Turoff, 2000; Jarvenpaa & Leidner, 1999). Existing research also identified factors that contribute to the presence of each boundary in global virtual teams. In addition, researchers also investigated other factors that work together with boundary issues to impact team collaboration such as trust (Jarvenpaa et al., 1998) and the design of the team project (Earley, 1993; Hiltz et al., 2000). This literature review served as a foundation for the investigation of two interventions to introduce global virtual teams into an engineering education course.

The first implementation of global virtual teams was investigated using quantitative evidence to contrast teams of U.S. students with global teams that had both Chinese and U.S. students. The second article presents a comparison of team performance of ten cross-boundary virtual teams with seven within-boundary virtual teams. It also examined the interaction of cross-boundary factor with two other factors on team performance: time and the number of tasks. Evidence showed that the cross-boundary teams outperformed within-boundary teams in team effectiveness and team member’s participation. In addition, team performance was shown to change over time and with the number of tasks. Cross-boundary team members were more actively involved in team collaborative learning activities than teams with only U.S. students. The author was intrigued with this finding that global virtual teams improved performance despite all the challenges they experienced during their cross-boundary collaboration.
The second implementation of global virtual teams took place in the following year. It was investigated in a case study presented in the third article, which explores this innovation in more depth. The third article approached the boundary issues in higher education from the angle of discontinuity and continuity (Watson-Manheim, Chudoba, & Crowston, 2002; Lu, House, Watson-Manheim, & Matzkevich, 2005) to investigate the divides and the benefits brought about by such boundaries. Students were involved in virtual collaboration on a project with five engineering tasks over seven weeks. The case study described the collaborative experience from three perspectives: the students, the course instructor, and the instructional designer. It examined qualitative data gathered through archives of online posts by 44 students in nine teams, student focus group sessions, and individual interviews with the course instructor and the instructional designer. The team set up and engineering students’ team projects were similar to the first year, so this study of a similar student group added participants and depth. The third article provided evidence of the presence of several boundaries and the impact of each boundary on student learning in higher education. Furthermore, the author found that the factors that had contributed to the existence of certain boundary issues in higher education were different from those identified by previous studies. For example, researchers have suggested that organizational boundary is characterized by discontinuity in organizational structure, administrative philosophy, and organizational affiliation among team members (Espinosa, et al., 2003). However, the third article here observed that the organizational boundary was present among student teams because of the different educational practices in preparing students in leadership skills and teamwork between the two higher education institutions. In addition, the third article illustrated evidence that multiple boundary issues interact with one another to have an impact on
collaborative learning. For example, in team projects that were culturally laden, it became possible for a student to become a project expert for their team when he or she had more access to relevant resources due to language skills and/or cultural roots. Furthermore, the third study argued for the importance of addressing existing or emerging continuities that came simultaneously with discontinuity introduced by boundaries of global virtual teams.

**Answers to the Research Questions**

This dissertation sought to answer three research questions as laid out in Chapter 1. The answers to these questions are now briefly provided.

1. What is the extent of knowledge or conceptual understanding among researchers with regards to boundary issues in global virtual teams?

Researchers have recognized the existence of boundaries in global virtual teams (Espinosa et al., 2003; Kock & Nosek, 2005) and have recognized the needs to define and measure these boundaries. Six boundaries that have been identified by previous researchers include organizational, technological, geographic, cultural, temporal, and functional boundaries. Most previous studies singled out specific boundary(ies), identified the factors that contributed to the existence of that boundary, and measured its impact on team performance and/or on team dynamics. Researchers also approached boundary issues from the angle of discontinuity and continuity. Some researchers have argued that the continuity aspect of boundary issues should be addressed simultaneously with discontinuity (e.g., Watson-Manheim et al., 2002).

Boundary issues have been found to have an impact on team performance individually and through interactions with other factors such as trust and the design of team
project (Espinosa & Carmel, 2003, 2004; Earley, 1993; Hiltz et al., 2000; Jarvenpaa & Leidner, 1999). Researchers have also recognized that boundary issues interact among themselves (e.g., Saunders, Van-Slyke & Vogel, 2004; Watson & Liu, 2000); however, only limited research efforts have been devoted to this direction.

In conclusion, the existing literature grasps the essential elements of boundary issues that were frequently presented in global virtual teams, and the need for further investigations was identified. For example, despite the fact that close to half of the empirical studies reviewed by the author were conducted using student participants, the special characteristics associated with a higher education setting have not been highlighted. Despite the fact that multiple boundary issues were present simultaneously in most global virtual teams, the existing literature has not attempted to study or measure all of the co-existing boundaries (Espinosa et al., 2003).

2. To what extent do boundary issues affect global virtual team performance, and to what extent do boundary issues interact with other factors to affect global virtual team performance?

Set in the context of international engineering education, the current dissertation found cross-boundary collaboration has a positive effect on team performance. In other words, despite the challenges posed by boundary issues, global virtual teams outperformed collocated teams in team effectiveness and in levels of team members’ participation in the collaboration. This finding contradicted what previous research has found that compared to collocated teams, virtual teams were found to be less effective and the communications among team members were found to be lengthy and confusing (e.g., Powell, Piccoli, & Ives, 2004; Mcdonough, Kahn & Barczak, 2001).
The current dissertation also provides evidence to illustrate that global virtual team performance changed over time and the number of team tasks. However, the author hesitates to conclude that time and the number of team tasks interacted with boundary issues to have an impact on team performance. The reason is because evidence also illustrates that the performance of collocated teams changed in a similar fashion over time and the number of team tasks. Therefore, further research effort is needed to determine if the changes in team performance are related to an interaction between boundary issues and these two factors.

3. What boundary issues have been found present in student global virtual teams, and how do boundary issues interact with one another to impact the global virtual team collaboration process?

Six boundary issues that have been found present in student global virtual teams situated in the context of international engineering education include organizational, technological, cultural, functional, temporal, and language boundaries. Compared to boundary issues identified by the existing literature, the current dissertation did not locate evidence for the presence of geographic boundary. Researchers also found it difficult to separate the geographic boundary from other boundary issues and to measure it (McDonough et al., 2001; O’Leary & Cummings, 2002). The current dissertation, however, found the language boundary obvious among student global virtual teams. Although language boundary is considered as one of the classic boundaries, this language divide has not been highlighted or systematically measured by previous researchers. English serves as the working language in most global virtual teams, so the needs for other language skills have been hidden, and this language boundary does not appear in the literature. Further research is
needed to confirm this assumption. This dissertation also argues for the importance of addressing continuity simultaneously with discontinuity.

The current dissertation identified a range of evidence to illustrate that boundaries interacted with one another among student team members. The author noticed that the temporal boundary and the technological boundary often came together to have an impact on team’s media choice and on team’s communication patterns. The technological boundary and cultural boundary interact with each other to have an impact on team collaboration. In addition, there was clear evidence that the functional boundary mingled with language, cultural, and geographic boundaries to change the team dynamics. The current research indicates a variety of interactions among boundaries, and further research is needed to measure more precisely the level of interaction and to measure the impact of such interactions on team collaborations.

Limitations

Several limitations of this dissertation need to be addressed. The first limitation comes from the generalizability of the research design and findings of the current dissertation. Researchers are concerned with the realism and generalizability of global virtual teams of students to their use in business and industry (e.g., Piccoli, Powell & Ives, 2004), so the findings from the second and third articles should not be generalized beyond engineering education without further research. In addition, although drawing generalizations is not the primary aim of the current dissertation, readers need to be cautioned that the case study of the third article is not generalizable. Furthermore, although the second study has set the stage for conducting verifiability tests in order to explore the transferability of these findings to new
contexts (Lincoln & Guba, 1985), it has yet to be seen if the study remains a unique case or if it has wider applications.

The second limitation comes from selection of participants. Using a convenience sample with students who registered for one undergraduate engineering class in 2006 did not meet the requirement of maximum random sampling for some statistical procedures. Luey & Raisinghani (2001) raised similar concerns when random sampling was not a possibility.

The third limitation comes from the composition of student teams. The teams are homogeneous in that all team members are sophomore students in civil engineering with similar educational backgrounds and ages. The teams are also homogeneous in that team members are only Chinese and American, other cultures were not included. Therefore, researchers raised concern that findings might be culturally or setting specific (Sosik & Jung, 2002). In both qualitative and quantitative articles included in this dissertation, the homogeneity of team composition might limit the maximum variation when trying to promoting validity and reliability.

The final limitation arises from the fact that the investigator is a participatory researcher. The investigator served as the primary instrument for data collection and data analysis, especially in the third study. Despite some advantages of being the human instrument, as described in article three, there are also shortcomings and biases that might have an impact on the study. Rather than trying to eliminate these biases or “subjectivities,” it is important to identify them and monitor how they may be shaping the collection and interpretation of data (Merriam, 2002). An investigator must take into consideration his or her stand on a number of important issues (Esterberg, 2002):
• What are the investigator’s biases and preconceptions?

• What are the investigator’s own investments in particular issues and in particular ways of seeing the world?

• What does the investigator already think he or she knows, and how does he or she know it?

Being aware of these issues is important to the present dissertation because they have shaped the way the investigator interacted with her participants and, more importantly, shaped the way the investigator interpreted the quantitative and qualitative data she collected.

**Delimitations**

This dissertation is restricted in scope to student global virtual teams whose members cross several traditional boundaries in order to collaborate. Neither the design of global virtual team collaboration, nor the analysis of specific team collaboration process is a central concern of this dissertation. Finally, gender differences and socioeconomic backgrounds of the team members are not considerations in relation to the outcomes of the study.

**Implication for Future Research and Practice**

In summary, the current dissertation developed better understanding of boundary issues in global virtual teams, especially in the context of higher education. The thrust of the three articles was to investigate the place global virtual team practice. Together, they answered the three research questions as laid out in chapter 1 in several ways. They provided both quantitative and qualitative evidence that the international virtual collaboration enhanced student learning. They also provided evidence to illustrate that boundary issues had
an impact on student learning individually and through interactions. This dissertation argued that while boundaries divided the working context of members in virtual teams, some boundaries can also work as a “bridge” to bring extraordinary opportunities for the team members.

Each article has raised questions that can be further debated, researched, and developed as laid out in several chapters of this dissertation. Overall, this dissertation suggests that research is needed to purposefully seek variation or diversity in sample selection to allow for a greater range of application of the findings by other researchers. It also suggests investigating factors that will not only minimize the challenges introduced by boundary issues, but also maximize the benefits that come with global virtual teams. For educators, it is important to prepare students for such international collaborative teamwork through team building exercises and through raising their awareness of the challenges and benefits introduced by boundary issues.

The findings also have implication for workplace using global virtual teams. They are recommended to consider the specific boundary issues they met and the interactions between them. Developing an understanding of specific components of boundaries presented in their virtual teams may precede recognition of strategies to bridge these discontinuities.

**Significance**

This dissertation contributes to the literature on global virtual teams in several ways. First, it contributes to the theoretic advancement of global virtual teams by providing the first literature review on research of such teams utilized in higher education and in industry. Second, it provides evidence for the advantages of such teams in undergraduate engineering
education at a time when the engineering sector is becoming increasingly global. In particular, it advances higher education pedagogy that adopts global virtual teams to develop students' intercultural competence. Third, this dissertation is especially beneficial for other higher education institutions considering implementing similar educational collaboration programs to that in the mid-west U.S. and Chinese universities. Finally, this study provides a foundation for future research of the boundaries that affect virtual team performance in a global education environment.

References


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